



**SOCIO-ECONOMIC STUDY ON  
WATER CONSERVATION  
TECHNIQUES IN SEMI-ARID  
AREAS**

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**Water Research Commission**



# **SOCIO – ECONOMIC STUDY ON WATER CONSERVATION TECHNIQUES IN SEMI – ARID AREAS**

**By**

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## LIST OF ACRONYMS

|             |                                                                      |
|-------------|----------------------------------------------------------------------|
| ARC         | Agricultural Research Council                                        |
| ARC-ISCW    | Agricultural Research Council – Institute of Soil, Climate and Water |
| ASA         | American Society of Agronomy                                         |
| <i>BbBb</i> | No mulch basin as well as runoff area                                |
| BCR         | Benefit Cost Ratio                                                   |
| CB: WHIG    | Community Based Water Harvesting Interest Group                      |
| CDF         | Cumulative Distribution Function                                     |
| CEB         | Crop Enterprise Budget                                               |
| CGIAR       | Consultative Group on International Agricultural Research            |
| <i>CON</i>  | Conventional                                                         |
| CPF         | Community Projects Fund                                              |
| CPF-SP      | Community Projects Fund – Support Programme                          |
| CYP-SA      | Crop Yield Prediction for Semi-arid Areas                            |
| ET          | Evapotranspiration                                                   |
| FAO         | Food and Agriculture Organization of the United States               |
| FSD         | First Order Stochastic Dominance                                     |
| FSP         | Free State Province                                                  |
| FSR         | Farming Systems Research                                             |
| FSRE        | Farming Systems Research and Extension                               |
| GDP         | Gross Domestic Product                                               |
| GM          | Gross Margin                                                         |
| IDS         | Institute for Development Studies                                    |
| IRWH        | In-field Rainwater Harvesting                                        |
| K-S         | Kolmogorov-Smirnov                                                   |
| NDA         | National Department of Agriculture, South Africa                     |
| NPV         | Net Present Value                                                    |
| <i>ObBr</i> | Organic mulch in the basin area with a bare runoff area              |
| <i>ObOr</i> | Organic mulch in the basin area as well as the runoff area           |
| <i>ObSr</i> | Organic mulch in the basin area and stone mulch on the runoff area   |
| PAR         | Participatory Action Research                                        |
| PRA         | Participatory Rural Appraisal                                        |

|             |                                                               |
|-------------|---------------------------------------------------------------|
| RSE         | Rainfall Storage Efficiency                                   |
| <i>SbOr</i> | Stones in the basin area and organic mulch on the runoff area |
| <i>SbSr</i> | Stones in the basin as well as on the runoff area             |
| SES         | Socio-economic Status                                         |
| SSD         | Second Order Stochastic Dominance                             |
| TDAVC       | Total Directly Allocatable Variable Cost                      |
| TFP         | Total Factor Productivity                                     |
| TNDAVC      | Total Non-directly Allocatable Variable Cost                  |
| VAT         | Value Added Tax                                               |
| WRC         | Water Research Commission                                     |
| WUE         | Water Use Efficiency                                          |

## LIST OF APPENDICES

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## EXECUTIVE SUMMARY<sup>1</sup>

In recent years, increased use of appropriate productivity-increasing technologies has provided many countries an avenue for dealing with the problem of food insecurity among their populations and the whole area of sustainable development in agriculture and natural resources (Sanders *et al.*, 1996; Byerlee and Husain, 1992; Byerlee and Eicher, 1997). However, a much greater effort is needed to promote greater intensification on small-scale farms.

The majority of small-scale farmers are located in less favoured agro-ecological conditions, with poor soils, and low and erratic rainfall. The development and transfer to farmers of production practices and techniques that encourage water and soil conservation, and increased water use efficiency can provide small-scale farmers with an opportunity to increase agricultural production. It is in response to this need that agricultural researchers at the Agricultural Research Council - Institute of Climate, Soil and Water (ARC-ISCW) at Glen Research Station in the Free State developed new production techniques based on in-field rainwater harvesting (IRWH) to help improve productivity and production of rain fed agriculture in semi-arid areas. However, before these water conservation techniques and other new production technologies can be transferred to farmers, analyses to assess their economic viability, social acceptability and environmental sustainability are required.

Using Thaba Nchu as a case study, this report deals with social, economic and environmental issues in rainwater harvesting systems designed to improve water management for crop production among smallholder farmers in semi-arid areas. Across most of the developing world, many water conservation projects have failed, despite good techniques and design, because of the failure to investigate their social and economic aspects. In other cases where improved water management and conservation techniques have been introduced, their sustainability and environmental impacts have been overlooked.

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<sup>1</sup> The present study is part of the bigger study on rainwater harvesting for agricultural production that was jointly undertaken by researchers at the Departments of Agricultural Economics and Sociology at the University of the Free State and the ARC - ISCW (Glen Research Station, Free State Province). For a more complete understanding of the potential role of rainwater harvesting for increasing agricultural production in semi-arid areas and the environmental sustainability of such practices the reader is advised to also consult Botha *et al.*, 2003.

New technologies (tangible creations as part of material culture) not only present opportunities for communities to improve its material well-being, it also influences the non-material culture (intangible creations such as beliefs, norms and values) of a community. One of the most urgent challenges facing a community is the need to adapt its non-material culture to material innovations. Such adjustments and acceptance are not always immediate. Sometimes they take decades; sometimes they never occur. Changes in the material culture take place at a faster pace than the non-material aspects of a community's culture. It is important to be aware of this difference when assessing the social acceptability of new technologies.

When considering this project, one of the conditions for the success of water conservation techniques is the acceptance by resource users – the farmers. Among other issues, chances of acceptance of new technologies are much greater if new production techniques are developed with adequate involvement of resource users, and when a context is created in which the level of skills of community members and the organisational capacity of communities can be improved to allow their effective management of the techniques. Furthermore, profitable technologies that are thought to result in socio-economic inequities and disruptions to the social organisation may be resisted by communities.

Smallholder farmers already operate in an environmental fraught with high levels of risk due to climatic and price variability. The risk levels and profit potential for investment of labour and other inputs must be acceptable, if the new techniques are to find use among farmers. The benefits generated by the new production technologies must be apparent to farmers as early as possible in the technology development or on-farm adaptation and adoption phase.

## STUDY AREA

On-station trials for the water harvesting/conservation techniques that are examined in this study took place at the Glen Research Station in the Free State. The farmers targeted to benefit from the use of the water conservation techniques are small-scale farmers in semi-arid areas, in particular farmers involved in crop production in the villages of Thaba Nchu in the Free State. In addition, a large area of land in the vicinity of Thaba Nchu has been earmarked for the establishment of small-scale farmers (Botha *et al.*, 2001) and it is hoped that the new

farmers, once they get established on the land, will also benefit from the adoption of these water conservation techniques. It is hoped that with a better understanding of water conservation technologies, in the future efforts will be undertaken to promote more widespread application of rainwater harvesting techniques among farmers in all parts of South Africa.

Thaba Nchu is found in the eastern part of the Free State Province about 60km east of Bloemfontein. The area comprises the "peri-urban" town of Thaba Nchu (estimated population of 109 400 people<sup>2</sup>) and a rural area consisting of 42 villages covering a total of 70 364 hectares. The 42 villages are spread across the area, north and south of Thaba Nchu town (see Figure 1).



FIGURE 1: MAP OF THABA NCHU

Source: Department of Geography, University of the Free State

<sup>2</sup> Mangaung Local Municipality, 2001

## RESEARCH AIMS

The main aim of the study is to carry out economic viability and social acceptability analyses, and an assessment of the environmental sustainability of in-field rainwater techniques. Although the study is conducted with smallholder farmers in the Thaba Nchu agricultural district, it is hoped that there will be some generalisability in the major findings of the analyses, and that the methods employed in the study can be applied in other parts of South Africa and the sub-region and help shed light on issues facing smallholder farmers in other semi-arid areas.

The specific objectives of the study are as follows:

- To develop an appropriate methodology for assessing social acceptability and for guiding the transfer of new technologies and production practices to smallholder farmers.
- To assess the economic viability of in-field rainwater harvesting techniques with potential applicability to semi-arid areas.
- To assess the sustainability of the new production systems based on water harvesting practices, in terms of its impact on the physical environment, its effects on farm incomes and economic contribution to the local communities, and on the social well-being of the people.
- To develop a simulation/spreadsheet model as an extension tool that will enable agricultural researchers and extension officers to determine the impact on profitability, risk and resource use requirements when there are some changes to some of the farm management variables of the in-field rainwater harvesting systems.

## METHODOLOGY

The study employs participatory research techniques, such as Participatory Rural Appraisal (PRA) and Participatory Action Research (PAR), to facilitate involvement of smallholder farmers in the diagnosis of constraints they face in their production activities and the formulation of technological interventions that can be employed to help overcome these constraints. The report discusses the essential features of the PRA and PAR methods, and the procedures followed in conducting PRAs and PAR in the study villages are described. Past experience has shown that while the perspective of outside experts often drive the research



into new technologies and production practices, expert opinion may not always coincide with farmers' felt needs and priorities. Thus, the resulting technologies are often inappropriate leading to low rates of adoption by farmers (Chambers, 1983; Chambers, 1992). As others have shown elsewhere, there is a need for close co-operation between farmers and communities who are the intended beneficiaries of agricultural research, and outside researchers in designing the research agenda, analysis of opportunities and constraints in the agri-system, and during the technology development process. Successful implementation of participatory research approaches requires a multidisciplinary research team. In the study reported here, a research team consisting of agronomists, agricultural economists and a sociologist was assembled.

There are ecological, climatological and economic constraints to production in semi-arid regions. When all other management practices are carried out efficiently, rainwater harvesting technologies may provide an opportunity for optimising production by increasing the available water for plant use. However, the expected gains to farmers from new technologies are an important consideration for farmers in deciding whether or not to adopt new production technologies. Economic and social analyses, and assessments of the ecological impacts of new agricultural technologies/ practices need to be carried out. Enterprise budgets are used to evaluate the impact of employing in-field rainwater harvesting techniques on farm household income, and to determine the area of land that an average household would need to bring under cultivation in order to produce enough food or generate sufficient income to acquire adequate food to meet its energy and nutritional requirements. In order to practice in-field rainwater harvesting, farmers first need to invest labour and other resources in creating the requisite infrastructure such as the basins for collecting water, and the runoff areas/micro-catchments. Although it takes large amounts of labour to construct the basins and the micro-catchments areas in the first year, these last for several seasons. An important consideration for farmers is whether the investment will payoff in the long-term. In the study, calculation of net present values generated by the production techniques help to answer this question.

Farmers select production techniques for their ability to minimise the impact of production and other risks. In the study, cumulative distribution functions for yield and returns based on simulated production are used in a stochastic dominance analysis to assess risk and its effect under the new production techniques.

A primary goal of many governments in developing countries is to ensure food security for all their people. The area of land that a household would need to plant maize to provide enough maize grain for a family of 5, and a surplus output to generate adequate income to allow the family to acquire other food items was calculated assuming a daily caloric requirement of 2 500 kilocalories per adult equivalent as the required minimum energy level for healthy and active life (and that carbohydrates supply 60% of total energy requirements). In other scenarios it was assumed that households sell all their maize output either as grain or green *mielies*, and in each case the area cultivated to maize to enable farmers to generate sufficient income to buy adequate food to meet their daily energy demand was calculated.

Other considerations, such as how the new technology fits in with other household activities, social and cultural considerations also play an important role in the decision by farmers to adopt new technologies. These considerations are dealt with in a social analysis of the IRWH techniques. Analysis of the environmental impacts has become an integral part of determining the desirability of new production technologies. In the present study a limited assessment of the impacts of IRWH techniques was carried out and involved measuring soil erosion effects and soil moisture levels across the production cycle.

## MAIN RESULTS

The new technologies should provide significant economic returns if farmers are to be persuaded to undertake the required investments. Profitability analyses using enterprise budgets show that there is a significant increase in farm income when farmers adopt rainwater harvesting compared to the income levels achieved under conventional crop cultivation. By adopting the simplest form of in-field rainwater harvesting – without the use of mulches in the basins and the runoff area, farmers can increase their income by about R800.00 per hectare in the case of maize production. Analyses of on-station production data suggest that farm income can be increased further with the use of organic or stone mulches.

In addition, investment analyses were carried out to assess whether it was worthwhile for farmers to invest in creating the basins and micro-catchments required for collecting rainwater in their fields. The results of the analyses suggest that farmers can increase their income by

undertaking IRWH, and that the investment will payoff over time. Farmers also need to be compensated for the risk that they take by changing from the conventional ways of producing to the new techniques. The results of the stochastic dominance analyses show that farmers will receive more profit with a lower risk of failure when using the IRWH techniques, which contributes to economic sustainability.

The improvement of rural households' food security situation is central to the National Department of Agriculture's policy. In this study estimations of the required farm size to produce enough food or income to meet the requirements of an average household in Thaba Nchu using IRWH techniques were made. It was found that about 8 (14) hectares of land are required to produce enough food (income) to last a family of 5 from one harvest to the next. With rainwater harvesting, these areas are substantially lower at about 3 to 5 hectares. Results from the field survey carried out in the study area showed households' expenditures levels were below the nationally determined poverty line. Improving agricultural production using IRWH techniques, thus provides potential for directly and immediately improving food security for households in Thaba Nchu.

While a conclusive assessment of social acceptability can only be made after several seasons have passed, regarding this project, tentative conclusions can be made regarding social acceptability of IRWH techniques, given the understanding generated about factors affecting social acceptability. The enthusiasm with which the new innovation was received, the high degree of participation by the local farmers during the demonstrations of the workings of IRWH techniques and participation during field trials, and subsequently the high number of farmers practicing IRWH during the first season suggest that these techniques are likely to be employed on a long term basis by many of the farmers in the study area. Based on these findings it can be recommended that extension efforts should be undertaken to encourage adoption and adaptation by farmers.

## **CAPACITY BUILDING**

Critical considerations in the design and conduct of the present study were how to ensure the involvement and participation of all role players (that is, members of particular communities, extension officers and researchers) in the research project, and to focus not only on solving

immediate socio-economic problems, but also on ensuring that the knowledge and skills of all concerned are increased. Participatory research approaches have the advantage of combining social investigations, educational work and action, and as such provide an avenue for both the diagnosis of constraints to production activities, formulation of potential solutions and development capabilities of research participants. In the process of undertaking the study reported here, capacity building became one of the important outcomes. Farmers who were interested in learning more about in-field rainwater harvesting techniques and in applying these techniques in their own gardens and crop fields were assisted by the researchers. Training in teamwork, motivation, group dynamics, leadership, *etcetera*, were also part of the research goals. In addition to empowering farmers during the research process, three students at the University of the Free State will complete their MSc. degrees by conducting further analysis of the information generated during the study.

### **POTENTIAL USERS OF THE RESEARCH RESULTS**

The results of the study have potential use among farmers, policy makers, agricultural extension officers and the research community. For farmers, rainwater harvesting can help improve crop production, food availability and increase income, while also reducing the risk of crop failure and maintaining or improving productivity of the land/resource base. For policy makers and agricultural extension officers, results clearly demonstrate the production and income advantages of "conservation farming" and this should make it easier to encourage farmers to conserve soil, water and other natural resources. The positive results also provide justification for use of public resources in programmes designed to encourage the conservation of natural resources, for example, subsidies to help farmers to undertake conservation works, and the hiring of more agricultural extension officers. For the research community working on rainwater harvesting and other water conservation techniques, a framework for working with farmers to develop appropriate interventions to address farmers' production constraints is developed and tested in the field with some positive results.

### **FURTHER RESEARCH NEEDS/ SHORTCOMINGS OF THE RESEARCH**

While the preliminary results reported here suggest that the use of IRWH techniques provides social, economic and environmental benefits, these findings come from assessment of the

techniques in a short period. There is a need for continued monitoring of the impacts (environmental, economic and social) of these techniques. In this regard it would be necessary to conduct an impact assessment study in three to four seasons from now. This will allow us to have a better understanding of the role that IRWH can play in the farming systems in semi-arid areas. Such a study will also include an assessment of the adoption patterns and its determinants, information which would be useful for guiding future work on water conservation efforts in other parts of the country. There is need for increasing the awareness of policy makers at national and sub-regional levels, of the potential of these production techniques.

## CHAPTER 1.

### INTRODUCTION<sup>1</sup>

#### 1.1 Motivation and problem statement

The rural population in Sub-Saharan Africa is the most affected by the problems of poverty and food insecurity. By the mid-1990s it was estimated that 39 percent of all people in the world facing food insecurity resided in Sub-Saharan Africa (FAO, 1996). About 72 percent of the poor in South Africa lives in the rural areas, most of them in communal lands in the former homelands (National Department of Agriculture, 1998). Slow economic growth in most of the countries in the region and the poor performance of the agricultural sector, coupled with rapidly growing populations means that the food gap will remain unresolved in the foreseeable future. Pinstrup-Andersen *et al.*, (1997) estimate that by 2010, 33 percent of the population in the region will still be without access to adequate food compared to 12.5 percent in South Asia and 5 percent in South East Asia.

Some authors have argued that rapid growth in agricultural annual production will be required in order to stimulate a satisfactory level of general economic development and to allow countries to begin to redress problems of poverty and food insecurity. In order to achieve growth in agriculture, land and labour productivity will need to be increased. The inadequacy of water and poor soil fertility limits the possibilities of using the land, an asset most easily accessible to most rural households, to create income-generating opportunities and to allow households to produce enough food to meet their requirements.

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<sup>1</sup>The present study is part of the bigger study on rainwater harvesting for agricultural production that was jointly undertaken by researchers at the Departments of Agricultural Economics and Sociology at the University of the Free State and the ARC – ISCW (Glen Research Station, Free State Province). For a more complete understanding of the potential role of rainwater harvesting for increasing agricultural production in semi-arid areas and the environmental sustainability of such practices the reader is advised to also consult Botha *et al.*, 2003.

A number of studies show that considerable parts of Africa have the potential to be highly productive and yields can be substantially raised from present levels with correct and good management of water resources (CGIAR, 1997; Byerlee and Husain, 1992; Byerlee and Eicher, 1997). On the other hand, inappropriate land use, poor management and the lack of inputs can lead to decline of productivity and land degradation, a situation that prevails in many parts of Africa. In recent years, increased use of appropriate productivity-increasing technologies has provided many countries an avenue for dealing with food security and the whole area of sustainable development in agriculture and natural resources (Sanders *et al.*, 1996; Byerlee and Husain, 1992; Byerlee and Eicher, 1997). However, a much greater effort is needed to promote greater intensification on small-scale farms.

In many cases small-scale farmers are located in less favoured agro-ecological conditions, with poor soils and low and erratic rainfall. The development and transfer to farmers of production practices and techniques that conserve and increase water use efficiency, and conserve soil can provide small-scale farmers with an opportunity to increase agricultural production. In an attempt to address the problems of water shortage and soil erosion in semi-arid farming areas, researchers at the Agricultural Research Council at Glen in the Free State have developed water conservation techniques with potential applicability for small-scale farmers. These techniques are called infield rainwater harvesting (IRWH) and involve rainwater harvesting, basin tillage, mulching and no till. During on-station trials the water conservation techniques have lead to increased maize, beans and sunflower yields, increases rainfall use efficiency and reduction in soil erosion during on-station trials. However, before the water conservation techniques can be transferred to farmers, further analyses to assess its economic viability, social acceptability and environmental sustainability are required.

This study deals with social, economic and environmental issues in rainwater harvesting systems designed to improve water management for crop production among smallholder farmers in semi-arid areas. Across most of the developing world, many water conservation projects have failed, despite good techniques and design, because social and economic considerations were not adequately investigated in the development of the projects. In other cases where improved water management and

conservation techniques have been introduced, their economic, sustainability and environmental impacts have been overlooked.

One of the conditions for the success of water conservation techniques is the acceptance by resource users – the farmers. Among other issues, chances of acceptance are much greater if new technologies developed with adequate involvement of resource users, and when a context is created in which communities' skill levels and social capital can be improved to allow their effective management of the technologies. Further more, interventions that may lead to socio-economic inequity and social disruptions may be resisted by communities.

Smallholder farmers already operate in an environmental fraught with high levels of risk due to climatic and price variability. The risk levels and profit potential for investment of labour and other inputs must be acceptable, if the new techniques are to find use among farmers. The benefits resulting from the use of new production technologies must be apparent to farmers as early as possible in the technology development or on-farm adaptation and adoption phase.

## **1.2 Project objectives**

The main aim of this study is to carry out economic viability and social acceptability analyses, and an assessment of the environmental sustainability of water conservation techniques designed for use by smallholder farmers in order to improve crop production. Although the study is conducted with smallholder farmers in the Thaba Nchu agricultural district, it is anticipated that there will be enough generalisability in the results and the methods applied to help shed light to the issues facing smallholder farmers in other semi-arid parts of the country.



Specifically, the following sub-aims guide the study:

- The need to develop an appropriate methodology for assessing social acceptability and for guiding the transfer of new technologies and production practices to smallholder farmers. This will be achieved through:
  - employing participatory research and rural development approaches when working with local farmers
  - using participatory approaches and formal survey techniques to gather socio-economic information that can be used in assessing the social acceptability of new technologies and farming practices
  - a literature survey to identify variables that may influence the social acceptability of new production techniques and also affect the transfer and adoption of these new techniques.
- To assess the economic viability of new in-field rainwater harvesting techniques with potential applicability to semi-arid areas through:
  - the development and use of crop enterprise budgets
  - the assessment of the ability of the new production techniques to help mitigate climatic risks faced by smallholder farmers in semi-arid areas
  - carrying out investment analyses of different configurations of rainwater harvesting techniques by determining net present values
  - the assessment of required size of production units that will be required to meet a farm family's food requirements.
- To assess the sustainability of the new production systems employing water harvesting practices, in terms of its impact on the physical environment (See Botha *et al.*, 2003), their effects on farm incomes and economic contribution to the local communities, and on the social well-being of the people.
- To develop a simulation/spreadsheet model as an extension tool that will enable agricultural researchers and extension officers to determine the impact on profitability, risk and resource use requirements when there are some

changes to some of the farm management variables for the in-field rainwater harvesting systems.

### 1.3 Research area

On-station trials for the water harvesting/conservation techniques that are examined in this study took place at the Glen Research Station in the Free State. The farmers targeted to benefit from the use of the water conservation techniques are small-scale farmers in semi-arid areas, in particular farmers involved in crop production in the villages of Thaba Nchu in the Free State. In addition, a large area of land in the vicinity of Thaba Nchu has been earmarked for the establishment of small-scale farmers (Botha *et al.*, 2001) and it is hoped that these emerging farmers may benefit from the adoption of these water conservation techniques.

Thaba Nchu, the area in which the water conservation/harvesting study was carried out is quite expansive, and is situated in the eastern part of the Free State Province about 60km east of Bloemfontein. The area comprises of the peri-urban town of Thaba Nchu (estimated population of 109 400 people), (Mangaung Local Municipality, 2001)) and rural Thaba Nchu consisting of 42 villages covering a total area of 70 364 hectares (see Table 1.1). The 42 villages are spread across the area, north and south of Thaba Nchu town (see Figure 1.1).

Thaba Nchu is semi-arid, with annual rainfall of about 500mm (Botha *et al.*, 2001). The rainfall events are generally not evenly distributed over the season and quite erratic. For crop production this means that farmers are not always assured of availability of moisture for use by crops during critical phases of plant growth. The soils in the region have a high clay content, and are subject to surface crusting and deep cracking (Botha *et al.*, 2001). The combination of the clay soils and their associated properties and sporadic but heavy showers that characterise the rainfall events in the region makes the soils susceptible to erosion. That little of the rainfall water percolates into the soil to become available for plant use, and that most of the water from rainfall is lost to runoff raises the need for measures to conserve water. The runoff also causes soil erosion and the loss of soil nutrients. The adoption of soil conservation measures is required if productivity of the agricultural system in the area is to be maintained and improved.



**FIGURE 1.1: MAP OF THABA NCHU**

Source: Department of Geography, University of the Free State

The vegetation in the area is dominated by grasslands with grass species suitable for livestock production (Morosi, 1999). Most households in the villages are engaged in agriculture, producing livestock and crops.

Before 1994, Thaba Nchu was part of the homeland of Bophutatswana. Land in the area was and is still communally owned, with the authority to allocate land controlled by a Tribal Authority under the leadership of Chief Moroka. Each village has a fixed amount of land which is divided into three use categories (residential, agricultural land and communal grazing) as shown in Table 1.1. Residential land and land for farming is allocated to individual households upon granting of approval to settle in the village by the Tribal Authority, while all members of the village have a right to graze animals in the communal pastures.

TABLE 1.1: VILLAGE SIZES, ARABLE LAND AND GRAZING CAPACITY AT THABA NCHU (HA), 1998.

| Village Name      | Residential  | Arable       | Grazing       |
|-------------------|--------------|--------------|---------------|
| Balaclava         | 20           | 354          | 846           |
| Bofulo            | 34           | 215          | 2 017         |
| Kommisiedrift     | 40           | 260          | 1 989         |
| Feloane'          | 30           | 80           | 1 208         |
| Gladstone         | 60           | 378          | 2 972         |
| Grootdam          | 20           | 200          | 840           |
| Houtnek           | 50           | 290          | 1 649         |
| Kgalala 1         | 70           | 300          | 1 974         |
| Kgalala 2         | 80           | 300          | 2 028         |
| Klipfontein       | 20           | 320          | 878           |
| Longridge         | 10           | 110          | 260           |
| Maraisdal         | 10           | 160          | 730           |
| Merino            | 40           | 170          | 1 995         |
| Middeldeel        | 25           | 190          | 1 852         |
| Motlatla          | 50           | 148          | 2 041         |
| Moroto            | 25           | 134          | 1 240         |
| Mothusi           | 30           | 327          | 1 727         |
| Morago            | 70           | 300          | 1 650         |
| Nogaspot          | 40           | 137          | 1 992         |
| Paradys           | 40           | 274          | 1 795         |
| Potsane           | 30           | 110          | 830           |
| Post              | 10           | 195          | 300           |
| Rhakhoi           | 20           | 200          | 1 175         |
| Rooibult          | 60           | 216          | 2 017         |
| Rooifontein       | 50           | 260          | 3 704         |
| Rietfontein       | 66           | 231          | 1 723         |
| Ratau             | 90           | 250          | 1 650         |
| Sediba Trust      | 50           | 250          | 1 049         |
| Sediba Scheme     | 15           | 80           | 225           |
| Seroalo           | 24           | 180          | 1 434         |
| Spitskop          | 42           | 190          | 1 964         |
| Springfontein     | 18           | 160          | 716           |
| Talla             | 52           | 514          | 2 486         |
| Tiger River       | 40           | 230          | 1 790         |
| Thubisi           | 26           | 300          | 1 528         |
| Tweefontein       | 40           | 280          | 1 210         |
| Victoria Nek      | 15           | 150          | 1 104         |
| Woodbridge Scheme | 15           | 110          | 320           |
| Woodbridge Trust  | 15           | 130          | 870           |
| Yoxford           | 36           | 266          | 2 179         |
| <b>TOTAL</b>      | <b>1 478</b> | <b>8 929</b> | <b>59 957</b> |

Source: Free State Department of Agriculture, Thaba Nchu office, 1998.

## 1.4 Outlay of the report

The objective of this report is to provide an outline of the theoretical framework and the methodology used to guide the study, and a discussion of the role of rainwater harvesting techniques in crop production in semi-arid and arid. The discussion will also focus on the specific rainwater harvesting techniques that were developed by

researchers at the ARC – ISWC at Glen. The report also presents results of a social acceptability study informed by Participatory Rural Appraisal (PRA) and Participatory Action Research (PAR) techniques, and a questionnaire survey carried out among households in Thaba Nchu. The economic viability of employing the rainwater harvesting practices is assessed by means of enterprise budgets, cash flow analyses and net present value analysis are employed to assess whether such investments are worthwhile for farmers. The likely impact of rainwater harvesting techniques on farmers' ability to mitigate climatic risks is also examined by calculating the cumulative distribution functions (CDFs) of the projected returns over the long term when farmers employ rainwater harvesting in the production systems.

The rest of the report is structured as follows: in the second chapter the theoretical framework and the methodology used to carry out the study are outlined. Chapter 3 discusses the technical aspects of IRWH systems and the constraints posed by inadequate moisture to crop production particularly in semi-arid rainfed agricultural systems. The potential for rainwater harvesting techniques in realising this constraint is discussed and particular in-field rainwater harvesting techniques examined in the present study are introduced.

Chapter 4 describes the processes undertaken in implementing some of the methods discussed in Chapter 2, such as the Participatory Rural Appraisal (PRA) and Participatory Action Research (PAR) approaches and the acquisition of quantitative data using questionnaire surveys. These methods are used to generate data that can be used to describe farming systems and for the economic analysis of production activities. Chapter 4 also reports the results of PRA and PAR exercises and the questionnaire survey. An assessment of how the introduction of rainwater harvesting techniques may affect the social well being of the communities is also presented in chapter 4. Chapter 5 presents and discusses the results of the economic analyses, based on the data generated from the Glen on-station trials and the on-farm field trials in Thaba Nchu. The discussion in Chapter 6 is a synthesis of the sustainability (economic, risk, environmental, and social) issues raised in the preceding chapters; and the chapter also provides some conclusions, recommendations and suggestions for further research.

## CHAPTER 2.

### **THEORETICAL FRAMEWORK AND METHODOLOGY FOR ASSESSING THE SOCIO-ECONOMIC IMPACT OF WATER HARVESTING TECHNIQUES**

#### **2.1 Introduction**

In many countries in sub-Saharan Africa agriculture still remains the main economic activity and source of livelihood for the majority of the population. For South Africa, even though agriculture's contribution to GDP stands at only 5 percent, agriculture provides employment for 13.2 percent of the labour force (40 percent of formal employment in the rural areas is in agriculture). About 44.6 percent of the country's 42 million people live in the rural areas and derive their livelihood mostly from agriculture and agriculture-related activities (National Department of Agriculture, 1998).

Given this situation, policies aimed at increasing incomes and the quality of life of the majority of the people will likely have to include strategies for improving agricultural productivity and production. Indeed in many jurisdictions agricultural development has already been identified as a crucial element in the drive for increasing the income earning opportunities for a large proportion of the population. There is need to develop new technologies that will help to increase productivity and production in agriculture. However, any new technologies that may be developed must be appropriate for the needs of the farmers: technologies will have to be economically viable, contribute to attainment of household food security and fit in with farmers' needs to minimise exposure to risk (as a result of climatic variations, price variations, among others), and eventually will have to be accepted by the farmers. Also of importance is that new technologies will have to allow for the maintenance or enhancement of natural and environmental resources.

The objective of this chapter is to provide a theoretical and methodological framework that may be used by agricultural scientists, agricultural extension officers and other researchers and policy analysts for guiding the process of technology generation, dissemination and evaluation.

The theoretical/methodological framework consists of the processes and techniques that may be used by scientists in identifying technological interventions that may help farmers to overcome production constraints. For example, limited and unreliable water supplies, due to low and highly variable rainfall in rain-fed agriculture. Experience has shown that while the perspective of outside experts often drive the research into new technologies and production practices, expert opinion may not always coincide with farmers' felt needs and priorities. Thus the resulting technologies are often inappropriate and leading to low rates of adoption by farmers (Chambers, 1983; Chambers, 1992). As others have shown elsewhere, there is a need for close cooperation between farmers and communities who are the intended beneficiaries of research, and outside researchers in designing the research agenda, analysis of opportunities and constraints in the agrisystem, and during the technology development process. Participatory approaches including PRA methodology provide an opportunity for local people and outside researchers to effectively share in the analysis of farm problems and in the search for solutions. In the report the essential features of the PRA methodology are outlined and some guidelines on how to conduct PRAs offered.

There are ecological, climatologically and economic constraints to production in semi-arid regions. When all other management practices are carried out efficiently, water-harvesting technologies may provide an opportunity for optimising production by increasing the available water for plant use. However, the expected gains to farmers from new technologies are an important consideration for farmers in deciding whether or not to adopt the new technology. This chapter will outline the approaches to conducting economic analysis, assessing the social and ecological impacts of new agricultural technologies/practices. The techniques are based on the comparisons of the costs and returns of using a new technology. Other considerations, such as how the new technology fits in with other household activities, social and cultural considerations also play an important role in the decision by farmers to adopt new technologies.

## 2.2 Theoretical framework

Farming systems research (FSR) is an approach to agricultural technology development that emphasizes the need for a more careful understanding of the conditions and constraints under which farmers operate to facilitate the development of technology better suited to their needs (Tripp *et al.*, 1990). FSR stems from the recognition that a range of economic and social factors affect the farm household, thus technology development needs to provide techniques and practices that are suitable to the specific agricultural system. A major feature of small-scale farmers is that they have a high degree of diversification of enterprises, resources and objectives. Small-scale farmers are typically involved in a number of production activities, for example, livestock and crop production, non-agricultural enterprises, and off-farm work. In addition, for small-scale farmers, labour and other household resources exhibit a considerable heterogeneity and lead to complex management strategies. Other characteristics of farm households, for example, the uncertain markets and climate risks make risk an important factor in farmers' decision making. Also the fact that small-scale farmers consume a large proportion of their production makes household food security a key objective in farm management.

These characteristics of small-scale agriculture strengthen the case for a systems approach in describing agricultural systems and for efforts at developing technological interventions that would meet farmers' requirements. Farming systems research is characterised by system-orientation. This means that interactions of various elements in an agricultural system, for example, between production activities, and complementarities in resource use, need to be taken into account when analysing the effect of changes in agricultural technology on the agricultural system. The approach is interdisciplinary, with various disciplines e.g. biological and social scientists involved in problem-solving. It is also location specific in that research can be designed to look at specific agro-ecological conditions, ensuring that the development of technologies suitable for such farmers receive attention. Another element of farming systems research is emphasis on the testing and assessments of new technologies on farmers' fields, under their conditions and using their criteria (Byerlee *et al.*, 1982; Byerlee, 1987). This provides the opportunity for farmer involvement in technology development and assessment.



Under farming systems research experimental results are assessed using formal agronomic, statistical and economic criteria, as well as being reviewed to assure that the conclusions are compatible with farmers' concerns and characteristics of the farming system (Tripp *et al.*, 1990). Schultz (1964) argues that poor farmers/small-scale farmers allocate production factors under their control efficiently. Thus, it can be assumed that their resource allocation behaviour can be described by the theory of optimizing farm-firm. When considering the adoption of new technologies the farm household will require that the use of the new technology result in a positive contribution to household welfare.

Although FSR places emphasis on the farming system, this does not mean that agricultural researchers should always follow a broad research agenda. Where necessary, research should focus on key enterprises in the system where introduction of technological innovation may lead to increase in productivity of the system (Tripp *et al.*, 1990). However, research on key enterprise should take into account interactions with other elements of the system. As such, analytical tools such as enterprise budgets can be used to assess the economic/financial viability of a new technology when applied to a given production activity.

The complexity and heterogeneity of environments requires that more decision making be in the hands of farmers. This is because farmers are likely to possess more location-specific knowledge that is useful for the design of appropriate productivity-enhancing technologies. This idea is consistent with theories of technological innovation such as the theory of induced innovation, whereby endogenous factors such as changes in resource endowments and in product demand play a critical role in determining the path of technical change. According to the theory of induced technical innovation farmers are induced to search for technical alternatives in response to changes in resource endowments and shifts in relative factor prices. Perceptive research institutes/researchers respond by making available new technical possibilities and new inputs to enable farmers to produce profitably under the new circumstance.

However, effective interactions among farmers and research institutions are required to guide the process of technical change along a socially optimal path. Farmer-

researcher interactions can be enhanced if farmers are organised into associations to enable them to apply pressure on research and extension services so that their concerns can be addressed. On the other hand, researchers can enhance their interactions with farmers by employing participatory research approaches such as the PRA (Tripp *et al.*, 1990).

Development of technologies acceptable to farmers needs to be complimented with consideration of long-run issues of sustaining productivity and maintaining the natural resource base. Aspects of the FSR approach, such as emphasis on location-specific adaptive research, when combined with increased levels of applied research may provide a way towards developing sustainable agricultural systems.

The following section describes the PRA methods and techniques.

### **2.2.1 Participatory research methodology**

In an attempt to answer the question "What is wrong in development?" Kotze and Kotze (1996) point out, *inter alia*, the gap between the expert and the people. They state that it would seem as though the vast amount of information made available by advisors to developing countries has simply had no effect. Edwards (cited in Kotze and Kotze, 1996) ascribes this state of affairs to the distance between the possessor of the information and those to whom it is supposed to be conveyed. Too often the information is inappropriate, partial and dated as a result of inappropriate research methods that satisfy nothing else but the expert's notion of science. In contrast to the expert, Kotze and Kotze (1996, p5) state that "the poor people appear incompetent and ignorant, and nobody dares to challenge the superior scientifically acquired knowledge". The expert often ignores data, knowledge and insight that could be obtained from the poor, the illiterate and the far-off. It is precisely those who have learned to survive with virtually nothing at their disposal that possesses valuable knowledge. "Indigenous networks of production, barter and mutual support, which have evolved over centuries and could form the basis for development, are sometimes destroyed by plans for commercial production" warn Kotze and Kotze (*ibid.*).

Due to alternative approaches in development and methodology, a growing body of literature within the field of small-scale farming is qualitative by nature. Because of

the many advantages of participatory research techniques, PAR and PRA was the research paradigm opted for in this research to investigate the socio-economic acceptability of the IRWH-technique by the people in the target communities. PRA, PAR and other participatory approaches in development and related work came about due to the need to merge learning and practice. Participatory approaches aim to involve stakeholders in planning, project implementation and evaluation; and to harness local initiatives as opposed to attempts at corralling support for centrally/externally conceived development plans. PRA should be looked at as a catalysing exercise that lays the foundation for on-going processes of empowerment and development. Coetzee *et al.* (2001, p547) state that 'PAR could be seen *primarily* as a methodology for empowering participants and only secondarily as a methodology for producing "research" in the conventional sense'. Babbie (2001, p288) defines PAR as a research paradigm where the researcher's function is to serve as a resource to those being studied - usually, disadvantaged groups - to empower them to act effectively in their own interest. The community should therefore define their problems and remedies and take the lead in research that will help them achieve their aims. PAR gives the community access to information with power. This power has in the past been kept in the hands of the dominant class, gender or group. Once the members of the community see themselves as researchers, they regain power over knowledge (Babbie, 2001). PAR is therefore a participative bottom-up approach in which the investigated become the investigators. True to the characteristics of participatory research, (see the list of characteristics below) all four communities played an active part in the entire research process. As partners and beneficiaries of this project their participation was of the utmost importance. As the farmers were partners in the process, they were the co-owners of the research results. They made their own decisions regarding the choice of crop and what to do with it, although they could be assisted in marketing it if they so wished to.

Participatory forms of research emerged during the 1970's as a response to the failure of conventional research techniques to address issues in Third World or developing contexts. Participatory research is based on the belief that development should be people-centred. People are central to any kind of development process, and communities should be part of the decision making process. The implementation of principles of PRA has brought about sentiments such as:

- opportunities for solidarity and togetherness;
- new challenges;
- structures capable of accommodating new inputs, i.e., based on reflexivity;
- opportunities for creativity;
- availability of work opportunities, i.e., not only "jobs";
- the possibility of self-realisation;
- the possibility of self-inspiration;
- total well-being; and
- the meaningfulness of individual existence.

To overcome feelings of disempowerment and doubt, people should be (and were) actively drawn into the development process. The keywords in this respect are: commitment, responsibility, self-critical awareness, sharing and trust.

#### **2.2.1.1 Characteristics of PAR**

Besides other characteristics of PAR, (see De Vos *et al.*, 2002, pp 423-27 for a comprehensive list of these) we pertinently focused on the following characteristics of this model in the research:

- *The development of knowledge and the role of knowledge as an instrument of power and control.* The members of the community were encouraged to actively take part in the research and become researchers on their own sites. In interviews with the farmers during February 2003 almost all of them indicated that they see themselves now as researchers who can use their knowledge to their own benefit.
- *PAR as applied research that is directed at practical problem solving.* During the same interviews the farmers also emphasised the benefit of the project in the sense that it addresses the problem of food security.
- *The principle of self-development, where people must organise themselves into action.* The farmers also credited the process for allowing them the opportunity to organise themselves into groups without prescribing them how to do it. They regarded the process as one of mobilising the members of the communities, of

them becoming self-reliant in solving the problem of "food shortage" as they put it.

- *Community forums, nominal groups, workshops, focus groups, in-depth interviewing and participant observation as data collection techniques and research procedures.* Together with the previous point, the farmers reported the mobilisation of the community members in the different data collection activities as something that they "enjoyed".
- *The multidisciplinary framework where all disciplines should be involved.* From the initial stage of the project it was decided that this research would be approached multidisciplinary, including researchers from the ARC and the University of the Free State (agricultural economists and sociologists).
- *The accountability of the community for the progress made with the project and also for the management of its own resources.* The fact that the project was to be one of partnership, was strongly emphasised and discussed with the communities already in the planning phases. They entered into this partnership project realising that they would have to use and manage their own resources. Even now the farmers are willing to accept this principle as they indicated during the interviews of February 2003 their willingness to accept the responsibility for the further course of the process.
- *Equal partnership in the research process and shared ownership.* Through the entire research process this aspect was continuously emphasised and accepted by all the partners and those who are implementing the IRWH-technique are already referring to it as their own "property" and no more to something that belongs to the "people of the ARC".
- *A desire to find useful solutions to the problem.* All the farmers express their frank desire to find a useful solution to the problem of food shortage as they regard it as "a matter of survival" and stated that "we have no option".
- *An interest in and commitment to change.* Although community members may all have a common interest in the problem, it cannot be assumed that they have a homogeneous view of the problem or of the ways in which it should be addressed. During the first meetings with the members of the communities it became clear that almost all of them realised the necessity to change their circumstances. Those farmers who accepted the invitation to become partners in the research project are

those who were interested in bringing about a change in their lives and who committed themselves to do something about it. There are, however, also those who did not accept the invitation. This might be for a number of reasons. Again, it cannot be assumed that all the members of the communities have a homogeneous view of the problem or of the ways in which it should be addressed.

- *The emancipatory nature of PAR.* The point of departure was that the people should be assisted to recover and to release themselves from the constraints of irrational, unproductive and unsatisfying social structures that limit their self-development and self-determination.
- *The stamina and patience that are required in PAR projects to deal with the competing demands for immediate action versus meaningful participation.* It was realised from the start of the research (and the partners still realise) that results (in this case acceptance of the IRWH-technique) will take some time to materialise. Acceptance of anything that is new is a long-term process that first has to take place in one's mind (a change on the value level) before it will concretely materialise.
- *The recognition of available resources in the community, such as values, culture, knowledge and experience, and that it must be used to its full potential.* As acceptance is first of all a process of a mind change, no attempt to bring about acceptance will succeed without taking into consideration the values, beliefs, culture, indigenous knowledge and experience of the people involved. These aspects were continuously born in mind, especially when the farmers were invited to share their knowledge and farming experience with each other.
- *The shift from a dependency model to the empowerment model, with a participatory approach where communities can do things for themselves in order to enhance community building and eventually improve their quality of life.* The empowerment of the communities was a high priority for the researchers.
- *PAR as a process of collective reflection and self-realisation in order to help the disadvantaged to regain their confidence in themselves. In this manner people are encouraged to share their experiences and to fight their way out of their problems.* The sharing of their experience helped the farmers to have confidence in themselves. They were excited in accepting the challenge to solve the problem of

"food shortage" and all of them saw themselves as "prosperous farmers in the next year or two".

- *The implementation of PAR projects in such a manner that a community gains a sense of ownership of a project so that they can then shape the necessary services as required.* Ownership of the project was one of the most important aspects of the project and was one of the outcomes stated from the beginning of the research. The farmers took this responsibility with great enthusiasm.
- *The ultimate goal of PAR is to improve self-esteem, self-reliance and self-determination.* These aspects are discussed in paragraph *i* below.

Because PAR can be seen primarily as a methodology for empowering participants and only secondarily as a methodology for producing 'research' in the conventional sense, and because it sometimes emphasises research and sometimes action, the "methodology" and the "findings" will in this section be presented simultaneously and not separately as in conventional research reports.

#### **i) Specific terms**

Specific terms that are important in the PAR model and that were focused on in this part of the research include the following: **community, mobilisation, capacity building, empowerment, human well-being, self-reliance and community participation.** As stated above, these "indicators" were used to "measure" the socio-economic acceptability of IRWH crop production techniques.

#### **a) Community**

Community in this context is seen by De Vos *et al.*, (2002, p 421) as a local community, a group of people in a small area, who share physical and social space. The communities in this study included the villages of Yoxford, Feloane, Paradys, and Talla, all located east of Bloemfontein and near Thaba Nchu. The awareness and interaction of individual, family and community strengths and mutual needs were recognised in these communities. PAR helps communities to create informal social support networks in cooperation with 'professional people', to "prevent or cure" a problem in the community. Social support networks (organisations such as the Community based Water Harvesting Interest Group or the so called CB: WHIG) were indeed established in these communities.

## b) Mobilisation

As the economic well-being and emotional stimulation of the community are becoming more important considerations, this research, in following the principles of PAR, strongly focused on the **mobilisation** of the community participants as active agents in the process of creating knowledge, reaching a collective objective and solving problems (Rahman, 1993, p17; Van Rooyen, 1998, p79, cited in De Vos *et al.*, 2002, p421). In line with the participatory character of PAR, the social action or change (adoption of new farming techniques) was community-initiated and defined – as a shared goal – by the participants themselves, on the basis of their own perception of reality. The change agents (the researchers) supported or helped the people concerned to undertake such actions. This also helped to ensure “continued adjustments of the actions to people’s unique circumstances” (Chitere & Mutiso, 1991 cited in Coetzee *et al.*, 2001, p546). As there were no suitable organisations in place in the communities, the researchers encouraged the participants to form new ones by means of “self-mobilisation”. Self-mobilisation implies that participants mobilise on their own to form an organisation whose structure and functioning are to be decided by them. In this respect Fals-Borda (1987, cited in Coetzee *et al.*, 2001, p546) recommends a technique called “valuing and applying folk culture”, which is based on the “recognition of essential or core values among the people in each region”. As a result of the research project, organisations such as the CB: WHIG was established.

In this research the diffusion of the research results (specifically with reference to the results of the research done by the researchers of the ARC at Glen regarding the IRWH-technique) to the participants was of the utmost importance. These participants had to be exposed to the results, they had to be familiarised with it and had to be sensitised for the possibility that changing their farming techniques could result in a better crop yield. They eventually had to become owners of the results. The diffusion of the “knowledge” was done at various occasions, *inter alia*, by means of demonstrations of the IRWH-technique at farmers days held at Glen and in the different villages mentioned above. Diffusion of these results to participants means that knowledge is returned to the participants who then should continue to become



owners of those results. This ensured that everyone within the community could actually become beneficiaries of that knowledge.

### c) Capacity building

Capacity building, according to Marais *et al.*, (cited in De Vos *et al.*, 2002, p421) refers to the potential and capacity of the people in a particular community and to the process of assisting them in developing skills at various levels in order to become the masters of their own development and thus acquire the capability to manage their own future. It is therefore a learning process characterised by flexibility, sustainability and a total capacity-building approach. As the research process unfolded, capacity building also became one of the important intended outcomes of the research project. Farmers and residents that were interested in learning more about the IRWH-technique and in applying it in their own gardens or on their fields, were visited by the researchers at regular intervals during the 2001/02 growing season. They were assisted to master the technical aspects of land preparation, planting, weeding, marketing, *etcetera*. Apart from the day-to-day activities, various formal technology exchange activities such as pre- and post-harvesting focus group discussions, information days and formal training workshops were held. Training in teamwork, motivation, leadership, group dynamics, *etcetera*, also formed part of the research outcomes.

### d) Empowerment

Empowerment, the process of increasing personal, interpersonal, socio-economic and political power, enables people to improve their circumstances. Participants claimed that they were empowered in many ways, and not only politically as it may seem like from the democratic nature of PAR. Participants gained knowledge by being part of an enquiry which created knowledge. Since PAR is action based, participants benefit from further knowledge and empowerment when actions are being activated. The development of a programme of action can only follow on the recommendations of the present research report. Other forms of empowerment through PAR are **conscientization**, also termed "consciousness raising" (the process by which subjects of research achieve a new way of understanding their position in society and how to change it), **emancipation**, **learning**, **strengthening of research capacities** and **generating autonomy** amongst the participants (Babbie and Mouton, 2001). PAR

endeavours to empower deprived and disenfranchised people with research capabilities so that they can identify and transform their situation for themselves. This takes place in an ongoing learning process for everyone involved. In this cooperative manner, (in which the researchers become part of the research population and also beneficiaries of the findings) more successful and more sustainable outcomes can be achieved. This means that all stakeholders involved in the study remain, therefore, involved in all stages of the research process. All the researchers involved in this project regard themselves not only the research experts who share research skills, but also co-learners who recognise and benefit from the skills and knowledge of all the stakeholders. Research now becomes a tool for action and a tool for empowering people to become involved in all aspects of the project and also to begin to take control of their own lives. Together, and as equal partners, the problem and its underlying causes (in this case socio-economic, political, cultural, environmental and natural factors) were investigated, while collective action was, and is still taken in order to bring about long-term solutions to the problem. The research and the resulting action, is regarded as a tool to bring about change by improving the quality of life of the communities concerned. De Vos *et al.* say that the "researcher... play(s) a catalytic, supportive, non-dominant, facilitative role" in this regard (2002, p422).

### **Conscientization**

The term "**conscientization**" is generally used to refer to raising participants' "self-awareness". This was primarily achieved through the incorporation of participants' own local knowledge. Their self-awareness was raised through collective self-inquiry (a series of social inquiries by the people during in-depth interviews and the PRA's that were undertaken). They were given the opportunities to "take over the stick" to have fun and to relax. They were asked to draw maps of their sites, gardens, crops, *etcetera*. For quite a number of them, to handle a pen appeared to be an unusual and even funny experience. The outcome of these collections of data gave very rich descriptions of how the people experience life in their communities.

### **Emancipation**

Emancipation refers to the establishment of self-critical communities of people who (can) create a new system of knowledge, which is considered to be a key element to

their empowerment and liberation, not only in political sense but also a liberation of their minds.

### **Learning**

The research process was also considered as a **learning** strategy aimed at empowering the participants. The central role that adult education plays was highly valued. The learning process did not merely form an integral part of the research, but was considered to be ongoing and inseparable from PAR function.

### **Strengthening the research capacities**

Empowering participants also carries the general meaning of **strengthening their research capacity** to solve problems and achieve their objectives. Coetzee *et al.* (2001, p549) state that the most important of all capacities to be developed, improved or strengthened is participants' capacity to conduct their own research. Fundamental to PAR is the commitment that all participants actually do research. For participants to learn how to collect and make sense of their own data, it is necessary for research techniques to be popularised (Elden and Chisholm, in Coetzee *et al.*, 2001, p549). Popularisation of research techniques means that participants are taught simpler, more economic, and controllable methods of research. By making use of examples, this was illustrated to the farmers during the in-depth interviewing sessions.

At various occasions, the farmers indicated that they are now equipped with the potential to understand their position in society better than in the past. Now that they understand the underlying socio-economic, political, cultural, environmental and natural causes of the problem, and learned the very basic principles of research, they realise that they can change their circumstances. During focus group sessions held in Yoxford and Feloane in January and February 2003, all the farmers present (58 in total) indicated that they are confident of becoming successful small-scale farmers within the next two years as a result of them being partners in the present research project.

### **(Human) well-being**

Barker (1995, p406) (in De Vos *et al.*, 2002, p422) regards welfare or **(human) well-being** as "the efforts of a community to help its people achieve a condition of overall health, emotional comfort and economic security". Human well-being (as was the case in this research) should be the focal point and aim of the total research endeavour and development process and includes well-being on all levels, including the social, economic, technological, political, cultural and spiritual potential of people in their communities (De Vos *et al.*, 2002, p422). Although the initial aim of this research project was the development of a water harvesting technique, and therefore focused on the technical level, the ultimate aim was sustainable food security and the improvement of the quality of life for all small-scale farmers. As stated above, the problem and its underlying socio-economic, political (bearing in mind that the whole area previously formed part of the former Bophuthatswana homeland), cultural, environmental and natural factors was discussed with the people of the different villages, and where necessary, explained to them. This understanding of the many dimensions of the problem contributed to a perceived sense of well-being amongst the farmers.

### **Self-reliance**

As mentioned above, PAR is also connected with **self-reliance**. De Vos *et al.* (2002, p422) defines self-reliance as "a driving force for creative activity that requires an awareness of one's creative assets, confidence in one's ability to solve life's problems, the courage to take on challenging tasks, and the stamina to make sustained efforts to accomplish them". The ultimate goal of the project is that the community becomes independent and empowered and to help its members to overcome the impairments in the community. The IRWH-technique was seen as a vehicle in mobilizing the community to the simultaneous involvement and engagement of all the members, in order to attain the agreed collective objective of the project. In an ongoing process of encouraging the farmers to take on the challenging tasks of maintaining their farming activities and motivating other members of the communities to join them in adopting new farming techniques, self-reliance became an aim that the communities strive for.

### **Community participation**

Community participation was seen as the creation of a democratic system and procedure to enable community members to become actively involved in the institutions and systems that govern their lives and to assume responsibility for their own human development. In the process of community participation, De Vos *et al.* (2002, p422) state that the members will be "economically uplifted, achieve social and economic rights, seek macro-social transformation, which includes social reconstruction, capacity building and sharing in the advantages of community development, and improve their decision-making power". Furthermore it provides a sense of belonging, a commitment to common goals, a willingness to assume responsibility for oneself and others, and a readiness to share and interact. In following the principles of PAR, the researchers, once committed to the upliftment of these communities, are also committed to their role as change agents in a process of development that will eventually lead to the enhancement of the community's social functioning, its self-reliance and the improvement of the quality of life of its members, as well as the overall betterment and well-being of the total community.

#### **2.2.2 Participatory rural appraisal (PRA)**

If researchers and other agencies involved in efforts to improve the quality of rural livelihoods are to instigate successful development projects, develop appropriate technologies to improve agricultural productivity and provide information to guide sound planning and policy decisions, they must acquire a certain level of information about the target communities. There is a range of methods available for gathering information and gaining knowledge about rural people and their situation. On one end of the spectrum are the "formal" techniques involving structured interviews with use of a questionnaire, and "informal" approaches where the researcher only defines general themes as the basis for questions at the other extreme. Growing dissatisfaction with the later, particularly for their failure to reach the "poorest of the poor" and to incorporate the opinions of local people and their knowledge has led to an increase in the usage of informal and more participatory research approaches in the past two decades.

Participatory research methods are favoured due to their contribution in helping to reduce the gap between the concepts and models used by professionals to understand

and interpret reality, and the concepts and perspectives of different groups in the community. Moreover, the emphasis on learning from and with the local peoples helps researchers to gain better insight into the many factors that are important in influencing household production decisions and livelihood strategies, for example, cultural, historical, socio-economic and political factors.

PRA is one of the participatory research approaches that are frequently used in agricultural and rural development research. It should be noted that PRA refers to a collection of techniques that may be used in diagnosing farm problems, identifying local needs and priorities, and to give direction to development programmes. PRA and similar methods have the advantage of generating knowledge and information which represent the perceptions and practices of different groups and communities in a relatively short time. Using PRA, information is provided in a more timely manner compared to the long-drawn formal surveys. The techniques used in PRA, ensure that the knowledge generated takes into account the perspective of both the researchers and the researched (Chambers, 1992).

A well planned PRA exercise will employ a number of activities to generate the required information, such as making use of existing and useful information, identifying and learning from key informants, as well as direct observation and asking questions about what is seen, and conducting guided interviews and group interviews with informal or selected groups. For example, looking at quality of housing can be a way to quickly judge the condition of household (state of deprivation). Other indicators that have been used include wealth in land and animals, tangible assets such as tools, beds, cooking utensils, and indicators of nutritional status.

If a PRA is carried out before formal surveys, there is the advantage that the surveys can embody concepts and categories of the local people and their local meanings. Reliance on questionnaire surveys alone may limit investigators to what can be asked, and it is generally difficult to get a good understanding of social relationships, for example, reciprocity, dependence, and exploitative relationships, from information from questionnaires. Questions that a researcher may not know how to ask may be revealed during group discussions, when informal/qualitative research methods are employed. Participatory research approaches are more amenable to helping identify

causal relationships (not simply correlations that statistical data can reveal) than formal questionnaire surveys, and thus generate insights about how rural life works.

Participatory research methods have found favour particularly among those who work with disadvantaged segments of society (e.g., resource poor farmers), because of their empowerment features. PRA allow pulling of knowledge and mutual stimulation when local people work in a group, knowledge is shared among researchers and local people. The communication media used during PRA are chosen so as to remove most barriers to learning and sharing among local people and researchers.

#### **2.2.2.1 Techniques used in PRA**

It is important to point out that PRA is a mindset not a blueprint, with a set of rules to be closely adhered to. While there are a number of techniques that have come to be distinctively identified with PRA such as village maps and transects, failure to employ these techniques in a given situation should not be taken to imply that the exercise was not a PRA. The emphasis in PRA should be appropriately on genuine participation and the researcher needs to be innovative in using other appropriate techniques of facilitation beyond the usual "menu" of PRA techniques to enhance participation by members of the community with whom he/she is working (IDS, 2001).

##### **i) Community mapping**

Diagramming is a tool that is often used in PRA. This includes the construction of maps that detail features surrounding the village/community, for example, resource maps or social maps, indicating locations of households within the village and their characteristics, such as the number of males, females and children in each household. The diagrams can also be a model representation of phenomena, for example, ranks or prioritisation, quantification of seasonal changes in rainfall, labour requirements, income and food supplies. Such exercises are carried out with the use of locally available materials, for example, stones or sticks used to indicate qualitative and quantitative differences. An advantage of this technique is that information is shared and there is an opportunity for crosschecking its accuracy as people correct each other. Also, the information is visible, and is owned by all participants. Diagramming

has the advantages that information is presented visually so that it is "seen" and better understood (Nabasa *et al.*, 1995). Also during the diagramming exercises, use can be made of media, which is familiar to farmers (e.g. diagrams drawn on the ground, use of sticks, stones and seeds), and all can participate in the process, whether literate or illiterate.

## **ii) Transects**

These are systematic walks during which the researcher has the opportunity to discover local practices, observes, and has the opportunity to ask local farmers about the noted practices. During the transect locals may talk about what things are done, how, why things are done the way they are, their perceptions and beliefs. The researcher has the opportunity on the other hand to look for practices that differ from the norm. This technique is important for learning about the farming system, identifying constraints and potential local solutions and other available resources (Nabasa *et al.*, 1995). Information gathered during the transect walk can be summarised in diagrams and charts.

## **iii) Focus groups**

This is when the researcher gathers a group of eight to twelve individuals and sets them in a circle. The researcher conducts an interview by going around in the circle to allow everyone to speak. In the process a discussion of the topic or issue at hand ensues, at the end of which the researcher then gathers individual responses. Focus groups are also used to collect information that the researcher would otherwise not be able to get by interviewing individual respondents, for example, participants' similarities and differences in opinion regarding a topic. By allowing people to get together and create meaning for themselves, and an opportunity to shape and reshape their opinions on a subject, group discussions can encourage learning. The focus group approach has the advantage of reducing the cost of gathering information, thus large amount of information can be gathered in a short space of time. However, focus groups are not the tool for obtaining detailed information about individuals, as such information may be sensitive.

The effectiveness and quality of information obtained from group discussions greatly depends on the researcher's ability to assemble a group of the right size, an



understanding of group dynamics and ability to moderate discussions in the group. For example, a large enough group should be selected to ensure that discussion can go on even when some participants do not actively participate in the discussions (while too large, a group may exert greater demands on skills of moderator). Also, care should be taken that the group is not dominated by one individual who may hijack the discussion. Also depending on the cultural context, it may be the case that women may not always feel free to express themselves in the presence of men.

During the group discussions questions should be open ended, using semi-structured approach, for example, more conversational. A list of prepared questions may be used only as a guide to assure that all the issues around which information is needed are covered during the interview.

#### **iv) Individual interviews**

*In-depth and more specific information about households, and information of a more sensitive nature (information which is more personal or relating to relations among groups) can be gathered during individual interviews. With individual interviews more time may have to be spent with each farmer compared to group discussions. The techniques of diagramming can still be used with individual respondents to enhance the learning and information sharing process. As with group discussions, questions should be open ended.*

Among the issues surrounding PRA and with other qualitative research methods is its ability to provide researchers with valid and reliable data. This issue has been addressed by a number of authors starting with a definition of validity and reliability in the context of qualitative research as opposed to quantitative research. Validity and reliability are about trustworthiness, whether findings of a research are worthy paying attention to (Lincoln and Guba, 1985), and credibility concerns the comparability between the reality of the researched and the description attributed to them. The vast literature on qualitative research methods suggests that the validity of PRA results can be improved through, for example, prolonged engagement with the researched communities, persistent observation, triangulation, providing opportunities for local people and other researchers to check the information.

The following general guidelines may be used by researchers to help plan and execute a successful PRA:

- Defining study objectives – what is the issue/question to be addressed by the study? What information is required to answer the questions, who are the research participants?
- Reviewing secondary data – increases efficiency of the study by avoiding gathering of information already available (duplication), allows more focus in observations, selection of appropriate sites, and identification of key variables ahead of time, helps place the study in context, allows use of contemporary and historical information to discern changes in farming systems' characteristics.
- Developing contacts with key persons – external agencies working with communities selected for the study, community leaders. Helps create channels for reaching community members and create trust between researchers and members of the community.
- Allocation of PRA team duties during the exercise – two or three initiators should be selected to guide the process.
- Implementation of PRA – arrival at the site.

It should however be noted that for policy formulation, some quantitative information on orders of magnitude are needed. Formal surveys and the use of questionnaires may be necessary for gathering such information.

### **2.2.3 Preparation for PRA and PAR surveys, and processes following participatory research strategy**

Good planning is a prerequisite for undertaking a successful PRA/PAR and for the exercise to achieve its intended objectives. To this end researchers sought out to learn about how the communities were structured, the leadership structures, the presence of various interest groups (e.g., producers' associations, etc.), before setting out to meet with the farmers. Discussions with the regional extension officer in Thaba Nchu provided some of this information. The team also sought the close cooperation of extension workers in setting up meetings in the selected villages. Since the extension workers are more familiar to local people, their presence can help allay the locals'

suspensions regarding the intentions of outsiders who come purporting to be working for the betterment of the communities. Many communities have had bad experiences with external agencies who assure them help to improve the lot of the locals but never to reappear. Extension workers, however, work for government departments without a tradition of seeking locals' participation in influencing policies and development programs. There is therefore need to have them sensitised to the new approach before they are invited to be part of the PRA/PAR team. In meetings prior to field visits, discussions were held with the extension workers during which the potential for increasing crop production using IRWH techniques was outlined. The agricultural extension officers were invited to be part of the process, jointly with the communities and researchers, of diagnosing problems in the farming system and the experimentation with water harvesting as technique to increase available moisture in farmers' fields. Even more importantly, the participatory approach as the philosophy to underpin interactions with communities was also discussed with the extension workers.

Although PRA/PAR consists of largely open-ended interactions with communities, it is still important for researchers to compile a list of questions that can be used to guide the discussion and to ensure that all pertinent issues are discussed, and that the critical information needs are met. For researchers to ask questions is in line with the participatory approach. It is an acknowledgement that farmers have some knowledge which outsiders can gain access to by letting farmers explain how they do things and the reasons for doing them the way they do. However, it is also important that farmers also have the opportunity to pose questions to researchers so that they can also tap into the knowledge of outsiders.

Prior to the field visits, the researchers met to discuss and draw a list of questions (open-ended). Examples of the questions include among others, the following:

- Which crops do farmers in the area grow? What types of livestock do you raise?
- How do you prepare the land before planting?
- What are the difficulties that you encounter in farming?

- What do you think can be done to overcome the constraints in farming?
- What are your goals as a farmer? What are the goals (your goals) of the community?
- What is the process by which a household can gain access to land (residential, agricultural and grazing land)?
- What are the rules that apply to the use and management of resources in the community?
- How does the community ensure that rules are followed?

It was decided that one member from the research team will be assigned the responsibility of guiding the discussion to ensure proceedings would not veer away from the central purpose of the PRA/PAR (to gather information relevant for agriculture in the area and for introduction of water harvesting techniques). Two weeks prior to the field visit the Regional Agricultural Extension officer sent out a letter to village headmen in each of the initial three villages (Paradys, Talla and Yoxford) requesting for a meeting between households and the researchers. The letter specified the date and time, and purpose of the meeting.

#### **2.2.4 Quantitative data**

PRA techniques are useful for generating a wealth of information that can help researchers to understand the social context in which farmers carry out their production activities. The information generated through PRA is largely qualitative, consisting of observations that are not readily reduced to numbers. However, the policy formulation process also requires a good understanding of the relationships among relevant variables, for example, the responsiveness of production to changes in commodity prices, or the relationship between asset ownership and household's choice of economic activity. Such relationships are better understood with the aid of quantitative data and the application of statistical analysis of the data. Surveys are typically used to gather quantitative data.

PRA and questionnaire surveys are both tools for generating information about the agricultural system, the characteristics of farmers and the results of production activities. This information is then analysed using agronomic, statistical and economic

methods to assess the socio-economic and ecological implications of a technology. The following section looks at the issue of social appropriateness of technology.

### **2.2.5 Social appropriateness of technology**

A number of social considerations need to be taken into account when developing technologies to be diffused to small-holder farmers. It is important to respect social structures and cultural practices among the targeted beneficiaries, that is, the developers of the technology should be cognisant of the impact the technology is going to have on these features of the agricultural system. Technical changes that result in sudden and disruptive impact on the existing social structures may be resisted by farmers, or if forced through may lead to undesirable consequences on both the agricultural system and on people's livelihoods.

It is also important that explicit consideration be made of the likely impacts of technical change on the poorest-of-the-poor. New technologies that give the poorest members of the community better opportunities for generating income and meeting food requirements would be ideal. In many instances the introduction of new technologies, for example, the introduction of mechanical power in agriculture, has resulted in worsening the position of the poor and landless by reducing employment opportunities. It is also important to consider, for example how technical change can alter the relationships between the rich and poor and between men and women, and the implications of the changes in the well-being of those affected. Studies of the Green Revolution in India (Agarwal and Narain, 1989) revealed, for example, that intensification of agriculture often increased the farm related tasks for women without diminution in their other tasks, and without a proportionate increase in their share of family income. Some technical changes, such as the move from hand labour oriented agriculture to animal and mechanical traction may transform the agricultural system from one where women have a prominent role to a male dominated system. This can lead to a reduction in the status of women because the other tasks they typically perform such as housework are under-appreciated.

## 2.2.6 Financial and economic analysis

### 2.2.6.1 Production function and enterprise budget

Assuming that the objective of the producer/farmer is maximizing profits, the farmer/manager must decide how to combine the available inputs in the physical production processes of the farm so as to achieve the profit maximizing objective of the farm enterprise. The concept of the production function is central to the production process of the farm firm. A production function is defined as "the technical relationship between inputs and output indicating the maximum amount of output that can be produced using alternative amounts of variable inputs in combination with one or more fixed inputs under a given state of technology" (Casavant *et al.*, 1999). The production function can be depicted as a graphical representation of production responses as obtained from a production schedule, which shows specific and unique points on the production curve.

The points can be depicted in monetary terms to determine how much income is generated from the costs spent to produce a particular level of output. In this way, enterprise budgets can be determined and will form specific and unique points on the farmer's production function. Typically, budgets are written plans for future actions based on forecasts, historical data, assumptions and experience. The plans (budgets) are expressed in physical and financial quantities (Standard Bank of South Africa, 1988). The enterprise budgets, even though traditionally a planning tool, can be used to determine if a given production activity is desirable/profitable (Crawford, 1999). It shows the costs and returns for a given production activity on a per unit basis (e.g., per hectare). The information and detail of enterprise budgets will vary due to circumstances, preferences and motives (The Standard Bank of South Africa, 1988). Enterprise budgets need to be compiled in detail as they contribute to better and more accurate planning and can take different forms. Enterprise budgets can be prepared using either financial (market prices) or economic prices. In the study, the budgets will be prepared using actual or market prices so that a financial analysis can be done to assess the attractiveness (profitability) of a production technique for the farmers. In-kind inputs and outputs will be included as well as those that are bought and sold in the market. Such inputs and outputs can be valued using farm-gate purchase or sale equivalents based on market prices (adjusted for transport and handling costs). The

value of output is calculated for a given production period by the product of the actual yield achieved and the unit (ton) market price of the output.

Enterprise budgets make provision for a gross margin analysis. The gross margin analysis can be looked at as summarizing the monthly machinery usage and the monthly transaction flow statement over the production season, and thereafter allows parametrical analysis to be performed. A parametrical analysis of the enterprise budget is usually done to capture the sensitivity of gross margin to yield and price fluctuations as well as the fluctuations of the cash balance over the season.

For the study enterprise budgets are developed for both the conventional and water harvesting techniques (Tables 2.1 and 2.2). For the conventional production system (Table 2.1), the enterprise budget will include three main financial components:

1. Gross receipts from production (Gross income/value of output)
2. Variable Costs (cost of variable inputs)
  - Pre harvest
  - Harvest and Post Harvest
3. Gross margin

The variable cost structure is broken down into pre harvest, harvest and post harvest sub components. The pre harvest sub component includes the cost of planting (seed and labour), fertilizers used, pest control/pesticides and weed control/herbicides. The harvest and post harvest comprises the cost of harvesting, threshing and the clearing of the area for the next crop. The variable costs are further divided into directly allocatable and non-directly allocatable variable costs. Non-directly allocatable variable costs include energy costs, repairs and maintenance. Total preharvest costs are computed as well as total post harvest costs. The gross margin above total allocatable costs is given by the difference between gross receipts from production and the sum of total pre and post harvest costs. Table 2.1 shows a proforma example of the enterprise budget for the conventional method.

The proforma enterprise budget (Table 2.1) describes the production technique in terms of the activities performed and the inputs used in each activity. The first column

records the activities and divides them into three main categories; gross receipts, variable costs and a summary of the costs. Variable costs are further divided into two groups being preharvest and harvest and post harvest costs. In the summary of the costs we have the total preharvest costs, the total harvest and post harvest costs, and finally the gross margin. The letters in the budget represent the prices, quantities and costs of inputs and outputs from production. The costs (last column from right) are given by the product of the price of input and the quantity of that input used in a production activity.



**TABLE 2.1 : STRUCTURE AND DETAIL OF THE ENTERPRISE BUDGET FOR THE CONVENTIONAL PRODUCTION TECHNIQUE IN THE STUDY AREA**

| GROSS MARGIN PER HA (R)                       |      |                  |          |      |
|-----------------------------------------------|------|------------------|----------|------|
| Place-production technique                    |      |                  |          |      |
| Farming area: GH                              |      |                  |          |      |
| Target yield: yy Kg/ha                        |      |                  |          |      |
| Seasons: year of production                   |      |                  |          |      |
| CROP                                          | UNIT | PRICE OR         | Quantity | Cost |
|                                               |      | COST PER UNIT(R) |          |      |
| Gross receipts from production                |      |                  |          |      |
| Crop products                                 | Ton  | A                | H        | AH   |
|                                               |      |                  |          |      |
| VARIABLE COSTS                                |      |                  |          |      |
| PREHARVEST :                                  |      |                  |          |      |
| Planting                                      |      |                  |          |      |
| Seed                                          | Kg   | B                | I        | BI   |
| Labour                                        | Days | C                | J        | CJ   |
| Fertilizers                                   |      |                  |          |      |
| Ammonium Nitrate                              | Kg   | D                | K        | DK   |
| Superphosphate                                | Kg   | E                | L        | EL   |
| Pest Control/Pesticides                       |      |                  |          |      |
| Bulldog                                       | L    | F                | M        | FM   |
| Application (labour)                          | Days | G                | N        | CN   |
| Weed Control/Herbicides                       |      |                  |          |      |
| Turbo                                         | L    | O                | P        | GO   |
| Application (labour)                          | Days | C                | P        | CP   |
| Hand weeding (labour)                         | Days | C                | Q        | CQ   |
|                                               |      |                  |          |      |
| HARVEST and POST HARVEST (labour)             |      |                  |          |      |
| Hand harvesting                               | Days | C                | R        | CR   |
| Threshing                                     | Days | C                | S        | CS   |
| Remove crop residue                           | Days | C                | T        | CT   |
|                                               |      |                  |          |      |
| Total Directly Allocatable Variable Costs     |      |                  |          | U    |
|                                               |      |                  |          |      |
| Margin Above Total Directly Allocatable Costs |      |                  |          | V    |
|                                               |      |                  |          |      |
| Non Directly Allocatable Variable Costs       |      |                  |          | Y    |
| Energy                                        |      |                  |          | W    |
| Maintenance and Repairs                       |      |                  |          | X    |
|                                               |      |                  |          |      |
| Total Preharvest Costs                        |      |                  |          | Z1   |
| Total Harvest and Postharvest Costs           |      |                  |          | Z2   |
| Gross Margin Above Total Allocatable Costs    |      |                  |          | Z    |
|                                               |      |                  |          |      |
| Assumptions                                   |      |                  |          |      |

For the *IRWH* techniques, the enterprise budgets are the same as for the conventional production system except there is no distinction between directly and non-directly allocatable variable costs (Table 2.2). The reason for this is that the non directly allocatable costs in conventional production (land preparation) is a fixed cost for the *IRWH* system as the cost is only incurred once (setting up the system) in the lifespan of the *IRWH* system. This is based on the assumption that all activities in the *IRWH*

techniques are performed by hand except during the initial land preparation where tillage is done by tractor. For the conventional technique, this cost is incurred every year and is entered as a variable non-directly allocatable cost. Secondly, an enterprise budget for *IRWH* techniques has an additional pre harvest cost; maintenance of the system during the growing season of the crop. The system may require that the basins be repaired occasionally due to damages to the basins and mulches by animals, people and rainfall. This, however, is a relatively minimal cost. The gross margin is computed as in the conventional system.

As Table 2.2 shows, the enterprise budget for the *IRWH* techniques includes the fixed costs at the bottom. The costs are not used in computing the gross margins but become important in the capital budget analysis (cost benefit analysis). The fixed costs are included in the calculation of the net margin, which in the study will be the enterprise profit.

Enterprise budgets become important management tools for the study in determining whether it will be profitable (desirable) to use a particular production technique or not, or simply to compare them in terms of their returns. However, enterprise budgets only show the value of production in the short term and are then important in determining the short-term viability of an enterprise (as measured by the gross margin) over a production season or an average over several production seasons.

Profitability can be seen as representing desirability, where it is defined in terms of the gross margin in the financial analysis and net margin is used in the cost benefit analysis.

**TABLE 2.2: THE STRUCTURE AND DETAIL OF AN ENTERPRISE BUDGET FOR THE IRWH TECHNIQUES IN THE STUDY AREA**

| GROSS MARGIN PER HA (R)                       |      |                  |          |      |
|-----------------------------------------------|------|------------------|----------|------|
| Place-production technique                    |      |                  |          |      |
| Farming area: GH                              |      |                  |          |      |
| Target yield: yy Kg/ha                        |      |                  |          |      |
| Seasons: year of production                   |      |                  |          |      |
| CROP                                          | UNIT | PRICE OR         | Quantity | Cost |
| Country: South Africa                         |      | COST PER UNIT(R) |          |      |
| Province: Free State                          |      |                  |          |      |
| Ecotope: mnb                                  |      |                  |          |      |
| Clay (%) in A-horizon: s%                     |      |                  |          |      |
| Plant Population: xx plants per hectare       |      |                  |          |      |
| Cultivar: cc                                  |      |                  |          |      |
| Gross receipts from production                |      |                  |          |      |
| Crop products                                 | Ton  | A                | H        | AH   |
|                                               |      |                  |          |      |
| <b>VARIABLE COSTS</b>                         |      |                  |          |      |
| <b>PREHARVEST :</b>                           |      |                  |          |      |
| Planting                                      |      |                  |          |      |
| Seed                                          | Kg   | B                | I        | BI   |
| Labour                                        | Days | C                | J        | CJ   |
| Fertilizers                                   |      |                  |          |      |
| Ammonium Nitrate                              | Kg   | D                | K        | DK   |
| Superphosphate                                | Kg   | E                | L        | EL   |
| Pest Control/Pesticides                       |      |                  |          |      |
| Bulldog                                       | L    | F                | M        | FM   |
| Application (labour)                          | Days | C                | N        | CN   |
| Weed Control/Herbicides                       |      |                  |          |      |
| Turbo                                         | L    | G                | O        | GO   |
| Application (labour)                          | Days | C                | P        | CP   |
| Hand weeding (labour)                         | Days | C                | Q        | CQ   |
|                                               |      |                  |          |      |
| <b>HARVEST and POST HARVEST (labour)</b>      |      |                  |          |      |
| Hand harvesting                               | Days | C                | R        | CR   |
| Threshing                                     | Days | C                | S        | CS   |
| Remove crop residue                           | Days | C                | T        | CT   |
|                                               |      |                  |          |      |
| Total Directly Allocatable Variable Costs     |      |                  |          | U    |
|                                               |      |                  |          |      |
| Margin Above Total Directly Allocatable Costs |      |                  |          | V    |
|                                               |      |                  |          |      |
| Total Preharvest Costs                        |      |                  |          | Y    |
| Total Harvest and Postharvest Costs           |      |                  |          | W    |
| Gross Margin Above Total Allocatable Costs    |      |                  |          | X    |
|                                               |      |                  |          |      |
| <b>FIXED COSTS</b>                            |      |                  |          |      |
| <b>LAND PREPARATION</b>                       |      |                  |          |      |
| Energy                                        |      |                  |          | U    |
| Repairs and maintenance                       |      |                  |          | V    |
| Construct basins (labour)                     | Days | C                | I        | Cj   |
| Pack mulch or stones (labour)                 | Days | C                | K        | Ck   |
| Total Fixed Costs                             |      |                  | I        | Zf   |
| Assumptions                                   |      |                  |          |      |

It is important to note that the analysis is only made at enterprise level not farm level, therefore, enabling one to calculate the net margin without having to determine what share of the farm level fixed cost to allocate to a given enterprise. Table 2.3 below shows the definition of profitability measures as used in the study.

**TABLE 2.3: DEFINITION OF PROFITABILITY (DESIRABILITY) MEASURES AS USED IN THE STUDY**

| Enterprise Budget Element   | Profitability Measures |
|-----------------------------|------------------------|
| Gross Income                |                        |
| <i>minus</i> Variable Costs | = Gross Margin         |
| <i>minus</i> Fixed Costs    | = Net Margin           |

Source: Crawford, 1999. p6

### **2.2.6.2 Risk Analysis**

Since enterprise budgets do not adequately address risk and uncertainties in production (Crawford, 1999 and Standard Bank of South Africa, 1988), there is need for a more detailed analysis of risk associated with the techniques. In the study, the main source of risk is taken to be inadequate and erratic rainfall, which has important implications on the yield, by implication, returns to production inputs. However, apart from rainfall, there are other sources of risk and constraints that the farmers have to deal with but it is impossible to deal with all of them at once. This necessitates a method to employ in order for one to quantify risk using available rainfall data for a given period of time. Annual rainfall data for the period 1922 to 2003, for the study area, was available and was used to predict the expected yield for each year in the period as explained in the section that follows.

#### **i) Long term yield and gross margin estimates**

Analyzing agricultural systems and their alternative management options experimentally in real time is generally perceived not feasible (Meinke *et al.*, 2001) due to the length of time and amount of resources required. However, well-tested simulation models offer a time and cost-efficient alternative to experimentation on the physical system (Keating and McCown, 2001). Simulation analyses have now become legitimate means of evaluating policy and resource management issues (Silburn and Connolly, 1998 and Howden *et al.*, 1999). Apart from their use as systems analytical tools, simulation approaches are often proposed as efficient tools to assist farmers' decision making. The results of simulation approaches may influence farmers' decisions directly by providing necessary background information about the likely

outcome of a decision and associated risks or indirectly by changing the policy framework which will in turn influence decisions on farms (Meinke *et al.*, 2001).

It is against this background that the study used CYP-SA model (Botha *et al.*, 2003) to estimate crop yields for the production practices based on long term rainfall data for the study area. The model predicts the yield based on the rainfall amount for a particular year; the annual rainfall data used was for a period of 81 years (1922-2003) in the study area. The predicted yield data was then linked to the developed enterprise budgets to compute the expected gross margins for each year in the simulation period. The estimation used base year prices (constant) for the whole period of estimation such that it is only the yield that varies for a specific production technique. The estimated gross margin is then given by:

$$GM_e = Py_b \cdot Y_e - [(Y_e/Y_b) \cdot TC_{hp} + TVC_b]$$

where:

$GM_e$  = the estimated gross margin

$Py_b$  = the output price in the base year

$Y_e$  = the estimated crop yield

$Y_b$  = the actual yield achieved in base year

$TC_{hp}$  = the total cost for harvest and post harvest in year

$TVC_b$  = the pre harvest total variable costs in base year

The factor  $(Y_e/Y_b) \cdot TC_{hp}$  is included in the calculation to capture the effect of the quantity of yield since the harvest and post harvest costs are dependent on the yield.

## ii) Estimation of probability distribution functions

Agricultural economists have been striving to adequately model risky environments and decision making processes of farmers for several decades. The universal agreement on the framework that is most appropriate is yet to be realized (Anderson and Dillon, 1992). However, the approach of "decision analysis" will be used where the decision-maker is seen as choosing so as to maximize subjective utility (Anderson,

*et al.*, 1977; Anderson and Dillon, 1992). This is a simple and satisfactory framework for considering farmers and risk.

A considerable portfolio of methods has been developed to put the deceptively simple ideas of decision analysis to work in a wide range of choice problems. According to the literature (Hein *et al.*, 1997, Langyintuo *et al.*, 2002; and Anderson and Dillon, 1992), cumulative distribution function analysis has been the most common of these methods and is adopted for the study. This is based on the fact that on-farm experimental trials are seldom done for more than three or four years thus the exact distributions of outcomes from field experiments are not known and must be estimated (Langyintuo *et al.*, 2002). The estimation method should not only depend on the number of observations and type of information available, but also on the objective of the analysis (Hein *et al.*, 1997). A simple empirical estimation method for the probability of outcomes was proposed by Hein *et al.* (1997), based on the assumption that the farmers' fields on which the trials were carried out are representative of the farming community. The probability of each outcome  $i$ , in year  $t$ , ( $P_{it}$ ) is estimated using the relationship:

$$P_{it} = (1/T)(1/f_t)$$

where:

$T$  = the number of cropping seasons

$f_t$  = the number of farmers participating in year  $t$

In the study, the predicted gross margins were each assumed to have an equal opportunity of occurrence over the period of estimation. That is, each one had a single chance of occurring during the period in question. The probability of an outcome ( $P_i$ ), over the period, is estimated by the following relationship:

$$P_i = (1/N)$$

where

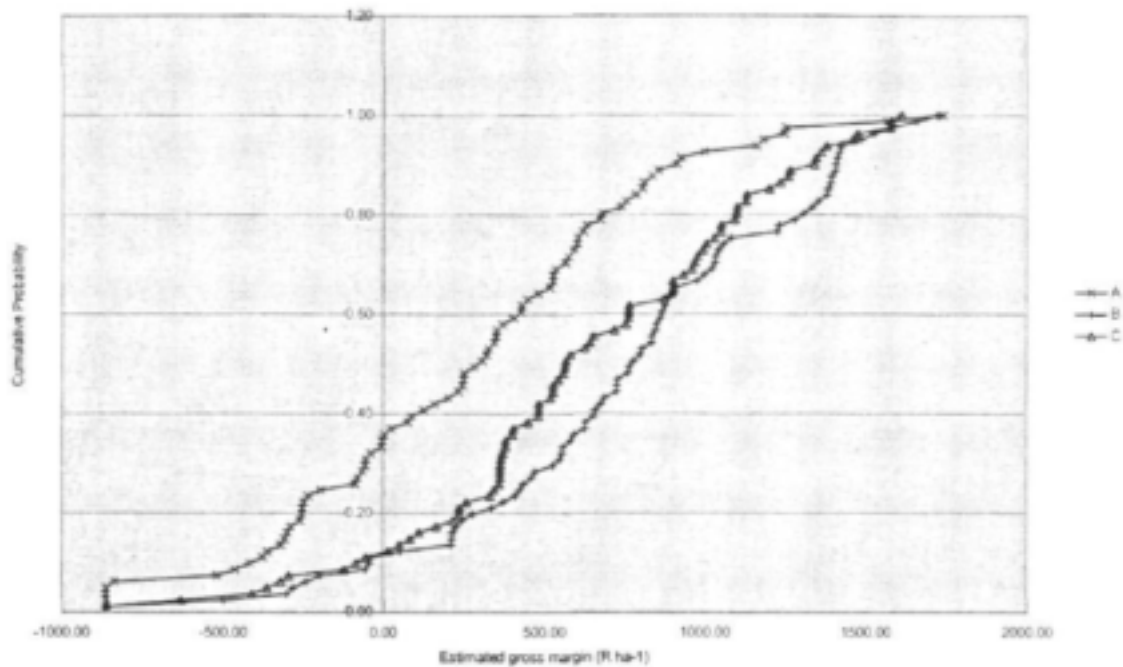
- $P_i$  = the probability of an outcome  
 $N$  = the total number of years in the period

After the probabilities were estimated, the predicted gross margins can then be arranged in ascending order and their cumulative probabilities calculated. The cumulative probability of an outcome is given by the probability of that outcome plus the sum of the probabilities of the outcomes below it. The cumulative probabilities were plotted against the predicted gross margins and the points connected with linear segments to come up with cumulative distribution functions for the estimation period. Linear segments are used, as opposed to a smoothing algorithm, since there is limited information on the nature of the distribution between successive points. In theory, the cumulative distribution function is strictly monotonically increasing (Langyintuo *et al.*, 2002).

The procedure will be repeated for each crop and three different scenarios being:

- i) conventional and water harvesting techniques with a half full profile planted on 17 December of each year
- ii) the most productive technique with a half full soil profile planted on three different dates
- iii) the most productive technique with five different soil water contents; full, three-quarter full, half full, a quarter full and empty

Figure 2.1 presents an example of a plot of cumulative distribution functions as used in the study.



**FIGURE 2.1: CUMULATIVE PROBABILITY DISTRIBUTION FUNCTIONS BASED ON GROSS MARGINS FOR A, B AND C PRODUCTION TECHNIQUES.**

Decision analysis can be extended without having to elicit decision makers' preferences by the idea of stochastic efficiency appraisal. The appraisal is used in the analysis as it relies on simple intuitive observations on farmer behaviour (Hein *et al.*, 1997), also the method does not impose restrictions on the decision maker's utility function. The procedure involves comparison and manipulation of probability distributions of uncertain consequences expressed as CDFs. Anderson *et al.* (1977) elaborated the procedures for first, second and third degree stochastic dominance. In first degree stochastic dominance (FSD) the CDF to the right of the other is dominant to the one on the left and would be preferred. FSD assumes that the farmer prefers more to less of an outcome. The rule implies that if the cumulative probability of a production technique is greater than the cumulative probability of another production technique for all levels of the outcome, then the production technique with the higher probability is dominated by the system with the lower probability (Hardaker *et al.*, 1997). Second degree stochastic dominance (SSD) is useful when the CDFs intersect. Neither distribution is dominant in the first degree but the one that has the more favourable (larger) worst possible outcome may be dominant in the second degree. The SSD can be determined graphically and by comparing the areas between the intersecting CDFs. Second degree dominance identifies those distributions which are of no interest to the risk averse decision maker and thus will not be of significant



importance in this study but will not be totally ignored. This is due mainly to the fact that the farmers in the study area are assumed to be risk averse and will most likely choose only those production techniques, which dominate in the first order.

From Figure 2.1, based on stochastic efficiency appraisal, A will be more preferred to C and B. However, C will be more preferred to B. This means that A is first order stochastically dominant to B and C, while C is dominant in the first order to B.

Stochastic dominance has been criticized for not taking into account errors in estimation of the cumulative distribution functions (Cochran, 1986). In order to account for this discrepancy, the study uses the Kolmogorov-Smirnov (K-S) test to determine to what degree the distributions are statistically different, i.e., to identify the reliability of the stochastic dominance comparisons. Generally, the K-S test is used to determine whether two distributions are significantly different (Steele *et al.*, 1997). The test is non-parametric, which means it is done at the distribution level instead of individual parameters such as mean and variance. The test statistic is applied to the maximum vertical distance between the distributions. If this value exceeds the critical level for the chosen significance threshold, the distributions are significantly different.

The K-S test statistic is defined as

$$D = \max_{1 \leq i \leq N} \left| F(Y_i) - \frac{i}{N} \right|$$

where  $D$  is the maximum distance between the cumulative distribution function

### 2.2.6.3 Net present value analysis

Project analysis is designed to permit project-by-project decision-making on the appropriate choices between competing uses of resources (Squire and van der Tak, 1946). Gittinger (1996) points out that economic analyses of agricultural projects are undertaken to compare the costs with the benefits and determine which among alternative projects have an acceptable return. The analysis is also referred to as cost-benefit analysis, which according to Brent (1998) is a social assessment of the cost and benefits of investment decisions. Sell (1991) identifies this as the fulfilment of the

requirements that not only the financial profitability is ensured but also the economic profitability.

The analysis requires that there be a criteria (informed by the objectives) to base the analytical system on, and Gittinger (1996) uses the objective of income maximization while other objectives are accommodated at other points in the process of project selection. The justification for this is based on the fact that in most developing countries, and also for most small-scale resource poor farmers, increased income is probably the most important objective of individual economic effort and increased national income is the most important objective of the national economic policy. In line with the above, for farms the objective is taken to be maximizing the incremental net benefit and for the society it is maximizing the contribution the project makes to the national (societal) income.

In the present study the objective is assumed to be increased income from production such that a household will be able to meet most of the household food/income requirements so as to achieve food security. This requires that the production techniques be able to maximize the net incremental benefit as measured by net margin. It is argued that an aggregation of the net incremental benefits for farming households will translate into the contribution to the societal income that results from the use of the production technique(s). This implies that if the techniques make a significant contribution to a farming household, then adoption by other members of the society will likely result in an increased benefit to the societal welfare. However, like in prior analysis of gross margins, the analysis is also performed at enterprise level as opposed to farm level so as to quantify the actual contribution brought about by the production techniques towards the maximization of farm/household income. Table 2.4 shows the schedule of the calculations of the criteria that are used in the study.

The production techniques in the study are mutually exclusive which means they are alternative methods of reaching the same goal (increased food/income), therefore, the economic analysis involves primarily choosing the most profitable and cost-effective alternative. The analysis uses three criteria to compare the results; net present value, internal rate of return and benefit-cost ratio. The base scenario is the conventional

production technique and will be compared with the different water harvesting techniques.

### **i) Criteria for Investment Appraisal**

The calculation of the viability of a project is obtained by analysing the structural timing of the net cash flows over the lifespan of the project (Sell, 1991). The analysis assumes that any resultant cash flow will be placed at the disposal of the farming household and the household will pay for any deficit. The criteria used in the investment appraisal of the production techniques are as follows:

#### **a) Net present value**

The net present value is the value that is obtained by discounting all periodic net cash flows at a predetermined rate of interest up to a point directly before the beginning of the investment. In the study, the difference between the benefits and costs for a specific water harvesting technique in the specified year is discounted using a (social) discount rate<sup>4</sup> and the result is compared with the same value calculated for the conventional crop production technique.

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<sup>4</sup> Detailed discussion of selecting an appropriate discount rate, see Conningarth Economists, 2002.

**TABLE 2.4: COMPARISON OF THE NET PRESENT VALUE AND BENEFIT COST RATIO FOR A CROP PRODUCTION BETWEEN A AND B PRODUCTION TECHNIQUES AS APPLIED IN THE STUDY**

| Enterprise level analysis (Crop)  |           |         |         |         |          |          |          |          |          |          |          |          |          |          |          |          |
|-----------------------------------|-----------|---------|---------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
|                                   | YEARS     | 1       | 2       | 3       | 4        | 5        | 6        | 7        | 8        | 9        | 10       | 11       | 12       | 13       | 14       | 15       |
| <b>A</b>                          |           |         |         |         |          |          |          |          |          |          |          |          |          |          |          |          |
| Gross Income                      |           | 1570.58 | 871.13  | 1573.80 | 0.00     | 727.03   | 1486.83  | 340.81   | 1048.44  | 887.05   | 1482.16  | 0.00     | 1175.80  | 472.72   | 1098.11  | 1089.83  |
| Discounted Total Gross Income 10% | 7878.74   | 1427.80 | 719.04  | 1032.16 | 0.00     | 851.43   | 838.28   | 374.89   | 507.27   | 291.38   | 575.27   | 0.00     | 574.58   | 136.95   | 288.84   | 258.89   |
| Discounted Total Gross Income 15% | 8884.31   | 1385.72 | 658.70  | 953.30  | 0.00     | 381.48   | 842.50   | 128.12   | 335.81   | 105.30   | 368.92   | 0.00     | 219.73   | 76.83    | 154.91   | 132.80   |
| Discounted Total Gross Income 5%  | 8688.34   | 1495.19 | 790.14  | 1188.74 | 0.00     | 889.83   | 1109.50  | 242.21   | 738.70   | 442.88   | 918.02   | 0.00     | 854.92   | 250.89   | 513.61   | 519.80   |
| Total Variable Costs              |           | 1302.81 | 1274.94 | 1284.82 | 1240.48  | 1269.25  | 1289.29  | 1253.97  | 1283.54  | 1287.88  | 1298.30  | 1260.48  | 1286.99  | 1259.19  | 1283.84  | 1283.29  |
| Fixed Cost                        |           | 100.00  | 100.00  | 100.00  | 100.00   | 100.00   | 100.00   | 100.00   | 100.00   | 100.00   | 100.00   | 100.00   | 100.00   | 100.00   | 100.00   | 100.00   |
| Discounted Total Costs 10%        | 10475.84  | 1275.10 | 1126.31 | 1047.95 | 915.57   | 870.20   | 789.86   | 804.80   | 845.43   | 559.02   | 529.57   | 489.83   | 481.04   | 293.71   | 368.41   | 331.13   |
| Discounted Total Costs 15%        | 8888.41   | 1219.68 | 1039.85 | 917.12  | 786.43   | 688.78   | 604.95   | 508.51   | 452.28   | 388.27   | 345.93   | 298.13   | 259.24   | 220.91   | 195.58   | 169.99   |
| Discounted Total Costs 5%         | 14188.38  | 1335.82 | 1247.11 | 1284.96 | 1302.82  | 1372.84  | 1548.17  | 1622.24  | 1518.43  | 1651.81  | 1659.17  | 1653.16  | 1722.33  | 1720.81  | 1698.93  | 1685.38  |
| NET MARGIN                        |           | 167.07  | -553.81 | -21.02  | -1340.48 | -642.22  | 87.84    | -1013.16 | -285.10  | -888.83  | 92.80    | -1348.49 | -211.39  | -886.47  | -287.73  | -1302.80 |
| CUMULATIVE NET MARGIN             | -25186.85 | 167.07  | -535.84 | -556.86 | -1637.35 | -2319.57 | -2232.33 | -3285.19 | -3588.29 | -4249.50 | -4148.30 | -5488.79 | -5730.18 | -6586.85 | -6874.38 | -7176.88 |
| NET PRESENT VALUE (10%)           | -3387.98  |         |         |         |          |          |          |          |          |          |          |          |          |          |          |          |
| NET PRESENT VALUE (15%)           | -2488.10  |         |         |         |          |          |          |          |          |          |          |          |          |          |          |          |
| NET PRESENT VALUE (5%)            | -6518.95  |         |         |         |          |          |          |          |          |          |          |          |          |          |          |          |
| <b>B</b>                          |           |         |         |         |          |          |          |          |          |          |          |          |          |          |          |          |
| Gross Income                      |           | 2194.28 | 1450.08 | 2039.88 | 0.00     | 1579.93  | 1579.72  | 773.80   | 1887.15  | 1180.40  | 2183.70  | 551.80   | 1585.03  | 892.53   | 1815.37  | 1511.76  |
| Discounted Total Gross Income 10% | 10833.42  | 1995.21 | 1139.14 | 1532.43 | 0.00     | 732.64   | 1017.50  | 397.08   | 787.57   | 508.80   | 841.91   | 178.81   | 534.48   | 258.53   | 424.32   | 378.27   |
| Discounted Total Gross Income 15% | 8467.84   | 1899.37 | 1097.13 | 1381.11 | 0.00     | 588.83   | 855.89   | 298.80   | 651.93   | 335.54   | 539.78   | 107.82   | 298.88   | 145.08   | 227.73   | 193.18   |
| Discounted Total Gross Income 5%  | 14871.42  | 2098.27 | 1516.08 | 1761.93 | 0.00     | 924.51   | 1477.30  | 549.93   | 1141.93  | 789.90   | 1349.81  | 293.28   | 881.49   | 473.33   | 813.85   | 756.06   |
| Total Variable Costs              |           | 1151.88 | 1152.88 | 1125.88 | 1045.25  | 1081.94  | 1023.58  | 1076.87  | 1121.01  | 1081.88  | 1151.88  | 1085.10  | 1107.85  | 1080.57  | 1109.51  | 1107.44  |
| Fixed Costs                       |           | 359.80  | 0.00    | 0.00    | 114.35   | 0.00     | 0.00     | 114.35   | 0.00     | 0.00     | 114.35   | 0.00     | 0.00     | 114.35   | 0.00     | 0.00     |
| Discounted Total Costs 10%        | 8483.32   | 1355.71 | 911.29  | 845.05  | 732.02   | 678.01   | 634.24   | 610.27   | 52.25    | 483.10   | 489.19   | 373.31   | 353.01   | 346.15   | 282.94   | 265.11   |
| Discounted Total Costs 15%        | 8288.92   | 1298.77 | 833.77  | 780.34  | 683.51   | 542.89   | 485.78   | 447.45   | 38.82    | 310.40   | 307.39   | 228.04   | 227.57   | 194.21   | 158.73   | 136.10   |
| Discounted Total Costs 5%         | 11397.73  | 1428.27 | 1600.15 | 972.85  | 954.51   | 855.58   | 838.44   | 845.87   | 78.81    | 703.89   | 764.84   | 822.74   | 816.51   | 833.89   | 889.19   | 832.70   |
| NET MARGIN                        |           | 893.00  | 548.79  | 915.70  | -1150.80 | 87.89    | 856.15   | -616.82  | 1575.14  | 38.44    | 937.70   | -883.50  | 476.14   | -302.30  | 502.36   | 484.32   |
| CUMULATIVE NET MARGIN             | 4328.31   | 893.00  | 1041.30 | 1955.00 | 795.80   | 883.39   | 1739.52  | 1323.10  | 2808.24  | 2888.88  | 3926.28  | 3150.88  | 3836.02  | 3533.83  | 4035.99  | 4500.31  |
| NET PRESENT VALUE (10%)           | 3389.18   |         |         |         |          |          |          |          |          |          |          |          |          |          |          |          |
| NET PRESENT VALUE (15%)           | 1878.81   |         |         |         |          |          |          |          |          |          |          |          |          |          |          |          |
| NET PRESENT VALUE (5%)            | 3179.87   |         |         |         |          |          |          |          |          |          |          |          |          |          |          |          |
| <b>INCREMENTAL: B MINUS A</b>     |           |         |         |         |          |          |          |          |          |          |          |          |          |          |          |          |
| Net Margin                        |           | 525.03  | 852.11  | 934.72  | 189.99   | 730.21   | 788.59   | 586.74   | 1879.24  | 789.35   | 845.10   | 776.59   | 886.53   | 894.08   | 789.09   | 786.82   |
| Net Margin Increase               |           | 525.03  | 927.08  | 92.81   | -753.93  | 549.32   | 38.38    | -171.85  | 1273.90  | -1101.19 | 76.15    | -88.11   | -90.48   | -102.45  | 206.51   | -23.17   |
| Cum Net Margin                    | 11817.38  | 525.03  | 1377.14 | 2311.88 | 2492.75  | 3222.06  | 3591.55  | 4588.29  | 6458.53  | 7227.58  | 8072.88  | 8469.67  | 8536.20  | 10120.28 | 10910.37 | 11677.20 |
| Present value of Total NM (10%)   | 882.18    | 477.30  | 278.51  | 82.07   | -514.88  | 341.08   | 21.86    | -88.10   | 588.10   | -487.51  | 28.32    | -23.87   | -28.87   | -28.88   | 54.25    | -5.55    |
| Present value of Total NM (15%)   | 582.42    | 458.55  | 247.32  | 54.32   | -431.50  | 273.11   | 18.59    | -84.80   | 416.31   | -313.03  | 18.80    | -14.84   | -16.51   | -16.85   | 29.12    | -2.85    |
| Present value of Total NM (5%)    | 721.98    | 500.03  | 298.87  | 71.38   | -820.18  | 430.43   | 28.84    | -122.13  | 881.35   | -709.84  | 48.89    | -39.82   | -50.37   | -54.33   | 104.05   | -11.15   |

The period of analysis is taken to be 15 years as it is the longest lifespan for the water harvesting techniques and allows comparison over the same period of time. The net present value (NPV) is specified as follows:

$$NPV = \sum \frac{b_j}{(1+i)^j} - \sum \frac{c_j}{(1+i)^j}$$

where:

- NPV = net present value
- i = discount rate
- $(1+i)^j$  = discount factor
- j = year

The interest rate on the bond market will serve as an indicator for the minimal acceptable discount rate. The farmers for whom the production techniques are meant are resource poor and not particularly active in the economy, therefore their discount rate will most probably be less than the market bond rate. In addition, the adoption of the techniques will most likely serve other economic needs apart from increased income like employment creation for the farming household and perhaps other members of the community. This will be the perspective that will be used in the study. Negative net present values indicate that the production technique is not viable and positive values indicate that the discounted benefits are larger than the discounted costs. This might mean that it will be more favourable to invest in the production technique, but this decision will only be after consulting with other criteria used in the study. The magnitude of the marginal net present value will be used as a measure of the increase in household wealth/well-being that arises from investing in water harvesting techniques as opposed to the continued use of the conventional production.

### b) Benefit Cost ratio (BCR)

The BC ratio is calculated as

$$BCR = \frac{\left( \sum \frac{b_j}{(1+i)^j} \right)}{\left( \sum \frac{c_j}{(1+i)^j} \right)}$$

This is simply the ratio of the present value of benefits to the present value of costs for each production technique. The filter criterion is that acceptable production technique has  $BCR > 1.0$ . For any given constraint on capital available in the first year (year zero), the optimal production technique will be one with the highest  $BCR > 1.0$ . One should note that BCR is a ratio of average benefits to average costs, but optimizing is done at the margin. Ranking the production techniques by magnitude of the BCR will not strictly be valid as they will be used in a capital constrained environment of resource poor small scale farmers. The ranking will nonetheless be important in indicating where the most returns will be made amongst the water harvesting techniques.

#### 2.2.6.4 Minimum area of land required for food security

According to Bickel *et al.* (2000), food security is defined as access by all people at all times to enough food for an active, healthy life. It includes at a minimum the ready availability of nutritionally adequate and safe foods and an assured ability to acquire foods in socially acceptable ways. Food security can also be broadly defined as adequate access to food at all times. The concept of food security is regarded by most development agencies as a guide for designing interventions in rural areas. This commitment carries with it the need to measure food security outcomes at the household and individual level as it provides the basis for monitoring the progress and assessing the impact of development projects aimed at alleviating food insecurity (Hoddinott, 1999). The concept of food security has evolved considerably over time resulting in approximately 200 definitions and 450 indicators of food security (Hoddinott, 1999; Maxwell and Frankenberger, 1992, and Riely and Moock, 1995).

As a result, there is an important methodological problem in determining which indicators and/or definitions are appropriate based on the project being proposed to achieve household food security. While there are many indicators of food security, Maxwell and Frankenberger (1992) made a distinction between two types of indicators of food security. These are the process indicators and outcome indicators. Process indicators are those that describe food supply and food access while outcome indicators describe food consumption. The outcome indicators have been found to be easier to use. Moreso, process indicators have been shown to be insufficient to characterise food security outcomes since there is little correlation between a very large set of process indicators and measures of food security outcomes (Chung *et al.*, 1997). IFAD (1997) also observed that there is little correlation between area-level food production and household food security. Process indicators compared to outcome indicators are prohibitively costly for most development agencies as they face significant financial and time constraints.

Hoddinott (1997) outlines four ways of measuring food security outcomes: individual intakes, household caloric acquisition, dietary diversity, and indices of household coping strategies. The methods are ordered from the time- and skill-intensive and more accurate to those that are quick, are relatively undemanding to implement, but more impressionistic.

The individual food intake is a measure of the amount of calories, or nutrients, consumed by an individual in a given time period. Household caloric acquisition, on the other hand while similar to the individual food intake, is the amount of calories, or nutrients, that are available for consumption by the household members over a specified period of time. The time period is usually 24 hours. The third method, dietary diversity, refers to the sum of the different foods consumed by an individual over a specified time period. The sum might be a simple arithmetic sum or the weighted sum. The index of household coping strategies is an index based on how households adapt to the presence or threat of food shortages.

The four methods of measuring food security outcomes also have different methods of collecting and analysing the data. However, for the purpose of this study the household caloric acquisition will be dealt with in more detail, as it is the method of

choice. Even though the method produces a crude estimate of the number of calories available for consumption by the household, it is easier and quick to implement. Secondly, compared to the individual food intake, the respondents cannot manipulate the answers. Since the questions asked for collecting data are retrospective not prospective, the possibility of individuals changing behaviour as a result of being observed are reduced considerably.

For this method, the data is acquired by asking the principal person responsible for preparing meals how much food he/she prepared over a period of time (about 7 or 14 days). The quantities are then turned into a measure of calories available to the house, after accounting for processing. The conversion of the data into calories is done in three steps:

- Conversion of all quantities into a common unit (e.g., kilogram)
- Converting the quantities into edible portions by correcting for processing
- Converting the edible portion quantities into kilograms by the use of standard caloric conversions

Caloric requirements are dependent on individual characteristics like age, gender, weight, body composition, and health status as well as other factors like climate, but typically a reference person needs to be defined as well as his or her caloric needs per day. This allows the use of household aggregating statistics like household equivalent to be used. There are no universal agreement on the caloric requirement figures but the estimates range from 1 885 to 2 500 kilocalories (Smil, 1994, and James and Schofield, 1990). These estimates thus provide a benchmark upon which the food security status can be evaluated, in other words, to determine if the household can meet the basic requirements to meet the food needs based on the types and quantities of food normally available to the household.

In the study, land is in most cases the only readily available productive asset that the households own. This implies that it becomes an important variable in the production function, as output (household food/income availability) will be dependent to a large extent on the available land. Given this, the minimum area of land required can be



determined by relating land to per hectare profitability (gross margin) and adult equivalent household income and/or caloric requirements.

The average household income requirements will be derived from the per month adult income requirements while the average caloric requirements will be based on average male person with moderate activity in a good state of health. As the literature has shown, there is no universally agreed upon figure. Following Aliber (2003) and based on the household demographics, average household adult equivalent will be calculated for the study area as follows:

$$\text{ADEQ} = (A + 0.5C)^{0.9}$$

where:

ADEQ = the adult equivalent

A = the number of adults in a household

C = the number of children in the family (where every household member below 15 is a child)

After the determination of the average household adult equivalent for the study area, the product of the average household adult equivalent and the average adult monthly income requirement will give the monthly average household income requirement, which value will then be extrapolated to a year. Household income requirement for a year is calculated as follows:

$$\text{HHIR}_y = \text{ADMIR} * \text{ADEQ} * 12$$

where:

HHIR<sub>y</sub> = the household income requirement per year

ADMIR = the adult monthly income requirement

ADEQ = the adult equivalent

Once the  $HHIR_y$  has been estimated, then other sources (apart from crop production) of household income will be summed up to determine the total income that the household receives from those sources. The sources will include remittances, social grants and salaries from off-farm employment. The sum of the income from other sources and from crop production will be the total income generated by the household.

The minimum area of land required will be determined by dividing the difference between total household income requirement per year and total income from other sources by the average per hectare income from production by a typical crop mixture. This implies:

$$W_m = (HHIR_y - HI_{os}) / FI_{cm}$$

where:

$W_m$  = the minimum area of land required

$HHIR_y$  = is the household income requirement per year

$HI_{os}$  = the household income from other sources

$FI_{cm}$  = the farm income from a typical crop mix

It is worth noting that the typical crop mix is assumed to be one where all the three crops (maize, sunflower and dry beans) are grown in equal proportions and the least productive IRWH technique is used for all the crops. This is intended to fully maximise the returns to production should a farmer adopt more productive IRWH techniques and increase his surplus income. The study will also use the poverty line (May, 1998) as the minimum income required by an adult.

For the household caloric requirement, the reference person's daily caloric requirement will be determined, from which the household caloric requirement will be estimated.

This is done by determining the most commonly consumed meals and amounts consumed of each food type. Since the household meals are carbohydrate based, it is assumed the source of the carbohydrates (maize) is produced from the household and

the other food types are purchased. After the determination of the quantities required of each food type, their cost is also determined so as to estimate the required additional income to acquire purchased items. Once this has been achieved, the procedure that follows is almost the same as that used in the income approach.

### **2.2.7 Sustainability in farming systems**

A precise definition of sustainability is illusive, but there is a general consensus that three interrelationships are crucial to the goals of sustainable development. These relationships are embedded in the economic systems, ecological systems and the socio-cultural systems. A number of definitions for sustainability have been put forward, for example, The Technical Advisory Committee of the Consultative Group on International Agricultural Research defines a sustainable agricultural system as "the successful management of resources in agriculture to satisfy the changing human needs while maintaining or enhancing the quality of the environment and conserving natural resources" (CGIAR, 1988). The Committee of the American Society of Agronomy states "A sustainable agriculture is one that, over the long-term, enhances environmental quality and the resource base on which agriculture depends, provides basic human food and fibre needs, is economically viable and enhances the quality of life of farmers and society as a whole" (ASA, 1989).

Most view key criterion of sustainable development as that provided by the 1987 World Commission on Environment and Development (the Bruntland Report). The concept of sustainable agriculture has been developing parallel but independent to the idea of sustainable development. Sustainable agriculture means different things to its different advocates. For some it is an alternative belief system to that underlying commercial agriculture, with emphasis being placed on reduced use of chemicals, for others it means family and group self-sufficiency, a respect for nature and ecosystems. The common thread among these somewhat differing views is the emphasis on the need for taking a holistic view to the problem of natural resources management, emphasising systems and connections. Issue of sustainable development can be explored by trying to answer the question how do we get to sustainable agriculture from here. This can be usefully explored by asking a related question, what makes people make the choices that they do. The answer to such a question includes gender differences, cultural differences, domestic and trade policies, land markets and land

tenure arrangements, personal characteristics, the costs of information, the nature of the adaptive learning, and the like. Sustainable agriculture thus has something to do with careful consideration of preserving the stock and quality of the productive resource base.

A general consensus among economists is that sustainability should be evaluated in terms of the standard of living of human kind (Lichtenberg, 1998). Sustainable agriculture or development is a pattern of resource use that results in a non-declining potential standard of living over time. The system has the capacity to provide at least as much of a livelihood in the future as it does in the present. Living standard is defined in terms of human consumption, the use of goods and services. Consumption takes the form of use of natural resources as inputs in production of consumer goods and services; and in other cases is more direct as in the enjoyment of scenic amenities and recreational opportunities. Human consumption produces by-products and waste, which are discharged on land, water and into the air, wherein they may be degraded.

Humans consume a mix of goods, which changes over time. Evaluating changes in a society's potential standard of living over time involves the comparison of different mixes of goods and services. Thus evaluating agricultural sustainability requires an index of production of productivity. Ehui and Spencer (1990) suggest that total factor productivity adjusted for changes in the quality of the resource base is an appropriate measure for sustainability. The adjustment made to TFP is inclusion of depreciation charge for changes in the stock of nutrients in the soil valued at the net marginal resource rent. If there was a physical change in the resource, this should equal the net natural increment due to growth less erosion. It is important to understand the system of property rights under which resources are exploited because it affects the way depreciation can be accounted for as well influenced. For example, under open access, resources do not produce rent, so ignoring depreciation is correct because under such a regime no agent stands to benefit from conservation effort in the future. Under unclear property rights, depreciation is either not altogether fully factored or there is a tendency to undervalue resources. In communal areas, property rights are secure enough to allow for certain investments such as conservation measures (Place and Hazell, 1993; Besley, 1995; Gavian and Fafchamps, 1996) with more secure rights really being important in allowing farmers access to capital markets to enable farmers

to undertake larger-scale investments (Feder and Onchan, 1987). Lichtenberg argues that in these circumstances soil erosion is modest, with the costs due to soil erosion being in the order of 1.5 percent of GDP for Mali, for example (observed by Bishop and Allen (1989) as cited by Lichtenberg, 1989) such that if depreciation in soil quality and quantity is not accounted for in measures of productivity this does not contribute to a significant bias in the resultant measure of sustainability.

The challenge faced by decision makers is how to feed an increasing population without irreparably damaging the natural resource base on which agricultural production depends. New technologies must be developed which not only increase food production but also maintain ecological stability and preserve the resource base, i.e. such technologies must be both economically viable and sustainable. Research should be planned and conducted with a sustainability perspective. There is little guidance in the literature, however, as to what practical methods are to be used for measuring sustainability and economic viability of production systems.

## CHAPTER 3

### TECHNICAL ASPECTS OF THE IN-FIELD RAINWATER HARVESTING SYSTEM

#### 3.1 Introduction

Water harvesting is a very broad concept with its roots in agricultural and domestic use. Irrespective of the use, four components are present:

- i) Source from which water is to be harvested, normally linked to a catchment area that differs in dimension depending on the use.
- ii) Infrastructure whereby the water can be collected, *viz.* channels, gutters etc.
- iii) A medium to store the water, *viz.* tanks, soil, dams etc.
- iv) Management of the stored water, which deals with the biophysical and socio-economical aspects.

A wide variety of water harvesting techniques for many different applications are known (FAO, 1993). Production uses include the provision of domestic and stock water, concentrations of runoff for fodder and crop production. Traditional crop production rainwater harvesting methods are ecotope specific and adapted to topography, climate and physical characteristics of the soils. An ecotope can be defined as an area in which the natural recourses (climate, topography and soil) that influence yield are reasonably homogeneous (MacVicar *et al.*, 1974). For example, on sandy soils trenches are most commonly used. Organic matter is also mixed deep into the profile to improve water and nutrient retention. Barry and Sonou (2003) reported that gravel soils in West Africa are compact, hard and infiltration is limited and tillage is difficult. Zai - ridges in the form of squares or honeycombs, and stone lines and bands are commonly used in these soils to overcome the restrictions. Clay soils on the other hand are particularly sensitive to water erosion through runoff created by high intensity rain events and low infiltration rates.

Hensley *et al.* (2000) proposed a water conservation technique that combines the advantages of water harvesting, no-till and basin tillage to stop runoff completely on

high clay soils. This technique is called the in-field rainwater harvesting technique (*IRWH*). Water conserved this way explained the significant increase in crop yields obtained with the *IRWH* technique in comparison to the conventional (ploughing) method (*CON*).

Although significantly higher crop yields were obtained with the new *IRWH* technique, it was realized that the full agronomic potential was not yet obtained. Evaporation dominates the hydrological cycle and measures such as mulches could be used to control evaporation and also siltation of the basins. Three objectives were formulated and thoroughly discussed in a WRC report (Botha *et al.*, 2003):

- To evaluate, for small plots on clay soils in semi-arid areas, different water conservation crop production techniques, which will enhance rainfall, use efficiency (PUE), promote food security, and ensure sustainable productivity.
- To develop the capacity, as technical assistants in this research field of 3 previously disadvantaged young people.
- To transfer the technology as effectively as possible by means of demonstration plots and information days to, (a) Department of Agriculture officials (especially those of the FSRE and Extension section), (b) the owners of small areas of land, and (c) to those who have access to communal land.

The aim of this chapter is to review some of the important agronomic and conservation aspects of the in-field rainwater harvesting technique. More information can be obtained in the WRC report (Botha *et al.*, 2003).

### **3.2 Nature of in-field rainwater harvesting (*IRWH*)**

A diagrammatic representation of the surface layout of the *IRWH* system is presented in Figure 3.1. Two distinct areas can be seen from the diagram, viz. a two-meter catchment area or runoff strip and a one-meter basin or collection area. The case of a 2:1 surface ratio is based on field experience with crops in a semi-arid environment. Maize and sunflower are planted in tramlines (1 meter wide) along the basins as indicated in the diagram. The tramline planting method is almost similar to standard maize practices used in the eastern Free State region. Although the surface area ratio

was kept constant during the study, it will probably decrease with an increase of the annual rainfall. However, it should be pointed out that the surface ratio needs to be researched before it can be recommended for full-scale application in other regions than was tested.

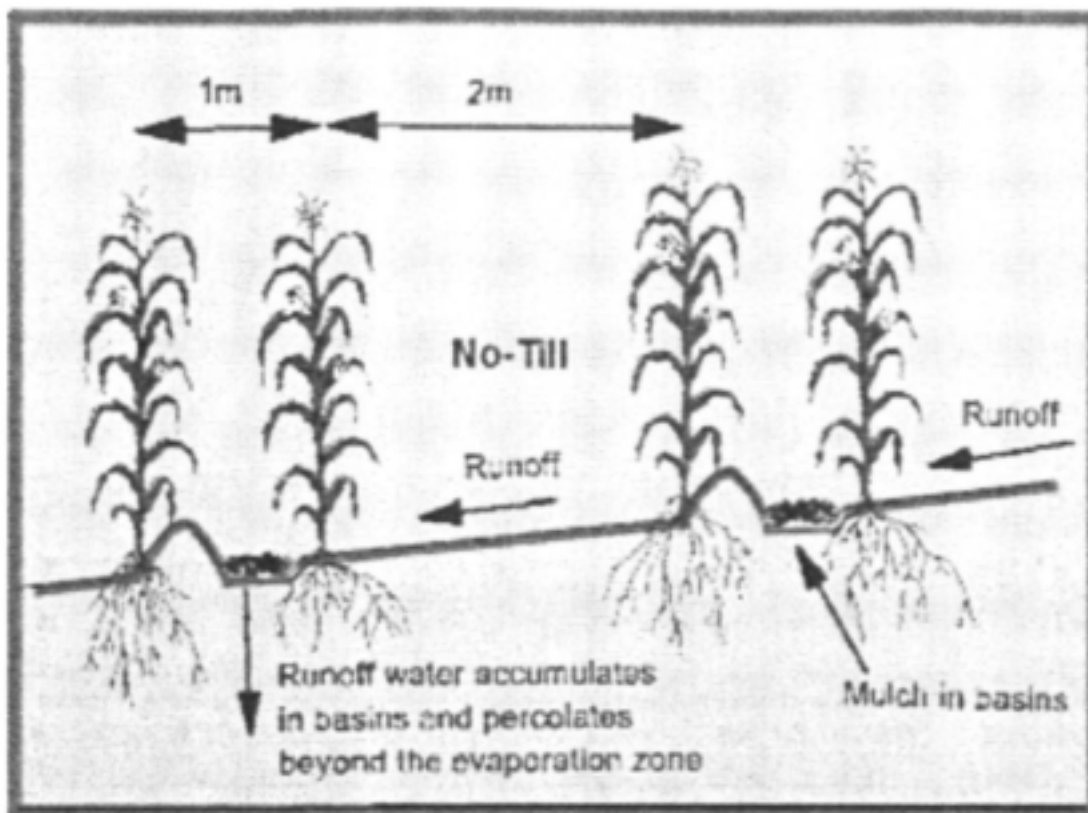


FIGURE 3.1:A DIAGRAMMATIC REPRESENTATION OF THE IN-FIELD RAINWATER HARVESTING TECHNIQUE (AFTER BOTHA *ET AL.*, 2003)

The volume of the basins together with the infiltration rate of the soil determines the surface storage capacity of the basins. The capacity of the basin must be able to hold the runoff from the biggest rainstorm. The user must be aware that the capacity might change with time depending on the amount of sediment that accumulates in the basins. Runoff-sedimentation experiments at Glen revealed that mulches on the runoff area and in the basin could significantly influence the lifespan of the basins and hence frequency of maintenance of the basins. Estimates showed that the basins would take between 12 and 81 years to fill up if no sediment is removed. The filling period depends on the type of mulch on the runoff area and in the basins. Mulch on the runoff area restricts sediment movement depending on the mulch type. The mulch types in the basin influence the capacity of the basin to absorb sediment. However, it



should be stated that all the *IRWH*-systems need yearly maintenance, in order to prevent overflowing during heavy rainstorms.

Experience with the clay soils at Glen showed that a 100 mm deep basin is sufficient to prevent overflow. Measures should be taken not to disturb the B-horizon when constructing the basins, because it can influence germination of the seed, especially plants from plant rows in or near the entrance of the basin.

The runoff area is sloped towards the basins to direct the surface water into the basins. Runoff created this way is called in-field runoff, which differs significantly from ex-field runoff that occurs on *CON* prepared fields. In-field runoff can be harnessed positively and used to enhance agronomic and environmental sustainability. It is known that raindrop impact can cause surface compaction and it therefore contributes to the formation of soil crusts, which stimulate in-field runoff. No-till is practised on the runoff strip to maintain a smooth surface. However, most of the clay soils in semi-arid environments have natural surface crust formation characteristics.

### 3.3 Role and function of the *IRWH* system

#### 3.3.1 Basin area

The role and function of the basin area is threefold, *viz.* to (i) stop ex-field runoff, (ii) maximize infiltration and (iii) store the harvested water in the soil surface beneath the basin.

The stoppage of ex-field runoff is a very important characteristic, which directly explains yield advantages obtained from *IRWH* systems in comparison to *CON*. Ex-field runoff is one of the major processes responsible for unproductive water losses in agriculture. Various short- and long-term studies on mono-crop maize, estimates that these losses can vary between 8 and 24 percent of the total annual rainfall, depending on rainfall intensity, soil characteristics and topography (Haylett, 1960; Du Plessis and Mostert, 1965; Bennie *et al.*, 1988). The basin area of the *IRWH* system acts as a surface storage medium where the "loss" can be converted into a "gain". The water is temporally stored in the basin until the infiltration process is completed. The infiltration rate depends on the soil surface conditions of the basin as well as the

internal drainage characteristics of the soil profile. A general rule is that the infiltration process should not last longer than 24 hours. Free water in the basin after the threshold period, is an indication of drainage problems that can lead to severe crop damages induced by water logging or oxygen deficient conditions. For example, the final infiltration rate of the Bonheim soil type at Glen is  $6 \text{ mm hr}^{-1}$ . Applying this to the threshold time of 24 hours reveals that rain events more than 144 mm can induce waterlogging conditions, although rain events of such a nature are highly unlikely. Mulch in the basins can also improve the surface structure of the soil, which will improve infiltration in the long run.

The rooting zone below the basin area is an important water storage medium. Water stored here is close to the roots of the crop due to the tramline planting method. The availability of the water depends on several soil and crop properties such as soil texture, structure, organic matter content, rooting density, rooting depth, etc. (Bennie, *et al.*, 1988; Van Antwerpen, 1988; Van Rensburg, 1988). Plant available water (PAW) is defined as the difference between the drained upper limit (DUL) and the lower limit (LL) (Ratliff *et al.*, 1983).

$$PAW = DUL - LL \quad (3.1)$$

The procedure for the determination of PAW is fully described in Chapter 2 of the WRC report (Botha *et al.*, 2003). DUL and LL are 456 and 240 mm respectively for sunflower produced on the Glen/Bonheim ecotope with a potential rooting depth of 1 200 mm. Simple calculations indicate a profile storage capacity of 216 mm or  $2160 \text{ m}^3 \text{ ha}^{-1}$ . Seeing that the basin zone comprises a third of the land, the storage capacity is  $720 \text{ m}^3$ . Frequent refilling of this zone is one of the major driving forces of rainwater harvesting. Rainfall events that create wetting fronts, which penetrate the soil deeper than 100 mm, contribute directly to higher transportation rates and lower evaporation rates. Additionally, the canopy of the crop also partially protects the stored water against evaporation through shading.

### 3.3.2 Runoff area

The runoff area has a dual role and function within the *IRWH* system. Firstly, it is designed to promote in-field runoff and secondly to act as a storage medium for water.

In-field runoff differs widely from ex-field runoff in their mechanism of producing runoff water. In-field refers to the transportation of water over a short distance of 2 m, while ex-field runoff occurs over an area of much greater size. Hensley *et al.* (2000) started with preliminary trials to investigate in-field runoff. They measured in-field runoff from a 2 m untilled runoff strips located on the Glen/Bonheim and Glen/Swartland ecotopes for a short period. They found in-field runoff to be 30 and 35 percent of the mean annual rainfall, respectively. This initial study was expanded to include mulch treatments, viz. stone (60 % surface coverage) and organic mulches (maize residue covering 60 % of soil surface) (Botha *et al.*, 2003). Results from this three-year experiment indicated that the average in-field runoff from the bare plots amounts to 43 and 39 percent of the annual rainfall for the Glen/Bonheim and Glen/Swartland ecotopes, respectively. Runoff from the runoff plots covered with stones amounts to 25 and 20 percent, respectively and on the plots covered with organic mulch amounts to 6 and 4 percent, respectively (Botha *et al.*, 2003). This is a clear indication that mulch type on the runoff area influences runoff on the *IRWH* plots. Long-term predictions revealed that organic mulch, stone and bare treatments have an 80 percent probability of harvesting 22, 90 and 156 mm, respectively, rainwater into the storage basins every year. On the other hand, the predictions for ex-field runoff from the *CON* treatments indicate a loss of 40 mm annually (Botha *et al.*, 2003).

Due to the 2:1 surface ratio of the system, the soil below the runoff area can store double the amount of water than in the basin compartment. Water stored in this compartment often reduced the risk of developing severe water stress during dry spells in the reproductive growth stage of the crop. However, this compartment is also more exposed to evaporation due to (i) less shading and (ii) shallower wetting fronts – a portion of the rain will be transferred to the basin through in-field runoff.

Balancing in-field runoff (or infiltration) with evaporation in semi-arid environments is the real art of *IRWH*.

### 3.4 On-station demonstration of water conservation through *IRWH*

#### 3.4.1 *IRWH* versus *CON*

For the illustration of the water conservation abilities of the *IRWH* system, three treatments of the bean-maize crop rotation experiment (Block C) were selected (Botha *et al.*, 2003). The treatments were: *CON*, *IRWH* with organic mulch in the basin area with a bare runoff area (*ObBr*) and stones in the basin as well as on the runoff area (*SbSr*). Mulch coverage was in all cases 60 percent of the surface area.

**Fallow period:** Application of water conservation measures during the fallow period is an important strategy to reduce production risk of crops. Matthews and Army (1960) developed a simple indicator for expressing the efficiency of such measures, *viz.* Rainfall storage efficiency (RSE):

$$RSE = \frac{\theta_{p(n)} - \theta_{h(n-1)}}{P_f} * 100 \text{ (\%)} \quad (3.2)$$

where:

- $\theta_{p(n)}$  = root zone water content at planting of the current crop (mm)
- $\theta_{h(n-1)}$  = root zone water content at harvesting of the previous crop (mm)
- $P_f$  = rainfall during the fallow season (mm)

RSE describes the ability of the soil to store water in the soil profile during the fallow season.

RSE calculations for the *CON*, *ObBr* and *SbSr* treatments revealed that the rainfall storage efficiency for the 00/01 fallow period was poor (*CON* = 12 %; *ObBr* = - 4 %; *SbSr* = - 8 %) in comparison to the 01/02 season (*CON* = 24 %; *ObBr* = 40 %; *SbSr* = 39 %). This poor efficiency was obtained despite the mulch protection that the two *IRWH* treatments experienced. Hoffmann (1997) estimated that mulch loses its water conservation advantage when drying cycles exceed 15 – 20 days under semi-arid

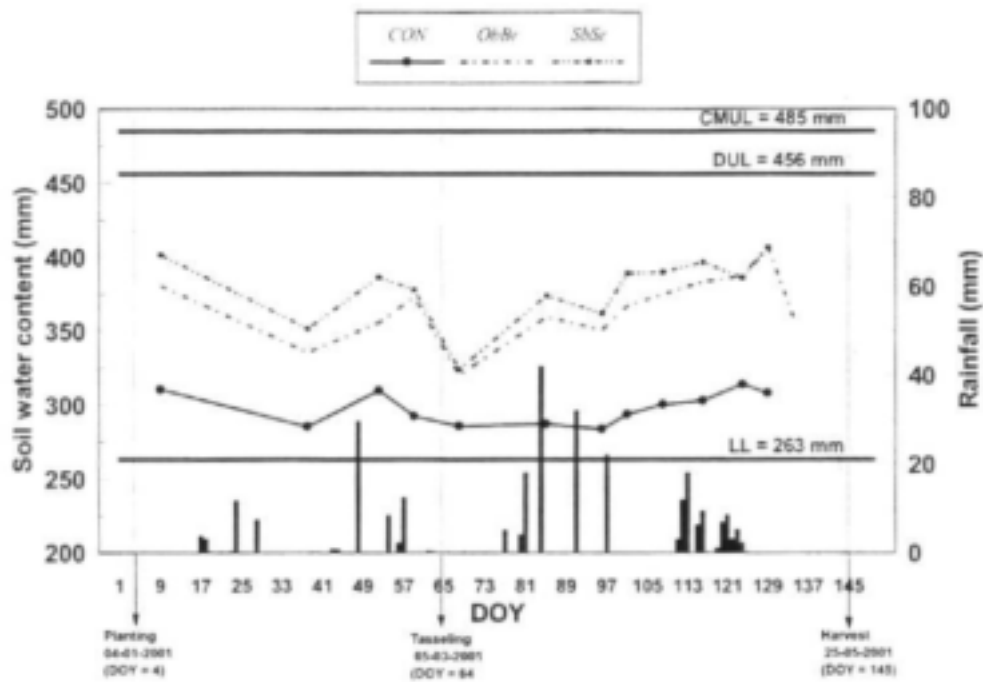
conditions. An analysis of the climatic conditions shows that the 00/01 fallow period was relatively dry in comparison to the 01/02 season. The rainfall of the 00/01 and 01/02 fallow period were 234 and 360 mm, respectively. The dry conditions of the 00/01 season were aggravated as indicated by the high reference evaporation of 1143 mm versus the 863 mm of the 01/02 season.

From the RSE results of the 01/02 season, it is clear that both *IRWH* treatments were more efficient than *CON* at storing rainwater in the soil profile during the fallow period. This phenomenon can be attributed to the fact that (i) ex-field runoff has been stopped and (ii) that the mulch restricted evaporation from the soil in this particular season.

**Growing season:** In order to analyze the water component during the growing season some background information on certain water related aspects needs to be explained viz. LL, DUL and the crop modified upper limit (CMUL). Hensley *et al.* (2000) determined all these limits for the Glen/Bonheim ecotope. The LL refers to conditions where the crop experiences severe water stress because the profile is depleted or dry. DUL refers to conditions where all the free water had drained from the rooting zone through gravitation forces. In the presence of a crop CMUL is used instead of DUL because it takes into account that crops can transpire while free water is present, providing that oxygen is not restricted. These limits are depicted in Figure 3.2 against the background of the soil water content measured during the 00/01 and 01/02 growing seasons.

Although the water content of both the *IRWH* treatments rises slightly above CMUL limit at the beginning of the 01/02 season, drainage was taken as zero for both seasons. It was assumed that the drained water would become available through capillary forces later in the season. Ex-field runoff for both the *IRWH* treatments was zero, while the *CON* experienced runoff of 16 and 24 mm for the 00/01 and 01/02 seasons, respectively. Evapotranspiration was calculated using the water balance equation for dry land crop production.

A)



B)

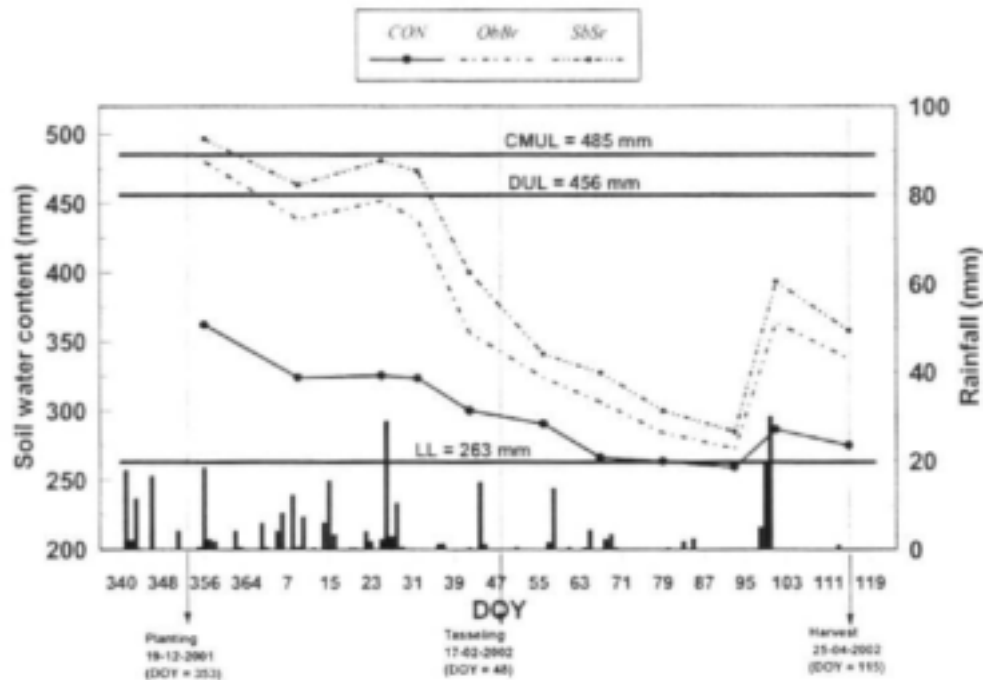


FIGURE 3.2: CHANGES IN THE SOIL WATER CONTENT OF THE ROOT ZONE (0 – 1200 MM) FOR MAIZE PLANTED IN A CROP ROTATION SYSTEM WITH BEANS DURING THE (A) 2000/01 AND (B) 2001/02 GROWING SEASONS ON THE GLEN/BONHEIM – ONRUS ECOTOPE WITH THREE CULTIVATION TREATMENTS.

The water content depicted in Figure 3.2 is the average for the plot measured with a CPN neutron water meter at the middle of the basin area and middle of the runoff area. Both graphs show clearly that the two *IRWH* treatments have induced a significant advantage in plant available water above the *CON* at the start of the growing season. Water conserved this way contributes directly to reach the optimum yield potential of a crop. The optimum yield potential is related to the vegetative growth stage (from planting until prior to tasseling), while the actual yield depends mainly on crop conditions from tasseling until the physiological ripe growth stage (reproductive period). When the water supply through rainfall is not enough to meet the demand of the crop, stored water in the soil profile will be used to balance the deficit. If the water stored in the soil profile only partially offset the deficit, then mild water stress will set in as was the case during the vegetative growth phase of the *CON* maize treatment during both seasons. At the end of tasseling, the two *IRWH* treatments had considerably more water available for the crop in comparison to the *CON*. Timely rains during the reproductive growth period of the 00/01 season refilled the soil profile of both *IRWH* treatments. The *CON* treatment did not show significant increases in water content as would be expected. This is a clear demonstration of the water conservation ability of the *IRWH* systems. Crop conditions during the reproductive period of the 01/02 season were harsh in comparison to the 00/01 season. The rainfall was 86 mm versus 199 mm for the 00/01 growing season. Fortunately, the stored water helped both *IRWH* treatments until a series of rain events, after day 95 after planting, refilled the soil profile again.

The grain yields of both *IRWH* treatments were significantly higher than the *CON* during the 00/01 and 01/02 season. The *CON* yields were 1489 and 1521 kg ha<sup>-1</sup>, for the 00/01 and 01/02 seasons, respectively, while the average yield of the *IRWH* treatments was 3132 and 3668 kg ha<sup>-1</sup>, respectively. The water use efficiency, expressed in terms of the grain yield per mm rain received, of the two *IRWH* treatments in Figure 3.2 were double that of the *CON*, at 2.5 and 2.7 kg grain ha<sup>-1</sup> mm<sup>-1</sup> for the 00/01 and 01/02 seasons, respectively.

### 3.4.2 Effect of mulching on infiltration versus yield relationship

For this discussion, three treatments from block A and B (Botha *et al.*, 2003) were selected, viz. *ObBr*, *ObOr* and *ObSr*. All treatments have organic mulch in the basins, but differ in mulch type placed on the runoff area.

Mulch has a significant influence on the surface redistribution of rain, mainly due to its effect on the infiltration process. The impact of mulch (organic and stone mulch with a 60 percent surface coverage vs. bare) on infiltration has been characterized by:

$$I_{RA} = P - IR \quad (3.3)$$

$$I_{BA} = P + IR \quad (3.4)$$

where:

P = precipitation (mm)

IR = in-field runoff is determined by empirically determined equations (Botha *et al.*, 2003)

$I_{RA}$  = infiltration on the runoff area (mm)

$I_{BA}$  = infiltration in the basin area (mm)

The infiltration ratio, viz. infiltration of BA to the infiltration of the RA, was calculated for each rain event. The mean infiltration ratio for the growing season was regressed using a third order polynomial function for maize and sunflower relative yield irrespective of season. The corresponding curve is presented in Figure 3.3. The mean yields for the three-year period for maize were respectively 3281, 3325 and 3098 kg ha<sup>-1</sup> for *ObBr*, *ObOr* and *ObSr* and for sunflower yields were 1928, 2227 and 2396 kg ha<sup>-1</sup>, respectively. The infiltration ratio estimated for the growing season was regressed using a third order polynomial function with corresponding relative seed yield of maize and sunflower irrespective of season. Yields were expressed as a fraction of the maximum yield obtained per season. The corresponding curve (Equation 3.5) is presented in Figure 3.3.



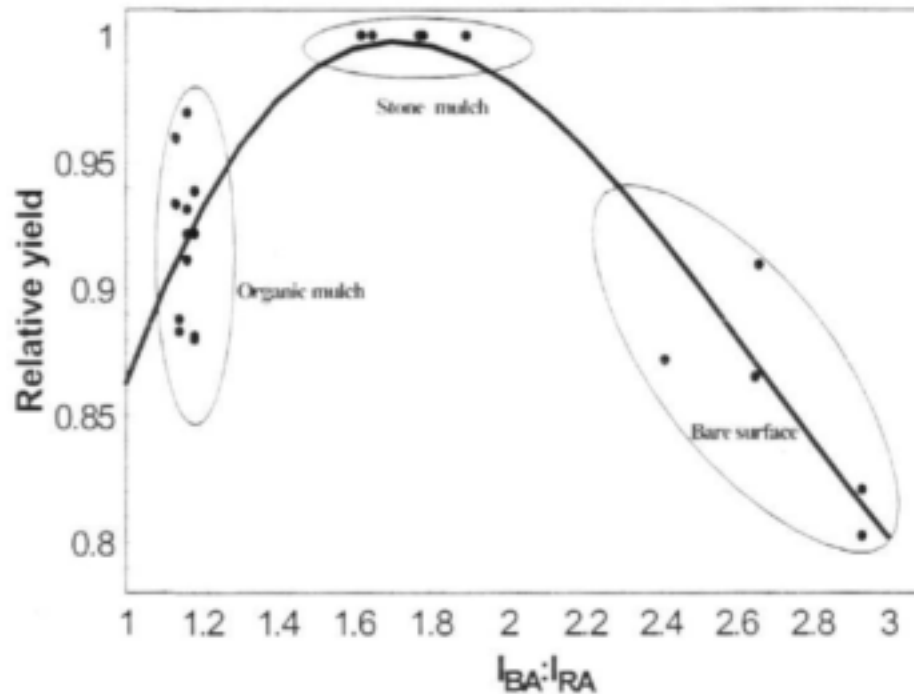
$$Y_{rel} = -0.0004788 + 1.3842506x - 0.5953291x^2 + 0.07436617x^3 \quad (3.5)$$

where:

$Y_{rel}$  = relative crop yield

$x$  = infiltration ratio on basin area: infiltration ratio on runoff area

FIGURE 3.3: RELATIONSHIP BETWEEN THE INFILTRATION RATIO ( $I_{BA}$ :  $I_{RA}$ )



(EQUATIONS 3.3 AND (3.4) AND RELATIVE CROP YIELD (MAIZE AND SUNFLOWER) AS AFFECTED BY MULCH COMBINATIONS; GLEN/BONHEIM ECOTOPE FOR THE THREE GROWING SEASONS 99/00, 00/01 AND 01/02

From the graph it is evident that organic mulch induced the lowest potential for water harvesting, but still produced a slightly higher seed yield than bare runoff conditions. Organic mulch decrease the evaporation rate, hence delaying the onset of the drying cycle period, which gives the crop a better change to extract water from the top 100 mm soil layer. Rain events that infiltrate the soil beyond the evaporation zone contribute directly to transpiration, which induces higher yields.

Stone mulch on the other hand induced the highest yield, but it did not induce the highest in-field runoff. The infiltration ratio varies between 1.6 and 1.9, which seems to be an ideal situation. An optimum balance between in-field rainwater harvesting and the restriction of evaporation was obtained.

### 3.5 Agronomic and environmental sustainability

The dominance of evaporation above the water processes during the fallow period was discussed in Section 3.4.1. It was clear that *IRWH* treatments were superior to the *CON* in conserving rainwater during the fallow period. However, when comparing various mulch treatments (*ObBr*, *ObOr* and *ObSr*) of the *IRWH* system with each other, it seems that mulch on the runoff area (*ObOr* and *ObSr*) were not better than the case in which the runoff area was left bare in restricting evaporation during the fallow period (in two of the three years) due to the extended length of the drying cycle. The average RSE (for the fallow period following harvesting of maize) was 26, 23 and 19 percent for *ObBr*, *ObOr* and *ObSr*, respectively and for the sunflower fallow period it was 28, 26 and 29 percent, respectively.

Mulch on the runoff area did not have a consistent effect on evapotranspiration (ET) during the three years of experimentation. The mean ET values for maize were 310, 284 and 296 mm for *ObBr*, *ObOr* and *ObSr*, respectively, while that of sunflower amounts to 313, 308 and 317 mm, respectively. The seed yield of *ObSr* was significantly higher than *ObBr* and *ObOr* in two of the three years for both crops, indicating that more water was directed towards transpiration than in the other two treatments. Water use efficiency (WUE) based on ET showed that organic mulch on the runoff area is more efficient in converting rainwater into seed than the bare treatment for both crops. The highest efficiency was obtained where stones were placed on the runoff area, irrespective of the crop. The mean WUE for maize was 10.0, 11.5 and 12.3 kg ha<sup>-1</sup> mm<sup>-1</sup> for *ObBr*, *ObOr* and *ObSr*, respectively. Sunflower amounts to 6.3, 7.4 and 7.6 kg ha<sup>-1</sup> mm<sup>-1</sup>, respectively.

## CHAPTER 4

### THE SOCIAL ACCEPTABILITY OF IN-FIELD RAINWATER HARVESTING (IRWH) CROP PRODUCTION TECHNIQUES

#### 4.1 Introduction and background

Irrigation agriculture is currently the biggest consumer of South Africa's scarce water resources. Savings on irrigation water through efficient farming practices will free precious water supplies for residential and industrial consumption. Assisting small-scale farmers to optimally utilise the water resources at their disposal is therefore of critical importance. The mission of the Department of Agriculture in the Free State is to create a better life for the people in the Free State through self-reliance and utilisation of agriculture and other resources within a sustainable living environment. Regarding smallholder farmers, the objective is to enable households to produce adequate quantities of food for own consumption, and possibly surpluses to sell and generate income.

In South Africa, as is the case in other developing countries, levels and incidence of poverty tend to be disproportionately high among the rural population. The poorest of the rural households mostly live in semi-arid and arid areas and rely on rain fed agriculture for their livelihoods, often farming on marginal and fragile soils. In dry areas lack of adequate water poses a major constrain to increasing agricultural production and attempts to develop other economic activities. However, many agricultural scientists agree that with the use of appropriate production techniques, especially those that encourage conservation of water and soil resources, it is possible to increase and sustain agricultural output in semi-arid areas (Hatibu, 2002). In particular, various water conservation techniques, among them rainwater harvesting, are seen as having the potential for increasing available water for successful crop production in semi-arid areas. While in many cases the biophysical properties of such techniques are well understood and their ability to increase yield proven, the lack of its widespread use remains unknown.

Some of the factors that have been hypothesised to be the cause of low levels of application of water conservation technologies by farmers, include the lack of information on the economic viability of the techniques, lack of understanding of the socio-economic impacts of applying the techniques and lack of knowledge among agricultural extension officers. Processes such as runoff, infiltration, drainage, evaporation and transpiration are by nature very complex to analyse and understand. These processes play an essential role in any crop production system. Farmers that are able to conceptualise the practical impact of each of these processes on crop yield, tend to adopt new sustainable technologies more readily than those who do not understand it. Consequently, the packaging and communication of information to communal farmers in rural areas holds the key to enhance the socio-economic acceptance of a particular technique.

This chapter discusses the results of social acceptability assessments of infield rainwater harvesting among smallholder farmers in the Thaba Nchu area. The study employed participatory research techniques and other standard research techniques such as questionnaire surveys to generate the data analysed in the sections that follow. The rest of the chapter is structured as follows: section 4. 2 describes the technique employed to select villages included in the study. A structured and purposive sample was created with the aim of selecting villages that are representative of the study area and capture the area's diversity in terms of demographics and economic activities. Sections 4. 3 discusses some conceptual issues and the choice of variables used in attempting to assess social acceptability. Detailed descriptions of the study villages and the results of the first set of PRA exercises carried out with farmers prior to implementation of on-farm field trials of IRWH techniques are outlined in section 4. 4. Section 4. 5 reports on the process that was undertaken to facilitate and manage field trials of IRWH techniques in the villages participating in the study, while sections 4.6 and 4.7 report on the procedures and results of the questionnaire survey. Section 4. 8 concludes this chapter.

## **4.2 Selecting villages for inclusion in the water conservation study**

Discussions with extension officers during a reconnaissance visit to the study area revealed that cattle, horses, sheep, pigs and poultry are the most common types of livestock produced in Thaba Nchu. Cattle and horses are raised mainly to supply draft power, traction for animal drawn carts used for transport locally, and for sale; while small stock are raised mainly to supply meat for households' own consumption.

There are 42 villages in the whole of Thaba Nchu. The villages are diverse in terms of economic activity, demographic structure and location. Although mixed farming (livestock and crop production) is practiced in all villages, farmers in the southern part of Thaba Nchu were reported to be more successful in producing livestock, as indicated by a higher off-take rate for the market.

The villages in the region also differ in the degree to which villagers are able to organise into groups to pursue collective interests. For example, in some of the villages households have organised themselves into livestock production, horticulture and field crops producer groups, and are pursuing efforts to attract outside financial and material resources (mostly from the Community Projects Fund – Support Programme (CPF-SP) administered by the provincial Department of Agriculture) to boost production. However, some of the villages were described by extension officers as lacking motivation to engage in self-help projects, and others seemed not to be cohesive enough to enable members to come together in pursuit of common goals. Discussions with the agricultural extension officers also revealed that the Thaba Nchu agricultural ward is divided into three zones, the northern, central and southern zones, for purposes of assigning agricultural extension officers.

The objective of the study is to assess the economic viability and social acceptability of water harvesting techniques whose intended end users are farmers working under wide range of conditions. It is thus important that the trial and assessment of new agricultural practices and techniques be carried out with a full understanding of the socio-economic and agro climatic conditions under which target farmers operate.

With this knowledge of the study area, three villages were initially selected for the study. Talla in the north, Paradys in the central zone and Yoxford in the south were chosen. Other than just the geographic locations, additional relevant information that was known about the villages through discussions with agricultural extension officers revealed that Talla was a relatively poor community, without community development projects taking place at the time of the study. This was attributed to the general lack of initiative among the residents and the lack of cooperation among community members making collective action difficult to attain. On the other hand Paradys already had a group of farmers who had started farming collectively producing sunflower and wheat for the market. Yoxford was identified as successful at producing livestock, and that a large proportion of the households in the village were female headed. However, as the study developed, a fourth village, Feloané, was included upon a request by farmers from the village that they were interested in being involved in the IRWH study.

Once the study sites were identified, the next phase of the research was to plan meetings with the communities and the community leaders and to discuss the constraints and opportunities for increasing agricultural production. The participatory research techniques (PRA and PAR) were deemed as the best vehicle through which to communicate research ideas with the farmers in the selected study sites (See chapter 2).

### **4.3 Some notes on conceptualisation and measurement**

Babbie and Mouton (2001, p111) state "conceptualisation is the process through which it is specified what is meant when particular terms are used." The product of the conceptualisation process is the specification of one or more *indicators* of what is in the mind, indicating the presence or absence of the concept that is being studied. To measure one's age without knowing the person's date of birth is relatively easy. All that is needed is a number of say 15 indicators of age. If there is agreement on these indicators, one could focus on them, and you would probably agree on the answer provided. Many social scientific variables have pretty obvious, straightforward measures, for example gender, age, and *etcetera*. Sometimes, however, there is no single indicator that will provide the measurement of a variable. Many concepts, as is the case with social acceptability, are not directly observable and are subject to varying interpretations – each with several possible indicators. In these cases, the

researcher will have to make several observations for a given variable. He/she can then combine the several pieces of information that have been collected to develop a composite measurement of the variable in question. As there is no standardised scale to measure social acceptance, it was necessary to spell out what indicators are going to be used. How can it be measured? What will the indicators be? Are the indicators that have been decided on valid indicators and is the measuring instrument reliable?

For purposes of this part of the project, and within the research design of PAR, the "indicators" of social acceptance is the extent to which the project succeed in enhancing the levels of mobilisation, capacity building, empowerment, human well-being, self-reliance and community participation. In other words, the research outcomes will be to enhance the levels of mobilising and empowering the communities that are part of the project; to increase its capacity building potential; to uplift the level of overall health, economic security and confidence in the people's ability to solve life's problems; and to create conditions conducive to community participation. These outcomes can only be observed as a process that develops over a long period of time and can therefore not be measured within the time limit of this single project.

#### **4.4 Results of the PRA**

A team of six researchers from the University of the Free State and the ARC participated in the PRA/PAR exercises. Two extension workers from the Provincial Department of Agriculture were at hand to join the team at Thaba Nchu. Two weeks prior to undertaking the visit to the study sites, a request to meet with community members was sent out to each village's headman through the agricultural extension officer.

The following sections summarise the results from the meetings held with farmers in the three villages.

#### 4.4.1 Paradys

The village of Paradys covers a total area of 2 109 hectares divided into three land use niches – 1 795 ha for grazing, 274 ha for crop farming and 40 hectares for residential plots. A total of 173 households reside in Paradys.

Paradys is linked to the town of Thaba Nchu 12 kilometres to the south by a good (untarmaced) road. A regular bus service (about 3 times a day) is available between Paradys and Thaba Nchu, and from there travellers can get buses and commuter taxis to other parts of Thaba Nchu, Botshabelo and Bloemfontein.

The soils in the Paradys area have high clay content and are of medium fertility (preliminary analyses by ARC soil scientists). The vegetation here is dominated by grasslands, and typical of semi-arid regions, rainfall is low (less than 600mm per annum) and is unevenly distributed (Botha *et al.*, 2001). Surface water is generally scarce. All of Thaba Nchu (the villages and the town) together with Botshabelo and Bloemfontein constitute the Municipality of Mangaung. Bloemwater, a company that supplies water for the city of Bloemfontein, is also contracted by the Mangaung Municipal Council to supply water for domestic use in Paradys and the other villages in Thaba Nchu. Water is not delivered directly to individual households, but two water points are located at the end of each street. Households have to pre-pay for the units of water that they are going to use.

The meeting at Paradys took place in one of the local church buildings. A member of the local youth group (who is also leader of the group of 50 farmers who decided to pool their land so that they could farm collectively) chaired the meeting. The headman (Mr. Moilwa) provided the opening remarks and did the introductions. About 70 individuals (men and women, and youths), a slight majority of whom were male, attended the meeting. In the opening remarks it was emphasised that the team comprised of researchers from the university and a research institute, and that the objective was to learn about farming practices in the village, and the constraints and opportunities facing farmers as they go about their business. It was important to state from the onset that the research team did not have material or financial resources to



give to the farmers so as not to raise unrealistic expectations about the nature of the benefits that could be derived from interacting with the team. Sometimes, when farmers think that at the end of a meeting with outsiders, there may be some money or other forms of support to be given out, they may not provide truthful information, choosing instead to project an image of extreme deprivation and helplessness in the hope that it makes them more likely to receive assistance.

Even though it is probably ideal to have groups of 20 or less individuals for group discussions to ensure that all participants have a chance to talk and make contributions, the group discussion was held with one large group. This was because the first meeting was an introductory one, whose main purpose was to acquaint the communities with the research, and for gathering general background information about the villages, which could be used for planning further PRA/PAR and the survey.

During the group meeting researchers sat among and mixed with the farmers to avoid the "them versus us" appearance. Communication between researchers and farmers was made easy because most farmers could comprehend and speak Afrikaans or English fairly well. The researchers asked a broad range of questions, for example, the type of crops that people grew, how they carried out land preparation, arrangements for accessing farm land, and constraints faced by farmers.

Almost all households in the villages have access to farmland, and the average farm size is 1.87 ha (3 morgans), although some farmers "own" up to 3.74 ha (6 morgans) of farmland. In many cases the additional land was acquired through taking over land left behind by former residents who move out of the village and settled in the new urban area of Botshabelo in the early 1980s. Surprisingly though, very few households are currently working their fields (many stopped cropping as long back as 10 years ago). Only three persons (Mr. Jimlongwe, Mr. Mothibi and Mr Lemeon) have continuously farmed their lands. These three are quite successful and each owns at least one tractor and equipment for land preparation and planting. It emerged during the group discussions that these farmers have considerable farming experience and knowledge. All three produced sunflower at a commercial scale.

Since 2000, a group of about 50 individuals have come together to form a cooperative so that they can produce crops together. They pooled their land and requested permission to use some of the unallocated agricultural land in the village. During the 2000/2001 agricultural seasons the group cultivated 18 ha of sunflower. The land on which the group works, belongs to individual members who pooled their plots in favour of group farming. The sunflower was marketed in Tweespruit, which is about 20km south east of Paradys. The group hires a truck to take their produce to the market.

Those who have been involved in crop production in recent years, used a tractor to prepare the land for planting. Some used their own tractors, while those who do not own one could hire one from the Provincial Department of Agriculture offices in Thaba Nchu. The Department runs a scheme in which it provides tractors (with a driver) for use by farmers if they can provide their own fuel and cover minor maintenance cost during their use of the tractor. Other husbandry practises such as planting and weeding are done by hand.

Besides sunflower, other crops grown by villagers (mostly on their homestead lands) include maize, wheat, potatoes, spinach and pumpkins. Crop yields were reported to fluctuate widely with the quality of the growing season. The other economic activity of significance besides crop production is livestock rearing – cattle, goats, sheep, horses, pigs and poultry. Livestock sales were reported to be the main source of income for many households. Some households have members working off-farm, mainly in manufacturing industries in Thaba Nchu and Botshabelo.

When asked about constraints they face in farming, top of the list was the destruction of the fence (stolen by thieves to be sold in Thaba Nchu) around the agricultural land. This was cited as the major disincentive to any attempts to cultivate the land, for fear of having crops destroyed by livestock. Because all fields are in one location, one perimeter fence is required around the whole area so that everyone's field is protected. It was reported that any effort by one farmer to fence off his/her individual plot would not be taken too kindly by the rest of the village. Measures such as letting in cattle to destroy the crop at night and theft of either the crop or the fence were said to be the ways through which "individualistic" actions get "punished". Farmers argued that

they would need some outside assistance (e.g., Community Projects Fund (CPF) of the Provincial Department of Agriculture) to buy a new fence, because this will require a large financial outlay, yet not having produced crops for many years now, there was no other way they could generate income. When asked how they would make sure that the new fence will not be stolen again, if some how they could get it rebuilt, farmers said they would need to form a village committee who will guard the fence and to ensure that those caught stealing or damaging the fence will be punished. In addition farmers stressed the need for better co-operation between the community and the police in the future. Farmers complained that at present the police are not helping because cases of fence theft reported to them are not fully investigated. Some community members alleged that in some cases when the police were presented with the name of a suspect they turned around and gave away the identity of the person who reported the crime to the suspect. Because of fear of reprisal villagers were afraid to report crimes to the police.

Other constraints faced by farmers include the inadequacy of water for agricultural production, as the rains are generally inadequate and uneven; and the lack of financial resources for the purchase of production inputs such as seed and fertiliser. Many farmers also pointed out that it had been a long time since they were involved in crop farming. If they were to successful growing again, they would need support from agricultural extension workers.

Land in the village is controlled by the Tribal Authority (whose offices are at Thaba Nchu), which in turn delegates the authority to allocate land to the village headman. An application for land has to be submitted to the headman, who in turn takes the application to the Tribal Authority. If there is still some unallocated land in the village, the Tribal Authority can grant permission for the allocation of a residential stand whose site number has a matching plot number for the use of the new household. Every household has the right to graze as many units of livestock as it desires in the village commons. The rights to homestead and agricultural land and to the commons are inheritable. During the meeting some villagers claimed to be without agricultural land even though they were allocated residential land through the normal channels. The headman promised to investigate such cases because each residential stand is supposed to have a corresponding agricultural plot.

#### 4.4.2 Talla

The village of Talla is situated at the northern end of Thaba Nchu, about 30 km from the town of Thaba Nchu. The village is serviced by a network of all-season gravel roads, and there is a regular bus service linking Talla to Thaba Nchu and other villages. There are 112 households living in Talla. The public amenities available in the village include a community hall, which is used for village meetings, and also functions as a pre-school centre. Public water standpipes are located at the end of each street. Here, households can fetch water for domestic consumption by using electronic cards that reflect the units for water that the household has paid for in advance. In Talla, like in the rest of the villages in Thaba Nchu, provision of water for domestic consumption is the responsibility of the Mangaung Municipal Council, who in turn has contracted Bloemwater to deliver this service. Villagers can obtain some of their provisions – foodstuffs, toiletries and non-prescription medicines - from two local shops. There are postal boxes at central location to which the village's mail is delivered and the household has to pay a nominal fee for the use of a mail box. There is no clinic in the village. A mobile clinic services the village and makes its call once a month. Most households have electricity and many others are on a waiting list to get their houses connected. As is the case with water, households have to pay in advance for electricity.

Talla is situated in a semi-arid region with rainfall of about 500mm unevenly distributed over the rainfall season. The soils are clay, which makes them potentially suitable for water harvesting (the other requirement is that the soil depth be at least 750mm). The vegetation in the area is largely grassland with a few trees and shrubs scattered around.

The meeting at Talla was held at the headman's compound. When the team arrived in the village the villagers had not yet assembled for the meeting even though the team arrived at the appointed time. The headman pointed out that in the past the people had bad experiences with people who promise to come to meet the villagers but never to show up, and as a result villagers have become reluctant to assemble for meetings before the visitors show up in the village. When they saw the research teams' vehicle parked at the headman's homestead, some of the villagers started arriving for the

meeting while the headman set out to inform more people of the arrival of the researchers. In the end about 30 people (men, women and youths) came to the meeting. The women and the youths (18-30 years) outnumbered the men. The headman introduced the research team and explained the purpose of the team's visit. The team's opening statement outlined the objective as being to learn about agriculture in the area, the constraints and opportunities facing farmers, and to work with locals to explore potential solutions to some of the problems encountered by farmers.

Again the meeting was held with one group. This group being smaller in size than the one at Paradys, was less concerned about some participants not having the opportunity to make their contributions. However, it was still important to encourage everyone to participate, especially the women. The researchers asked farmers about their agricultural activities and used a checklist of questions to steer the discussions. At first some of the participants, particularly the youth, were quite argumentative, insisting that they would have been much happier if the team had employment creation projects in mind, since there was high unemployment among their ranks. They argued that since young people lacked direct access to land, they did not see how agricultural improvement would help them specifically. In the course of the discussion and as it became clear that vibrant agriculture in the area could lead to spin-offs in rural agro-industries and agribusiness, the youths started showing some interest in the proceedings of the meeting.

Farmers in Talla produce livestock – cattle, sheep, goats, pigs and horses, and crops – mostly vegetable crops (spinach, pumpkin, potatoes and cabbage) grown on homestead land (backyard gardens). Field crop production in the village stopped several years ago and not even a single farmer reported to be currently involved in crop production. Livestock sales, state provided pension income for the elderly and state provided child support (child grant) for children under the age of seven years were cited as the major sources of income for village households. Other households receive remittances from members working in off-farm employment.

Like in Paradys, lack of a fence around the village's agricultural land was said to be the major reason why farmers were not able to engage in crop production. Without a

fence a lot of labour would have to be expended to keep livestock from straying into the fields during the cropping season, and crops would be likely destroyed during the night when there won't be anyone on guard. The lack of natural fencing material (trees and tree branches) means that farmers need to purchase barbed wire and metal poles for the fence and this can be very expensive. Villagers complained that without having produced crops for many years and without jobs, they lack the financial resources required for the purchase of fencing materials. They would like the government (provincial or national) to assist them to put up a fence. The villagers suggested that once a new fence was erected, they would form a committee for guarding the fence and to come up with measures to deter its destruction.

Lack of water was also said to be hampering crop and animal production in the village. The villagers had a borehole and a windmill constructed at the edge of the village to provide water for a community garden and for watering livestock. Water is pumped into a tank and from there it is channel to the garden via a small canal while another pipe channels some of the water to a drinking trough for livestock. The villagers would like to see more effort put into the development of water sources for agricultural purposes.

Inadequate financial resources for the purchase of production inputs (seed, fertiliser, and pesticides) was cited a constraint to crop production. There is also the lack of money to buy fuel to allow the farmers to use the government provided tractors. Land preparation is mostly done using tractors since most households do not possess animal-drawn farm equipment. Farmers were aware of the possibility of obtaining loans from a number of sources (e.g., the Landbank), but felt that without a fence around their fields, and lacking the skills to farm at a commercial level, they would not be able to effectively utilise the loans.

Land in the village was said to be controlled by the Tribal Authority (whose offices are at Thaba Nchu), which in turn delegates the authority to allocate land to the village headman. An applicant has to pay a fee of R230 upon which he/she is allocated a residential stand (with an assigned site number) and an agricultural plot with a matching plot number. Every household has the right to graze as many units of

livestock as it desires in the village commons. The rights to homestead and agricultural land and to the commons are inheritable.

#### **4.4.3 Yoxford**

Yoxford is located 30 kilometres south of the town of Thaba Nchu. It is linked to Thaba Nchu by an all season gravel road and regular bus service provides the locals with transport to town where they can catch buses and commuter taxis to various destinations around the Province. There are 86 households in the village. Public amenities in the village include a primary school, a tuckshop and a small community hall. For health services, the village depends on a mobile clinic which comes around once a month.

The meeting at Yoxford was held in the local community hall. A group of about 40 individuals (women, men and youths) attended the meeting, with the men commanding a slight majority. In introductory remarks the researchers pointed out to the farmers that they are not from a funding or donor agency and as such they did not have financial or material resources to give to them. The researchers expressed their interest in exploring together with farmers the nature of the agrisystem in the area, and the constraints and opportunities faced by farmers; and that together they can engage in the search for solutions to some of the problems facing the farming community.

The meeting was held in one group with a member of the village (a representative of the headman) occupying the "chairman's" position. A member of the research team facilitated the discussions with the aid of a checklist of questions to guide the discussion and to ensure that at the end of the meeting the information requirements for the study were met. The meeting lasted for about 3 and half hours. Many of those present had a chance to put across their opinions on the various issues that were discussed and seemed to do so without any hesitation. Through the course of discussions participation by women attending the meeting was encouraged. Although they appeared hesitant at first, as the meeting progressed the women realised that they will be listened to and need not further encouragement to voice their opinions. The youth were also actively involved during the discussion. In fact the representative of the headman who "chaired" the meeting is a member of the local youth group.

The soils in the area are clay, and the vegetation is mainly grasslands with a few scattered shrubs. The rainfall is low (about 500mm per annum) and unevenly distributed. At present livestock rearing is the main agricultural activity in the village as field-crop production stopped several years ago. The types of livestock raised in the area include cattle, sheep, goats, pigs, horses and poultry. For many households in the village, cattle sales are a very important source of income although there were complaints about prices received for stock. Farmers also complained that often the buyer does not pay them promptly.

When farmers used to grow crops in their fields they grew maize, wheat, sunflower, beans and sorghum. At present crop production is limited to backyard gardens (homestead land) and mainly to vegetable crops. There is a community garden where some members of the village have been assigned some individual plots. Here plot owners grow vegetable crops – cabbages, carrots and beetroot – under irrigation. Before the area came under the jurisdiction of the Mangaung Municipal Council, irrigation water was supplied from a borehole powered by a windmill. When Bloemwater started providing water for the village under contract from the Mangaung Municipal Council, they dismantled the borehole and now the same system that supplies water for domestic use supplies water for irrigation. Plot holders are not happy because they have to pay for the water at the same rates as for domestic consumption. Some of the villagers who cannot afford to pay for irrigation water have left their plots lying idle. Villagers were unhappy because they were not consulted when the decision to close down their borehole was made. The borehole had also been used as a source of water for livestock. Bloemwater refused to construct a water pipe to deliver water to drinking troughs for animals, arguing that their responsibility is to provide water for domestic use only and not for agricultural purposes.

At the moment there are limited opportunities for income generation in the village outside agriculture, yet agriculture is not exactly thriving at present. For most households the most reliable source of income is pension income for elderly members of the household.

The lack of fences around the agricultural land was reported to be the main reason why many farmers had stopped growing crops in their fields. Other constraints faced



by farmers include the inadequacy of water for agricultural production, as the rains are generally inadequate and uneven; and the lack of financial resources for the purchase of production inputs such as seed and fertiliser. Many farmers also pointed out that it had been a long time since they were involved in crop farming. If they were to successful growing again, they would need support from agricultural extension workers.

Land in the village is controlled by the Tribal Authority (whose offices are at Thaba Nchu), which in turn delegates the authority to allocate land to the village headman. An applicant for land submits his/her application to the headman who in turn takes it to the chief (Chief Moroka). If there is still some unallocated land in the village, the chief will give his permission for the applicant to be granted land for the establishment of a homestead and for farming as well as the right to use the village commons. The rights to homestead and agricultural land and to the commons are inheritable.

#### **4.5 Selection of farmers for field trials**

Following the first group meetings in villages and the questionnaire survey, another round of PRA meetings were held with farmers in the villages of Paradys, Talla, Yoxford and Feloané to determine the level of interest among farmers to participate in field trials of the water harvesting techniques during the 2001/2002 cropping season. The village of Feloané, located about 13 kilometres northwest of the Thaba Nchu town, was added as a potential site for establishing trials for water harvesting after some members had made representations to the researchers, expressing their interest in participating in the research.

The objective was to set up demonstration plots in each village on which the effect of applying water harvesting can be compared with conventional practice, if there was sufficient interest among farmers to participate in the exercise. The water harvesting trial would be divided into two plots, one managed by the farmers themselves with guidance from the research team, with the researchers managing the other plot.

The aim of the meetings was for researchers and the farmers to plan for the carrying out of the trials – selection of plots where the trials would be located, the selection of

a team of farmers to act as a project committee for purposes of the trial, the choice of crop for each village for the first season of the trials and the supply of inputs. In each village 10 members volunteered for the management committee, and the volunteers selected a chairperson and a deputy. During the meeting, the role and function of the committee was discussed, namely that they would act as a link between the farmers and the researchers, make decisions regarding the timing for carrying out husbandry practices (such as weeding, application of pesticides, etc.) on the trial plots, and to mobilise all interested farmers to come and work on the trial plots. In all villages, some farmers expressed interest in applying the water harvesting technique in their backyard plots.

Following the meetings, arrangements were made for conducting soil surveys to determine soil depth and other soil properties at the sites selected for the trials to make sure that the soils were suitable for water harvesting. Most households in all the villages have suitable soils in the backyard gardens. In Talla the soils in the fields were found to be generally shallow (less than 500mm deep). There is a risk of flooding and water logging during unusually wet seasons when water harvesting is applied on shallow clay soils. It was decided that for Talla, application of the technique would be limited to backyard gardens and vegetable crops for the time being. In the future adaptations of the technique to suit soils such as those found in Talla would be sought. Farmers in Yoxford chose to start with both maize and sunflower, those in Paradys and Feloané chose sunflower and maize, respectively. The farmers in Yoxford chose maize because of the need to produce food for household consumption, and sunflower because of its potential to generate cash income. The same reasons were cited by farmers in Paradys and Feloané for choosing sunflower and maize. In Paradys those currently involved in crop production already grow sunflower, and probably before the arrival of the research team farmers had already planned to grow the crop for the 2001/2002 season. However, the ARC research team advised farmers that it would be better (for maintaining soil fertility) to adopt a crop rotation system that will involve the planting of all 3 crops.

The participatory process is not always smooth and without conflicts. Invariably conflicts arise because participation challenges the long held perceptions of what the role of each party involved should be. For researchers, the process may seem overly

time consuming as they often have to conduct their activities on the backdrop of ever declining budgets and pressures to get as much mileage out of every research dollar. So spending many hours with farmers sometimes having to explain the same point over and over using different approaches does not meet the requirement of having to generate as much information as possible in a short time. Also, having farmers question researchers perceptions of farmers' problem and proposed solutions may not sit comfortably with researchers' traditional role as the seat of modern knowledge. Having open discussions with all members of the community also challenges the position of local elites who consider themselves better informed. Convincing locals that they have a role to play in framing the development agenda is not easy either because, for a long time they have evolved expectations of outsiders coming laden with development in their pockets. Of importance though is that the emergence of such conflicts highlights the erroneousness of the assumption of homogenous rural communities, that people will have a similar understanding of issues and readily accept the solutions proffered to them.

#### **4.6 Preparation and implementation of the formal survey**

Although some valuable information about the households and the agrisystem in the study villages was gained from the PRA exercises, it is important for the analysis of the potential impact of water harvesting techniques on household welfare, to understand how decisions are made at the household level and the factors that are likely to influence those decisions. Detailed and household specific information is best acquired through household surveys. Formal household interviews with the use of questionnaires are commonly used to elicit and record information about households.

To gain an in-depth understanding of the agricultural households in the Thaba Nchu area, and a better insight of how the adoption of water harvesting will affect the participating households and the factors that might influence its success, detailed household level data was gathered in a socio-economic survey using a structured questionnaire (See Appendix A1). A total of 124 households from the three villages of Paradys, Talla and Yoxford were interviewed.

The survey gathered information on household characteristics (e.g., household size, educational attainment of the head of the household, household wealth and income), farming practices, household food intake and expenditure, use of agricultural support services and households' opinions on production and support services constraints.

In designing the questionnaire particular attention was given to simplify the questions and the style in which the questions were formulated. In the questionnaire, the order of the questions was such that simpler questions such as the age of the household head (respondent), family size and other information pertaining to the household were asked first. Such questions can be answered without much effort on the part of the farmer and this can serve to relax the respondent who otherwise may feel intimidated by an interviewer carrying pen and paper when probably the respondent has not had much formal education.

The survey type was a single visit and relied on farmer recall on a lot of the items in the questionnaire. Before the questionnaire could be used for the surveys, a pre-test (pilot study) was carried out, in which a sample of households in a village other than the three selected villages were interviewed. The pre-test provided an opportunity to make adjustments to the questionnaire, for example, the rephrasing of some questions that the informants found difficult to understand; and it also provided the opportunity for the interviewers to practise their interviewing skills before the actual interviews.

Although an English version of the questionnaire was used in the field, the interviewers were provided with a Sesotho translation so that they could study it and ensure a consistency in the interviewers' translations of the questions during the surveys.

## **4.7 Results of the Survey**

This section provides a preliminary summary of the results from the survey. A total of 124 households, about 40 from each village were interviewed. A summary of household characteristics is presented in Table 4.1.

TABLE 4. 1: SOCIO-ECONOMIC CHARACTERISTICS OF HOUSEHOLDS OF SAMPLE, 2001

|                                                  | Mean (standard deviation) | Mode              |
|--------------------------------------------------|---------------------------|-------------------|
| <i>Labour Supply</i>                             |                           |                   |
| Household size                                   | 4.96 (2.20)               | 4                 |
| Number of male adults                            | 1.35 (1.47)               | 1                 |
| Number of female adults                          | 1.66 (1.08)               | 1                 |
| Duration in current village (years)              | 26 + <sup>a</sup>         | 26 + <sup>a</sup> |
| Age of household head (years)                    | 50+ <sup>b</sup>          | 50+ <sup>b</sup>  |
| Educational attainment of household head (years) | 1 to 7 <sup>c</sup>       | 7 <sup>c</sup>    |
| <i>Asset Holdings</i>                            |                           |                   |
| Land (hectares)                                  | 1.87 (1.04)               | 1.87              |
| Number of cattle                                 | 4.08 (5.92)               | 0                 |
| <i>Income (Rand) (per month)</i>                 |                           |                   |
| Pension (and other government transfers)         | 327.50 (0.75)             | 0                 |
| Remittances from household members               | 236.45 (579.76)           | 0                 |
| Expenditure on food                              | 277.87 (164.77)           | 300               |
| <b>Number of Observations</b>                    | <b>124</b>                | <b>124</b>        |

a,b,c, these variables were elicited as ranges (e.g., 21 -25 years, or grade 1 to 7)

Of the total of 124 households surveyed, 77 (62 %) of the respondents are female. Of the female respondents, 32 (or 26 % of the sample) are heads of households. The average household size for the sample was 5 persons per household. There is a fair amount of variability in the household size in the sample as suggested by the standard deviation (in brackets), while most households have 4 members as shown by the mode. Most households have more adult female members than adult male members. On average households have only 3 adults (male and female). Smaller-holder agriculture is generally highly intensive, and with 3 adult members households may not have sufficient labour particularly during critical periods of weeding and harvesting. About 54 percent of the respondents have at least a primary level (up to 7 years of formal schooling) of education. The majority of the households have lived in the

current village for more than 26 years, with 78 percent reporting to have arrived in the current village about 40-50 years ago, when most of the villages were established.

The average farm size for the sample households is 1.865 hectares (3 morgans), while some households have up to 3.73 hectares (6 morgans) of farmland. Although in principal all households are guaranteed access to agricultural land, only 70 (56 %) of sample households reported having access to land. There is a need for an investigation into the reason why as many as 30 percent of the households do not have access to agricultural land. There is a possibility that a significant number of these households do have assigned agricultural plots but since there is no cropping currently taking place in the villages, these households have never bother to ask the headman to show them their assigned plots. However, the headmen of the villages also concede that most agricultural land has already been allocated and that it is no longer possible to find land for new households.

Without crop production, and with few employment opportunities, most households rely on livestock sales, state provided pension for the elderly and on remittances for cash income. Thirty-four (27 %) households in the sample had at least one member involved in off-farm employment, mostly as factory workers in Thaba Nchu and Botshabelo. Of the households that have some of their members engaged in off-farm employment, 5 households had 2 members employed off-farm and 2 had 3 members engaged in off-farm employment. On average the member engaged in off-farm employment sent home R236 per month. A majority of the households in the study area do not have this source of additional income as suggest by a mode of zero (0) for this variable. Pension income is also a significant source of income for households in the region. Sixty (48 %) of the households had a member receiving old age pension (R570 per month), and 20 households had more than one member eligible for the pension. On average pensions contribute R327 to household income for households in the region, about 65 percent of reported cash income. This figure is comparable to the estimate by Carter and May (2001) for all rural households in South Africa.

About 77 percent of the households own some livestock, mostly cattle. The average herd size is 4 head of cattle per household. Among the cattle owners, 37 households had sold at least one head of cattle in the previous year. The reasons for selling cattle

varied, but most households reported to have sold cattle so that they could pay for their children's school fees, or to enable them to pay for funeral expenses and in other cases livestock were sold to enable the household to purchase food, clothing and other household commodities.

Households in this region do not own many other productive assets. Only 11 households owned an animal drawn cart, while only 16 households owned an animal drawn plough. Seven households in the sample owned a tractor and some tractor drawn farming equipment. A 1993 survey found that 50 percent of black South Africans live in poverty suffering material deprivation and human insecurity (Carter and May, 2001). Mechanisms by which people can escape poverty include asset accumulation, which provide a structural escape from poverty. It has been estimated that about 60 percent of poor people are caught in chronic poverty. Characteristics of such people is that they have similar endowments and face similar constraints to use the endowment. Poverty then may be best measured in terms of asset ownership and entitlement combinations that map to an expected livelihood.

Risk and vulnerability play an important role in inability of poor households to escape from poverty traps. When households have low resilience to shocks such as droughts they end up being forced to sell off assets or their circumstances make them neglect accumulation of productive assets (accumulation failure) as they struggle to survive. Over time such households spiral down to a situation where they are trapped in poverty.

Some rather crude expenditure estimates show that households spend on average R278 (about 50 % of cash income) on food per month. Of the sampled households, 49 percent (61 households) relied exclusively on the market to source all their food requirements. Food supplies are purchased mainly from Thaba Nchu, but some items can also be purchased at the local shop.

The land tenure systems under which many smallholder farmers operate is frequently cited in the literature as a major disincentive to the adoption of sound land husbandry. It is argued that communal and allocated lands are frequently abused because farmers and graziers do not feel any responsibility for conservation of the land and the

pastures. In the arable lands farmers do not have an incentive to construct conservation measures if they are to be trampled by another's cattle when fields are open to communal grazing after harvest. In the communal grazing lands, it pays for the farmer to over-use the pastures because if he does not, someone else will, and he will be the loser. With this in mind farmers were asked about the rights they currently enjoy with respect to the agricultural land and the homestead land. The results are reported in Table 4.2.

Although the type of rights conferred to land users under a communal tenure system are fairly well understood to be only usufruct rights, such an understanding of the land rights may differ with what farmers actually do on the ground. The law prohibits any sale of communal land, but 71 households (57 % of the sample) reported that they could sale their homestead land. This was corroborated by the headman, who explained that because households often make substantial improvements on homestead land (through the construction of house, fences, etc.), if the household has to leave the area and needs to recover the value of its investment it has to be able to sell the homestead. Purportedly, what is being sold is the value of the improvements, but it is not entirely clear how one can separate the value of the improvements from the value of the land in such situations. Of those households that reported having access to agricultural land, 60 percent said they could sell their farm land if they wanted to (particularly if they had to relocate away from the village).

The other rights enjoyed by a significant number of the households are the right to rent out land, and the right to bequeath land to offspring or other relatives. The significance of the type of analysis and the results presented in Table 4.2 is that it seeks to understand land tenures in terms of those characteristics that may be of importance for farm-household decision-making. Moreover, examining land tenures in terms of their specific characteristics can allow the detection of changes that may be taking place in the system which may not be noticeable if tenures are described in broad terms as either communal, state or private. In the case of Thaba Nchu, practices which are contrary to the common understanding of communal tenure (the system in effect in the area), such as the sale of land, were reported to be taking place in different guises. The presence of improvements on the land is cited as presenting a strong case why transfers of land involving monetary payments may be justified.



Water conservation measures are a type of land improvement for which a farmer can demand compensation if he decides to move out of farming. It can thus be concluded that investments in the water conservation works will not be negatively affected by the land tenure regime, since farmers can transfer land and recover the value of their investments.

#### **4.8 Assessment of social acceptability**

As reflected in a number of government policies and programmes it is widely stressed that agricultural growth is crucial for poverty alleviation and rural development. In order to achieve agricultural growth new technologies and production practices that increase productivity have to be adopted by small-holder farmers. However the new techniques are only likely to be accepted by farmers if they:

- i) address the felt needs of farmers
- ii) lead to significant increases in household incomes
- iii) do not create conflict with other livelihood strategies employed by households
- iv) do not conflict with local customs

In this study two approaches were utilized: a participatory approach and a farming systems approach. The participatory approach was used to diagnose and address problems in the development and adoption of new production practices – and in this way increase the likelihood for the use of the new technologies. This in turn would lead to the potential increase in production and farm incomes. It is vital to understand farm households, because it is only through this understanding that one can predict /understand how they will interact with new technologies and production practices. In addition a farming systems approach was employed in which the impact of other aspects of the farmers environment (culture, social norms, social structures, rules and regulations governing resource use and management) on the adoption of new production practices were explored. A final assessment of whether or not a new innovation is acceptable to a community can only be executed a number of seasons after the introduction of the innovation. Then criteria such as the number of farmers who have adopted it can be used in such an assessment. At this stage however, only preliminary assessment can take place regarding the acceptance of the new method by farmers.

Table 4. 2: Land rights enjoyed by farmers on arable and homestead land, 2001

| Right                         | Number of households reporting to enjoy right |                |
|-------------------------------|-----------------------------------------------|----------------|
|                               | Arable Land                                   | Homestead Land |
| <u>Sell</u>                   |                                               |                |
| Sell without approval         | 24 (34.3)                                     | 49 (39.5)      |
| Sell with approval            | 18 (25.7)                                     | 22 (17.7)      |
| Do not possess right          | 28 (40)                                       | 53 (42.7)      |
| <u>Rent</u>                   |                                               |                |
| Rent without approval         | 19 (27.1)                                     | 37 (29.8)      |
| Rent with approval            | 31 (44.3)                                     | 40 (32.3)      |
| Do not possess right          | 20 (28.6)                                     | 47 (37.9)      |
| <u>Bequeath</u>               |                                               |                |
| Bequeath without approval     | 22 (31.4)                                     | 34 (27.4)      |
| Bequeath with approval        | 14 (20)                                       | 17 (13.7)      |
| Do not possess right          | 34 (48.6)                                     | 73 (58.9)      |
| <u>Gift</u>                   |                                               |                |
| Gift without approval         | 12 (17.1)                                     | 25 (20.2)      |
| Gift with approval            | 8 (11.4)                                      | 9 (7.3)        |
| Do not possess right          | 50 (71.4)                                     | 90 (72.6)      |
| <u>Pledge</u>                 |                                               |                |
| Pledge without approval       | 16 (22.9)                                     | 37 (29.8)      |
| Pledge with approval          | 4 (5.7)                                       | 6 (4.8)        |
| Do not possess right          | 50 (71.4)                                     | 81 (65.3)      |
| <u>Exclude</u>                |                                               |                |
| Exclude all times             | 46 (65.7)                                     | 124 (100)      |
| Exclude during growing season | 1 (1.4)                                       |                |
| Do not possess right          | 23 (32.9)                                     |                |
| Number of observations        | 70 (100)                                      | 124 (100)      |

During group discussions with farmers in the region, water scarcity was identified as a major constraint to agricultural production and there was consensus that in-field rainwater harvesting techniques provided a possible solution to the problem. It was therefore decided that trials using these techniques would be important. The farmers were enthusiastic about being involved in the trials and in all the villages the group discussions and demonstrations were well attended by men, women and the youth. This trend continued throughout the growing season when field trials of the techniques were conducted in the different villages (particularly in Feloane, Paradys and Yoxford). At village level, the local leadership was supportive of the endeavour

In addition to this enthusiasm from ground level, the officials of the local office of the Provincial Department of Agriculture also indicated a keen interest in the potential of in-field rainwater harvesting techniques to increase agricultural production. Agricultural extension officers for the area thus participated actively during the field trials.

The close partnership between all those involved in the promotion of water harvesting techniques contributed to the empowerment of all parties. The farmers learnt how to prepare their fields for rainwater harvesting and also gained new knowledge about how to undertake other practices such as weed control and application of fertilizers. During group discussions other aspects of agriculture, for example, managing farm finances were also discussed.

Given the fact that the standard of living of farm households in the Thaba Nchu area is low, and there is lack of alternative economic opportunities outside agriculture, it is important to optimize this economic area/sector. Currently, available agricultural resources are under utilized and conventional agriculture does not generate adequate returns to farmer's investment. This new project (in-field rainwater harvesting) presents a valuable opportunity to improve agricultural production and farm incomes and ultimate the standard of living for the people involved. The farmers in Thaba Nchu seem to be willing to utilize new technologies that will help improve their standard of living. This is illustrated by the following: in the 2002/2003 season, following the field trials during 2001/2002, households in Yoxford spontaneously

organized themselves into labour sharing groups in order to start preparing their homestead gardens for in-field rainwater harvesting. This indicates true acceptance of the technique and illustrates that participants have realized what benefits the techniques holds for them personally.

From these preliminary indications, and considering the fact that a number of households were already involved in the collection of runoff water into open pits in their gardens and using it to water vegetables during dry spells, the in-field rainwater harvesting techniques will find widespread use among farmers in Thaba Nchu. However, only a comprehensive study in a few years time, will provide more concrete evidence about the extent to which the practice has been accepted and utilized by farmers. Such a study would also be useful for providing information about the patterns of adoption of new technologies among small-holder farmers that can benefit other farming communities in South Africa.

#### **4.9 Summary**

Thaba Nchu is a semi-arid area and receives about 500mm of rainfall annually, most of it during high intensity storms, and is unevenly distributed over the cropping season. This makes crop production in the area very risky as crops are likely to experience moisture stress during the critical growth phase. The soils in the area have high clay content and are subject to surface crusting, which promotes high runoff. Under these circumstances agricultural production is severely constrained and farmers are generally discouraged from engaging in crop production.

Without agricultural production and lacking alternative economic opportunities, farm households in Thaba Nchu are generally quite poor. Results from a household survey conducted in the area, showed households income to be substantially below the poverty line, and food intake to be low and lacking variety. Government transfers in the form of old age pensions and child support grants comprised the largest portion of cash income (at 65% of total household cash income).

From the group discussions held by the researchers and communities following participatory research principles, most community members indicated that their present circumstances (food insecurity, lack of employment opportunities, etc) were

not satisfactory and that improving agricultural production provided a potential means for more secure livelihoods. Against this background suggestions to try in-field rainwater harvesting as a new production technique were discussed with farmers. These water conservation techniques had undergone several years of agronomic trials on-station at the Glen Agricultural Research Station under agro climatic conditions similar to those in the study area. The on-station trials showed that by using these techniques available moisture (by collecting runoff) for crop production was increased and crop yield could increase by up to 50 percent when compared to the utilisation of conventional tillage, and soil erosion minimized.

Although results from on-station trials proved the benefits of applying water conservation techniques, the widespread use of these techniques by farmers requires that farmers themselves be involved in diagnosing problems in their farming system and in the identification of potential solutions to the problems. Encouraging farmer participation in all stages of developing and applying innovations in farming will enhance the uptake and application of innovations. But it is also necessary to demonstrate to farmers that new innovations result in increased returns.

The results of the economic analyses of the infield rainwater harvesting techniques show that greater gains are made in dry beans production than with the other two crops (maize and sunflower), however, water harvesting increases returns considerably for all the crops. Where conventional production exposes farmers to a lot of risk, water-harvesting techniques reduced risk considerably for maize and sunflower production, whereas in the case of dry beans production risk was even reduced to zero.

## CHAPTER 5

### EMPIRICAL RESULTS OF THE ECONOMIC VIABILITY ANALYSIS

#### 5.1 Introduction

The discussion of the results of the economic analysis covers three different but related aspects. These are profitability analysis, risk analysis, and long-term economic feasibility of the *IRWH* techniques. Based on the information generated in the above analyses, the minimum area of land required, using different *IRWH* techniques, to provide an average household in the study area with its income/food requirements is estimated. The minimum farm size is estimated using two approaches, firstly by calculating the income required to enable an average household to achieve a standard of living just above the poverty line as determined in various poverty studies for South Africa, and then calculating the area of land the household would have to crop under maize to allow it to achieve this income level. The second approach takes a food security perspective by determining the area of land that an average household would need to bring under cultivation to produce enough food to allow it to attain the medically recommended minimum energy requirements for its members to be able to lead a healthy and moderately active life.

All the analyses mentioned above are linked together in a simulation model which can be used to examine the impact on total gross margin, risk minimisation and the required farm size, as a result of changes in either output and input prices, and changes in the proportion of farm area allocated to each crop, among other changes.

The analyses reported here employ base year (1999/2000) prices as obtained from the Micro-Combud Budgets (Free State Department of Agriculture, 2000) for the three crops included in the study. The prices for maize, sunflower and dry beans were R570  $\text{ton}^{-1}$ , R1040  $\text{ton}^{-1}$  and R2900  $\text{ton}^{-1}$ , respectively.

## 5.2 Profitability of IRWH techniques

To investigate the profitability of employing IRWH, crop enterprise budgets were developed for each crop and IRWH technique. Here profit refers to the gross margin from production - the difference between gross returns and allocable variable costs. The enterprise budgets were developed for on-station experimental production data and for on-farm trials (in Thaba Nchu on farmers' fields) production. On-station trials of the IRWH techniques were conducted over three seasons - 1999/2000, 2000/2001 and 2001/2002. Production data (yield and cost) used in the enterprise budgets for on-station production are average figures for the three seasons, while for on-farm trials data for the 2001/2002 season is used.

In the Sections 5.2.1 to 5.2.3 below, enterprise budgets for on-station and on-farm production of maize, sunflower and dry beans employing a selected number of IRWH techniques are presented, while the remainder of the enterprise budgets are contained in Appendices A2, A3, and A4. Tables summarising all the gross margins for each crop under all the IRWH techniques are also presented in the sections that follow.

### 5.2.1 Maize

The results for the analysis of profitability of maize production using IRWH techniques are presented in Tables 5.1 to 5.5. Tables 5.1 to 5.4 present crop enterprise budgets (CEBs) using selected IRWH techniques on-station and on farmers' fields in Thaba Nchu (on station *CON*, *BbBr*, *ObSr*, and on-farm *BbBr*), while Table 5.5 presents a summary of the gross margins for the production of maize using all IRWH techniques. Other CEBs for maize production are contained in Appendix A2.

Table 5.1 presents the enterprise budget for on-station maize production using the conventional tillage (*CON*). The yield and cost data used in the budget are averages for the three seasons - 1999/2000, 2000/2001 and 2001/2002. On station trials took place at Glen, in the Bloemfontein farming area of the Free State Province, South Africa. The ecotope is the Glen/Bonheim-Onrus with clay content in the A-horizon of 45 percent. The maize cultivar planted was PHI 3394 at a rate of 22 000 plants per hectare and target yield of 2 750 kg ha<sup>-1</sup>. The prices used in the budget are for the base year (1999/2000). Most of the production activities were done by hand and/or

hand-held tools. Fertilizers were applied at the time of planting. Land preparation for *CON* was done using tractor and tillage implements.

On-station *CON* production of maize yielded average gross receipts of R1706 ha<sup>-1</sup>. The average total directly allocatable variable costs (TDAVC) totalled R938 ha<sup>-1</sup>. The average TDAVC included the costs of seeds, fertilizers, chemicals, harvesting and the cost of labour used to perform the different activities. All the prices and costs are market prices and include value added tax (VAT) at the applicable rate at the time of the study. The calculated margin above TDAVC is R776, determined as the difference between the gross receipts and the TDAVC.

The total non-directly allocatable variable costs (TNDAVC) were also calculated and it included mostly the costs associated with land preparation by tractor. This included the repairs and maintenance costs of the tractor and plough and cost of energy (fuel and lubricants). The repairs and maintenance costs also included the cost of the labour required to operate the tractor and the implements. The average TNDAVC were found to be R301 ha<sup>-1</sup>.

The costs are further divided into preharvest costs and harvest and post harvest costs. The preharvest costs include all the costs of the activities and inputs used prior to harvesting of the crop. The average total preharvest costs summed up to R1173 ha<sup>-1</sup> whereas the harvest and post harvest costs totalled R67 ha<sup>-1</sup>. The total preharvest and harvest and post harvest cost was calculated to be R1240 ha<sup>-1</sup>. This value then gives the total cost of production of maize using the conventional production technique and allows the calculation of the gross margin, which is used as a measure of profitability. The gross margin from production is given by the difference between the total gross receipts and total cost of production. The calculated gross margin above allocatable costs is R466 ha<sup>-1</sup> for maize production under *CON*.



**TABLE 5.1: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE CON PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS**

| GROSS MARGIN PER HA (R)                                               |      |                  |                      |         |
|-----------------------------------------------------------------------|------|------------------|----------------------|---------|
| Glen- Conventional                                                    |      |                  |                      |         |
| Farming area Bloemfontein                                             |      |                  |                      |         |
| Target yield: 2 750 Kg/ha                                             |      |                  |                      |         |
| Seasons: 1999/2000, 2000/2001, 2001/2002                              |      |                  |                      |         |
| MAIZE                                                                 | UNIT | PRICE OR         | Average over 3 years |         |
| Country: South Africa                                                 |      | COST PER UNIT(R) | Quantity             | Cost    |
| Province: Free State                                                  |      |                  |                      |         |
| Ecotope: Glen/Bonhem-Onrus                                            |      |                  |                      |         |
| Clay (%) in A-horizon: 45%                                            |      |                  |                      |         |
| Plant Population: 22 000 plants per hectare                           |      |                  |                      |         |
| Cultivar: PHL 3394                                                    |      |                  |                      |         |
| Gross receipts from production                                        |      |                  |                      |         |
| Maize grains                                                          | Ton  | 570.00           | 2.99                 | 1706.01 |
| VARIABLE COSTS                                                        |      |                  |                      |         |
| PRE-HARVEST :                                                         |      |                  |                      |         |
| Planting                                                              |      |                  |                      |         |
| Seed                                                                  | Kg   | 11.40            | 4.00                 | 45.60   |
| Labour                                                                | Days | 15.00            | 8.07                 | 121.00  |
| Fertilizers                                                           |      |                  |                      |         |
| Ammonium Nitrate                                                      | Kg   | 1.82             | 150.00               | 273.00  |
| Superphosphate                                                        | Kg   | 1.79             | 39.21                | 70.19   |
| Pest Control/Pesticides                                               |      |                  |                      |         |
| Bulldog                                                               | L    | 237.00           | 0.10                 | 23.70   |
| Application Labour                                                    | Days | 15.00            | 5.73                 | 85.90   |
| Weed Control/Herbicides                                               |      |                  |                      |         |
| Turbo                                                                 | L    | 79.60            | 1.50                 | 119.40  |
| Application (Labour)                                                  | Days | 15.00            | 5.79                 | 86.90   |
| Hand weeding (labour)                                                 | Days | 15.00            | 3.06                 | 45.90   |
| HARVEST and POST HARVEST                                              |      |                  |                      |         |
| Hand harvesting                                                       | Days | 15.00            | 1.64                 | 24.60   |
| Threshing                                                             | Days | 15.00            | 1.72                 | 25.80   |
| Remove maize stems (Labour)                                           | Days | 15.00            | 1.10                 | 16.45   |
| Total Directly Allocatable Variable Costs                             |      |                  |                      | 938.55  |
| Margin Above Total Directly Allocatable Costs                         |      |                  |                      | 767.46  |
| Non Directly Allocatable Variable Costs                               |      |                  |                      | 301.38  |
| Energy                                                                |      |                  |                      | 171.64  |
| Maintenance and Repairs                                               |      |                  |                      | 129.74  |
| Total Preharvest Costs                                                |      |                  |                      | 1173.02 |
| Total Harvest and Postharvest Costs                                   |      |                  |                      | 66.91   |
| Gross Margin Above Total Allocatable Costs                            |      |                  |                      | 466.08  |
| Prices are for the base year, 1999/2000                               |      |                  |                      |         |
| Weed and pest control done by hand and/or chemicals                   |      |                  |                      |         |
| All activities done by hand and/or hand tools except soil preparation |      |                  |                      |         |
| Fertilisers applied at time of planting                               |      |                  |                      |         |

Table 5.2 presents the average enterprise budget for maize production using the *BbBr* technique. The enterprise budget is the same as above except that the production technique, *BbBr* is an *IRWH* technique where no mulches are used in the basins nor the runoff strip.

When using this technique, maize production shows an improvement in yield from 2.99 ton ha<sup>-1</sup> to 4.46 ton ha<sup>-1</sup>. The latter results with average gross receipts of R2542

ha<sup>-1</sup> and gross margin (profit) of R1396 ha<sup>-1</sup>. As opposed to *CON*, the *BbBr* enterprise budget does not make a distinction between directly and non-directly allocatable costs. The reason being that the non-directly allocatable costs in *BbBr* account mostly for the fixed costs and they include the land preparation costs. The fixed costs are included at the bottom of the budget but are not used in the calculation of the gross margin but are used to calculate the net margin, which becomes the enterprise profit. This is the actual income that the farmers will receive by using the *IRWH* techniques, however, the net margin will be discussed in more detail in the cost benefit analysis later in the chapter.

An important characteristic of the *IRWH* techniques is its dependence on labour. As the budget shows, the bulk of the production costs are channelled towards the payment of labour. This is to be expected since most of the activities are done by hand. Table 5.2 reveals that the total amount charged for labour is R613 ha<sup>-1</sup> and the total allocatable variable costs are R1145 ha<sup>-1</sup>. Labour costs account 54 percent for more than half the total allocatable variable costs; is of all the production costs. As with other inputs in production, labour is assumed to be paid for, at market prices, even for on farm trials where it was "freely" available from the participating farmers.

From the fixed cost in the CEB, it can be seen that labour also accounts for a significant proportion of the costs. This implies that the techniques will be more suitable to households that have most of the household members available to work on the fields since they will save considerably on labour.

**TABLE 5.2: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE *BBBr* PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                               |          |                              |
|-----------------------------------------------------------------------|------|-------------------------------|----------|------------------------------|
| Glen - Bare, basins and runoff strip                                  |      |                               |          |                              |
| Farming area: Bloemfontein                                            |      |                               |          |                              |
| Target yield: 2 750 kg/ha                                             |      |                               |          |                              |
| Seasons: 1999/2000, 2000/2001, 2001/2002                              |      |                               |          |                              |
|                                                                       | UNIT | PRICE OR<br>COST PER UNIT (R) | Quantity | Average over 3 years<br>Cost |
| Gross receipts from production                                        |      |                               |          |                              |
| Maize                                                                 | Ton  | 575.00                        | 4.46     | 2547.20                      |
| <b>VARIABLE COSTS</b>                                                 |      |                               |          |                              |
| <b>PRE-HARVEST</b>                                                    |      |                               |          |                              |
| Planting                                                              |      |                               |          |                              |
| Seed                                                                  | kg   | 11.40                         | 4.00     | 45.60                        |
| Labour                                                                | Days | 15.00                         | 8.00     | 120.00                       |
| Fertilizers                                                           |      |                               |          |                              |
| Ammonium Nitrate                                                      | kg   | 1.62                          | 150.00   | 273.00                       |
| Superphosphate                                                        | kg   | 1.79                          | 39.21    | 70.19                        |
| Pest Control/Pesticides                                               |      |                               |          |                              |
| Bulldog                                                               | L    | 237.00                        | 0.10     | 23.70                        |
| Application labour                                                    | Days | 15.00                         | 5.75     | 86.25                        |
| Weed Control/Herbicides                                               |      |                               |          |                              |
| Turbo                                                                 | L    | 79.60                         | 1.50     | 119.40                       |
| Application labour                                                    | Days | 15.00                         | 5.75     | 86.25                        |
| Maintenance labour                                                    |      |                               |          |                              |
| Repair basins                                                         | Days | 15.00                         | 14.75    | 221.25                       |
| <b>HARVEST and POST HARVEST labour</b>                                |      |                               |          |                              |
| Hand harvesting                                                       | Days | 15.00                         | 2.55     | 37.50                        |
| Threshing                                                             | Days | 15.00                         | 2.56     | 38.40                        |
| Remove maize stems                                                    | Days | 15.00                         | 1.64     | 24.57                        |
| Total Allocatable Variable Costs                                      |      |                               |          | 1145.84                      |
| Margin Above Allocatable Variable Costs                               |      |                               |          | 1391.36                      |
| <b>FIXED COSTS</b>                                                    |      |                               |          |                              |
| <b>LAND PREPARATION</b>                                               |      |                               |          |                              |
| Construct basins labour                                               | Days | 15.00                         | 10.35    | 155.25                       |
| Energy                                                                |      |                               |          | 90.00                        |
| Repairs and maintenance                                               |      |                               |          | 114.35                       |
| Total Fixed Costs                                                     |      |                               |          | 359.60                       |
| Prices are for the base year, 1999/2000                               |      |                               |          |                              |
| All activities done by hand and/or hand tools except soil preparation |      |                               |          |                              |
| Fertilizers applied by hand at time of planting                       |      |                               |          |                              |
| Chemical and hand control of weeds and pests                          |      |                               |          |                              |

Table 5.3 presents the average enterprise budget for maize production using the *ObSr* technique. The budget also has the same parameters as in the *ObBr* enterprise budget, but of interest is the yield and gross margin, which show a great increase from both *CON* and *BbBr*. The yield is 5.58 ton ha<sup>-1</sup> compared to 4.46 ton ha<sup>-1</sup> in *BbBr* and 2.99 ton ha<sup>-1</sup> in *CON*. The resultant gross margin from production is R2191 ha<sup>-1</sup>.

It should also be noted that, *ObSr* has higher fixed cost than *BbBr*. This is to be expected since there is more labour needed to put the structure especially in the packing of the stone and organic mulch on the system. This, however, is worthwhile

as shown by the returns from production under the system. For *BbBr* the fixed costs are R359 and for *ObSr* is R548.

Table 5.4 presents the enterprise budget for maize production in Yoxford, Thaba Nchu using the *BbBr* technique. The budget is also identical to the *BbBr* enterprise budget for the Glen trial, except that this one was on the farmers' fields in Yoxford. It is important to highlight that the technique also gave better returns on farmers' fields as it did in the on-station trials, as Table 5.5 will later show. The technique yielded 4.37 ton ha<sup>-1</sup> and the GM was R1261 ha<sup>-1</sup>.

**TABLE 5.3: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE *OBSR* PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS**

| GROSS MARGIN PER HA (R)                                               |      |                              |          |                              |
|-----------------------------------------------------------------------|------|------------------------------|----------|------------------------------|
| Glen - Organic much in the basins and stone much in runoff strip      |      |                              |          |                              |
| MAIZE                                                                 |      |                              |          |                              |
| Country: South Africa                                                 |      |                              |          |                              |
| Province: Free State                                                  |      |                              |          |                              |
| Ecotope: Glen/Barkham-Drusa                                           |      |                              |          |                              |
| Clay (%) in A-horizon: 45%                                            |      |                              |          |                              |
| Plant population: 22 000 plants per hectare                           |      |                              |          |                              |
| Cultivar: PH 3394                                                     |      |                              |          |                              |
| Target yield: 2 750 kg/ha                                             |      |                              |          |                              |
| Seasons: 1999/2000, 2000/2001, 2001/2002                              |      |                              |          |                              |
|                                                                       | UNIT | PRICE OR<br>COST PER UNIT(R) | Quantity | Average over 3 years<br>Cost |
| Gross receipts from production                                        |      |                              |          |                              |
| Maize grain                                                           | Ton  | 570.00                       | 5.56     | 3177.94                      |
| VARIABLE COSTS                                                        |      |                              |          |                              |
| PREHARVEST                                                            |      |                              |          |                              |
| Planting                                                              |      |                              |          |                              |
| Seed                                                                  | kg   | 11.40                        | 4.00     | 45.60                        |
| Labour                                                                | Days | 15.00                        | 8.12     | 121.96                       |
| Fertilizers                                                           |      |                              |          |                              |
| Ammonium Nitrate                                                      | kg   | 1.62                         | 160.00   | 273.00                       |
| Superphosphate                                                        | kg   | 1.79                         | 39.21    | 70.19                        |
| Pest Control/Pesticides                                               |      |                              |          |                              |
| Spading                                                               | L    | 227.00                       | 0.10     | 23.70                        |
| Application (labour)                                                  | Days | 15.00                        | 5.73     | 85.95                        |
| Weed Control/Herbicides                                               |      |                              |          |                              |
| Turf                                                                  | L    | 75.60                        | 1.50     | 113.40                       |
| Application (labour)                                                  | Days | 15.00                        | 5.79     | 86.85                        |
| Maintenance (labour)                                                  |      |                              |          |                              |
| Repair basins                                                         | Days | 15.00                        | 2.28     | 34.15                        |
| HARVEST and POST HARVEST (labour)                                     |      |                              |          |                              |
| Labour                                                                | Days | 15.00                        | 3.14     | 47.10                        |
| Threshing                                                             | Days | 15.00                        | 3.20     | 48.00                        |
| Remove maize stalks                                                   | Days | 15.00                        | 2.06     | 30.77                        |
| Total Allocatable Variable Costs                                      |      |                              |          | 986.71                       |
| Margin Above Allocatable Variable Costs                               |      |                              |          | 2191.23                      |
| Total Pre harvest Costs                                               |      |                              |          | 860.82                       |
| Total Harvest and Post harvest Costs                                  |      |                              |          | 125.90                       |
| Gross Margin Above Total Allocatable Costs                            |      |                              |          | 2191.23                      |
| FIXED COSTS                                                           |      |                              |          |                              |
| LAND PREPARATION                                                      |      |                              |          |                              |
| Energy                                                                |      |                              |          | 90.00                        |
| Repairs and maintenance                                               |      |                              |          | 114.35                       |
| Construct basins (labour)                                             | Days | 15.00                        | 10.35    | 155.25                       |
| Pack stones (labour)                                                  | Days | 15.00                        | 8.72     | 130.80                       |
| Pack mulch (labour)                                                   | Days | 15.00                        | 3.86     | 57.95                        |
| Total Fixed Costs                                                     |      |                              |          | 548.25                       |
| Prices are for the base year - 1999/2000                              |      |                              |          |                              |
| All activities done by hand and/or hand tools except soil preparation |      |                              |          |                              |
| Fertilizers applied by hand at time of planting                       |      |                              |          |                              |
| Chemical and hand control of weeds and pests                          |      |                              |          |                              |

**TABLE 5.4: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE BBBR PRODUCTION TECHNIQUE IN VOXFORD DURING THE 2001/2002-PRODUCTION SEASON**

| GROSS MARGIN PER HA (R)                                                                                                                                                                                                                                                                                                |      |                               |          |                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|-------------------------------|----------|----------------------|
| <b>MAIZE</b><br>Country: South Africa<br>Province: Free State<br>Ecotype: Gari/Burhaim-onus<br>Clay (%) in A-Horizon: 40%<br>Plant Population: 22 000 plants per hectare<br>Cultivar: PH1 3354<br>Farming area: Thabo Nchu/Bloemfontein<br>Target yield: 2 750 kg/ha<br>Planting date: 22/12/2001<br>Season: 2001/2002 |      |                               |          |                      |
|                                                                                                                                                                                                                                                                                                                        | UNIT | PRICE OR<br>COST PER UNIT (R) | QUANTITY | Value or Cost per ha |
| Gross receipts from production                                                                                                                                                                                                                                                                                         |      |                               |          |                      |
| Maize                                                                                                                                                                                                                                                                                                                  | Ton  | 570.00                        | 4.37     | 2491.47              |
| <b>FIXED COSTS</b>                                                                                                                                                                                                                                                                                                     |      |                               |          |                      |
| <b>LAND PREPARATION (labour)</b>                                                                                                                                                                                                                                                                                       |      |                               |          |                      |
| Construct basins                                                                                                                                                                                                                                                                                                       | Days | 15.00                         | 23.33    | 350.00               |
| <b>VARIABLE COSTS</b>                                                                                                                                                                                                                                                                                                  |      |                               |          |                      |
| <b>PREHARVEST</b>                                                                                                                                                                                                                                                                                                      |      |                               |          |                      |
| Planting                                                                                                                                                                                                                                                                                                               |      |                               |          |                      |
| Seed                                                                                                                                                                                                                                                                                                                   | kg   | 11.40                         | 4.00     | 45.60                |
| Labour                                                                                                                                                                                                                                                                                                                 | Days | 15.00                         | 8.12     | 121.80               |
| <b>FERTILISERS</b>                                                                                                                                                                                                                                                                                                     |      |                               |          |                      |
| Ammonium Nitrate                                                                                                                                                                                                                                                                                                       | kg   | 1.62                          | 142.86   | 260.51               |
| Superphosphate                                                                                                                                                                                                                                                                                                         | kg   | 1.79                          | 117.65   | 210.59               |
| <b>Pest Control</b>                                                                                                                                                                                                                                                                                                    |      |                               |          |                      |
| Bulking                                                                                                                                                                                                                                                                                                                | L    | 237.00                        | 0.10     | 23.70                |
| Application (labour)                                                                                                                                                                                                                                                                                                   | Days | 15.00                         | 5.78     | 86.70                |
| <b>Weed Control</b>                                                                                                                                                                                                                                                                                                    |      |                               |          |                      |
| Turbo                                                                                                                                                                                                                                                                                                                  | L    | 79.00                         | 1.50     | 119.40               |
| Application (labour)                                                                                                                                                                                                                                                                                                   | Days | 15.00                         | 6.00     | 90.00                |
| Hand weeding (labour)                                                                                                                                                                                                                                                                                                  | Days | 15.00                         | 5.64     | 84.60                |
| <b>MAINTENANCE (labour)</b>                                                                                                                                                                                                                                                                                            |      |                               |          |                      |
| Repair basins                                                                                                                                                                                                                                                                                                          | Days | 15.00                         | 6.00     | 90.00                |
| <b>HARVEST and POST HARVEST (labour)</b>                                                                                                                                                                                                                                                                               |      |                               |          |                      |
| Hand Harvesting                                                                                                                                                                                                                                                                                                        | Days | 15.00                         | 2.41     | 36.11                |
| Threshing                                                                                                                                                                                                                                                                                                              | Days | 15.00                         | 2.52     | 37.76                |
| Remove maize stems                                                                                                                                                                                                                                                                                                     | Days | 15.00                         | 1.61     | 24.12                |
| <b>Total Allocatable Costs</b>                                                                                                                                                                                                                                                                                         |      |                               |          | <b>1230.38</b>       |
| <b>Margin: allocatable variable costs</b>                                                                                                                                                                                                                                                                              |      |                               |          | <b>1261.09</b>       |
| <b>Total Pre harvest Costs</b>                                                                                                                                                                                                                                                                                         |      |                               |          | <b>1132.40</b>       |
| <b>Total Post harvest Costs</b>                                                                                                                                                                                                                                                                                        |      |                               |          | <b>97.98</b>         |
| <b>Gross margin of Total Allocatable Costs</b>                                                                                                                                                                                                                                                                         |      |                               |          | <b>1261.09</b>       |
| <b>FIXED COSTS</b>                                                                                                                                                                                                                                                                                                     |      |                               |          |                      |
| <b>LAND PREPARATION</b>                                                                                                                                                                                                                                                                                                |      |                               |          |                      |
| Construct basins (labour)                                                                                                                                                                                                                                                                                              | Days | 15.00                         | 10.35    | 155.25               |
| Fuel                                                                                                                                                                                                                                                                                                                   |      |                               |          | 90.00                |
| Repairs and maintenance                                                                                                                                                                                                                                                                                                |      |                               |          | 114.35               |
| <b>Total Fixed Costs</b>                                                                                                                                                                                                                                                                                               |      |                               |          | <b>359.60</b>        |
| Prices are for the base year like in experimental plots, 1999/2000<br>All activities done by hand and/or hand tools<br>Construction of water harvesting system done with the help of other villagers<br>Fertilisers applied by hand at time of planting<br>Chemical and hand control of weeds and pests                |      |                               |          |                      |

Table 5.5 summarizes the results (rounded off to the nearest Rand) of the gross margin analysis using enterprise budgets for maize in the study area. The different water harvesting techniques are compared with the conventional production technique used in the study area.

From Table 5.5, it can be seen that considerable increases in profits from maize production are obtained by the use of *IRWH* techniques as opposed to *CON*. For the on-station trials, *BbBr* resulted in a higher gross margin than *CON* and the increase is quite significant, R466 for *CON* against R1396 for *BbBr*. The increase in profits is R930, which is almost a 200 percent increase in returns. For the on-farm trials, the same is also true. In Feloane, *BbBr* resulted in profits of R1227 and R1577 for field trials and homestead gardens, respectively, as opposed to *CON*'s R908, while in Yoxford *CON* had negative profits (R253) and R511 and R1261, for field and homestead *BbBr*, respectively. It is worth noting that the homestead trials seemed to outperform the field trials. This might be due mainly to the fact that the homestead trials could be monitored more closely by the farmers as opposed to the field trials, which were managed collectively by the group of farmers.

The increases in profits are significant and positive (for both field trials and homestead garden trials) as a result of the use of *IRWH* techniques. It is important to note that the *BbBr* technique is the simplest *IRWH* technique, thus it implies that tremendous gains in profits will be made by the move from *CON* to *IRWH* techniques.

Moving onto other variations of *IRWH*, the highest profits were obtained with *ObSr* (R2191), then *SbSr* (R2168), followed by *ObOr* and *SbOr* with R2101 and R2079, respectively, and finally *BbBr* with R1446. In comparing the *IRWH* techniques, there are positive increases in profits as one moves from the simplest to the most complex technique. The subsequent increase in profits between the *IRWH* techniques are positive but not as drastic as those between moving from *CON* to *BbBr*. The increase from *BbBr* to *ObBr* is only R50 ha<sup>-1</sup>, from *ObBr* to *ObOr* is R655 ha<sup>-1</sup> whereas between *ObOr* and *SbOr*, is only R22. From *ObOr* to *SbSr*, the increase in profits is R90 ha<sup>-1</sup> and finally from *SbSr* to *ObSr* is R23 ha<sup>-1</sup>. From the results, the move from the simpler technique to a more advanced technique brings about significant gains in profits as observed between *BbBr* and *CON* and between *ObBr* and *ObOr*. These gains may be attributed to a better conservation of the water in the soil. In *ObBr*, the water that infiltrates into the runoff strip is not protected from evaporation and thus might be lost, but for *ObOr* the water is protected from evaporation both in the basins and the runoff strip and thus used for productive transpiration.

It is evident from the results that the use of *IRWH* techniques in the production of maize will result in significant gains in profitability. This will improve the household income generation/food production ability and thus may help in reducing food insecurity at the household level<sup>5</sup>.

**TABLE 5.5: GROSS MARGINS (R HA<sup>-1</sup>) FOR MAIZE PRODUCTION UNDER DIFFERENT TECHNIQUES FOR ON-STATION AND ON-FARM TRIALS FOR THREE PRODUCTION SEASONS**

| Place<br>Production technique | Gross Margin (R ha <sup>-1</sup> ) |
|-------------------------------|------------------------------------|
| Glen (on station)             |                                    |
| <i>CON</i>                    | 466                                |
| <i>BbBr</i>                   | 1396                               |
| <i>ObBr</i>                   | 1446                               |
| <i>ObOr</i>                   | 2101                               |
| <i>SbOr</i>                   | 2079                               |
| <i>SbSr</i>                   | 2168                               |
| <i>ObSr</i>                   | 2191                               |
| Feloane                       |                                    |
| Field                         |                                    |
| <i>CON</i>                    | 908                                |
| <i>BbBr</i>                   | 1227                               |
| Homestead gardens             |                                    |
| <i>BbBr</i>                   | 1577                               |
| Yoxford                       |                                    |
| Field                         |                                    |
| <i>CON</i>                    | -253                               |
| <i>BbBr</i>                   | 511                                |
| Homestead Gardens             |                                    |
| <i>BbBr</i>                   | 1261                               |

From Table 5.5 it can be seen that generally the on-station trials outperformed the on farm trials for those production techniques which were carried out on both trials (*CON* and *BbBr*). This may be explained by the fact that the on station trials were performed under almost ideal (experimental) conditions and that the researchers had already acquired some expertise on the techniques. The on farm trials, on the other hand, were

<sup>5</sup> While the present study uses maize grain as the marketed output, there is a possibility for farmers to increase profits by selling the maize as green *mielies* (fresh cobs). However, the market for that is quite



performed under the actual (farm) situations of uncertainty, limited resources and a relatively low level of expertise. It should be noted that the farmers who participated in the on farm trials were just at the beginning of their learning curve as the *IRWH* techniques were completely new production techniques in the study area. The difference in performance between the on station and on farm trials seems to persist across all crops used in the study, as the sections that follow will show. In spite of this difference, the *IRWH* techniques proved to outperform the conventional production techniques normally used by farmers for all crops.

### 5.2.2 Sunflower

The results for sunflower production are presented in the same format as those for maize above. The results are presented in Tables 5.6 to 5.10, the other tables can be found in Appendix A3. Tables 5.6 through 5.10 present examples of on-station sunflower production using *CON*, *BbBr* and *ObSr* and on-farm sunflower production using *BbBr*. Table 5.10 presents a summary of the gross margin analysis for all the on-station and on-farm CEBs for sunflower production.

Table 5.6 presents the average enterprise budget for the production of sunflower using the conventional production. The crop was produced in Glen in the Bloemfontein farming area, Free State Province, South Africa. The ecotope is the Glen Bonheim-Onrus having 45 percent clay content in the A-horizon. Production was during the 1999/2000, 2000/2001 and 2001/2002-production seasons. The cultivar planted was SNK 74 at a rate of 33 333 plants per hectare with a target yield of 1 750 kg ha<sup>-1</sup>.

On-station conventional production of sunflower yielded average gross receipts of R31 ha<sup>-1</sup> over the three years of the trials and average total directly allocatable variable costs (TDAVC) totalled R902 ha<sup>-1</sup>. The average TDAVC were calculated as in Table 5.1 as well as in all the other analyses of the CEBs. The calculated margin above TDAVC was R332.

The average TNDAVC were found to be R301 ha<sup>-1</sup>. The average total preharvest costs summed up to R1044 ha<sup>-1</sup> whereas the harvest and post harvest costs totalled R158 ha<sup>-1</sup>

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limited and will require certain ideal conditions. In addition, the analysis is based on market prices and there seems to be no defined market price for green *mielies*.

<sup>1</sup> giving a total of R1203 ha<sup>-1</sup>. The calculated gross margin above total allocatable costs is R31 ha<sup>-1</sup> for sunflower production under *CON*.

Compared to maize, sunflower gave lower returns. This might be explained by the fact that during the 1999/2000 and 2000/2001-production seasons, sunflower yields were very low compared to the 2001/2002-production season. It might imply that the first two seasons were unsuitable for sunflower. Another reason might be that the trials were done on virgin land that might have had soil borne diseases and pests that affected the sunflower yields. Nonetheless, sunflower showed improvements during the third season as the yield almost doubled from that of the previous two seasons.

With the above in mind and the results in Table 5.1, it can cautiously be deduced that conventional production of sunflower may not be a viable option in the study area as it has very low returns. However, the results from the table may not be conclusive as the trials were only carried out for three seasons. A longer trial period might result otherwise but going by the results conventional production of sunflower is not a viable option.

TABLE 5.6: ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION UNDER THE CON PRODUCTION TECHNIQUE IN GLEN DURING THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.

| GROSS MARGIN PER HA (R)                                               |      |                              |                          |            |
|-----------------------------------------------------------------------|------|------------------------------|--------------------------|------------|
| <b>SUNFLOWER</b>                                                      |      |                              |                          |            |
| Country: South Africa                                                 |      |                              |                          |            |
| Province: Free State                                                  |      |                              |                          |            |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                              |                          |            |
| Clay (%) in A-horizon: 45%                                            |      |                              |                          |            |
| Plant Population: 33 333 plants per hectare                           |      |                              |                          |            |
| Cultivar: SNK 74                                                      |      |                              |                          |            |
| Glen - Conventional                                                   |      |                              |                          |            |
| Farming area: Bloemfontein                                            |      |                              |                          |            |
| Target yield: 1 750Kg/ha                                              |      |                              |                          |            |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                              |                          |            |
|                                                                       | UNIT | PRICE OR<br>COST PER UNIT(R) | Average over three years |            |
|                                                                       |      |                              | Quantity                 | Cost/Value |
| Gross receipts from production                                        |      |                              |                          |            |
| Sunflower                                                             | Ton  | 1040.00                      | 1.19                     | 1234.83    |
| <b>VARIABLE COSTS</b>                                                 |      |                              |                          |            |
| <b>PREHARVEST :</b>                                                   |      |                              |                          |            |
| Planting                                                              |      |                              |                          |            |
| Seed                                                                  | Kg   | 23.37                        | 2.50                     | 58.43      |
| Labour                                                                | Days | 15.00                        | 6.25                     | 93.75      |
| <b>Fertilizers</b>                                                    |      |                              |                          |            |
| Ammonium Nitrate                                                      | Kg   | 1.82                         | 185.71                   | 337.99     |
| Superphosphate                                                        | Kg   | 1.79                         | 39.21                    | 70.19      |
| <b>Pest Control/Pesticides</b>                                        |      |                              |                          |            |
| Bulldog                                                               | L    | 237.00                       | 0.10                     | 23.70      |
| Application (labour)                                                  | Days | 15.00                        | 5.78                     | 86.70      |
| <b>Weed Control/Herbicides</b>                                        |      |                              |                          |            |
| Hand weeding (labour)                                                 | Days | 15.00                        | 4.85                     | 72.71      |
| <b>HARVEST AND POST HARVEST (labour)</b>                              |      |                              |                          |            |
| Hand Harvesting                                                       | Days | 15.00                        | 4.86                     | 72.83      |
| Threshing                                                             | Days | 15.00                        | 2.12                     | 31.78      |
| Remove sunflower stems                                                | Days | 15.00                        | 3.61                     | 54.10      |
| <b>Total Directly Allocatable Variable Costs</b>                      |      |                              |                          | 902.17     |
| <b>Margin Above Total Directly Allocatable Variable Costs</b>         |      |                              |                          | 332.66     |
| <b>Non Directly Allocatable Variable Costs</b>                        |      |                              |                          | 301.38     |
| Energy                                                                |      |                              |                          | 171.64     |
| Repairs and maintenance                                               |      |                              |                          | 129.74     |
| <b>Total Pre harvest Costs</b>                                        |      |                              |                          | 1044.85    |
| <b>Total Harvest and Post harvest Costs</b>                           |      |                              |                          | 158.70     |
| <b>Gross Margin Above Total Allocatable Costs</b>                     |      |                              |                          | 31.28      |
| Prices are for the base year, 1999/2000                               |      |                              |                          |            |
| All activities done by hand and/or hand tools except soil preparation |      |                              |                          |            |
| Fertilisers applied by hand at time of planting                       |      |                              |                          |            |
| Chemical and hand control of weeds and pests                          |      |                              |                          |            |

Table 5.7 presents the average enterprise budget for sunflower production using the *BbBr* technique. When using this technique, sunflower production shows an improvement in yield from 1.19 ton ha<sup>-1</sup> to 1.62 ton ha<sup>-1</sup>. The latter translates to average gross receipts of R1681 ha<sup>-1</sup> and gross margin (profit) of R641 ha<sup>-1</sup>. The *BbBr* enterprise budget does not make a distinction between directly and non-directly allocatable costs for the same reason that was advanced earlier on in the discussion of

maize. The cost of setting up the *BbBr* system for sunflower is R359 as shown at the bottom of the CEB.

**TABLE 5.7: ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION UNDER THE *BBBR* PRODUCTION TECHNIQUE IN GLEN DURING THE 1999/2000, 2000/2001 AND 2001/2002 PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                              |                      |                |
|-----------------------------------------------------------------------|------|------------------------------|----------------------|----------------|
| <b>SUNFLOWER</b>                                                      |      |                              |                      |                |
| Country: South Africa                                                 |      |                              |                      |                |
| Province: Free State                                                  |      |                              |                      |                |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                              |                      |                |
| Clay (%) in A-horizon: 45%                                            |      |                              |                      |                |
| Plant Population: 33 333 plants per hectare                           |      |                              |                      |                |
| Cultivar: SNK 74                                                      |      |                              |                      |                |
| Glen - Bare basins and bare runoff strip                              |      |                              |                      |                |
| Farming area: Bloemfontein                                            |      |                              |                      |                |
| Target yield: 1 750Kg/ha                                              |      |                              |                      |                |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                              |                      |                |
|                                                                       | UNIT | PRICE OR<br>COST PER UNIT(R) | Average over 3 years |                |
|                                                                       |      |                              | Quantity             | Cost           |
| Gross receipts from production                                        |      |                              |                      |                |
| Sunflower                                                             | Ton  | 1040.00                      | 1.62                 | 1681.33        |
| <b>VARIABLE COSTS</b>                                                 |      |                              |                      |                |
| <b>PREHARVEST :</b>                                                   |      |                              |                      |                |
| <b>Planting</b>                                                       |      |                              |                      |                |
| Seed                                                                  | Kg   | 23.37                        | 2.50                 | 58.43          |
| Labour                                                                | Days | 15.00                        | 6.25                 | 93.75          |
| <b>Fertilizers</b>                                                    |      |                              |                      |                |
| Ammonium Nitrate                                                      | Kg   | 1.82                         | 185.71               | 337.99         |
| Superphosphate                                                        | Kg   | 1.79                         | 39.21                | 70.19          |
| <b>Pest Control/Pesticides</b>                                        |      |                              |                      |                |
| Bulldog                                                               | L    | 237.00                       | 0.10                 | 23.70          |
| Application (labour)                                                  | Days | 15.00                        | 5.78                 | 86.70          |
| <b>Weed Control/Herbicides</b>                                        |      |                              |                      |                |
| Hand weeding (labour)                                                 | Days | 15.00                        | 5.24                 | 78.53          |
| <b>Maintenance (labour)</b>                                           |      |                              |                      |                |
| Repair basins                                                         | Days | 15.00                        | 4.99                 | 74.83          |
| <b>HARVEST and POST HARVEST (labour)</b>                              |      |                              |                      |                |
| Hand Harvesting                                                       | Days | 15.00                        | 6.62                 | 99.27          |
| Threshing                                                             | Days | 15.00                        | 2.68                 | 40.20          |
| Remove sunflower stems                                                | Days | 15.00                        | 4.91                 | 73.70          |
| <b>Total Allocatable Variable Costs</b>                               |      |                              |                      | <b>1040.28</b> |
| <b>Margin Above Total Allocatable Variable Costs</b>                  |      |                              |                      | <b>641.06</b>  |
| <b>Total Pre harvest Costs</b>                                        |      |                              |                      |                |
|                                                                       |      |                              |                      | <b>824.11</b>  |
| <b>Total Harvest and Post harvest Costs</b>                           |      |                              |                      | <b>216.16</b>  |
| <b>Gross Margin Above Total Allocatable Variable Costs</b>            |      |                              |                      | <b>641.06</b>  |
| <b>FIXED COSTS</b>                                                    |      |                              |                      |                |
| <b>LAND PREPARATION</b>                                               |      |                              |                      |                |
| Construct basins (labour)                                             | Days | 15.00                        | 10.35                | 155.25         |
| Energy                                                                |      |                              |                      | 90.00          |
| Repairs and maintenance                                               |      |                              |                      | 114.35         |
| <b>Total Fixed Costs</b>                                              |      |                              |                      | <b>359.60</b>  |
| Prices are for the base year , 1999/2000                              |      |                              |                      |                |
| All activities done by hand and/or hand tools except soil preparation |      |                              |                      |                |
| Fertilisers applied by hand at time of planting                       |      |                              |                      |                |
| Chemical and hand control of weeds and pests                          |      |                              |                      |                |

As with the production of maize using *ObSr*, sunflower (Table 5.8) also shows improvements in production from *CON* and *BbBr*. *ObSr* has a gross margin of R1371

ha<sup>-1</sup> compared to R31 ha<sup>-1</sup> and R641 ha<sup>-1</sup> for *CON* and *BbBr*, respectively. It should be pointed out that while *ObSr* gives better returns from production than the other techniques, it has higher costs of establishment than all the techniques as shown by the enterprise budget. The cost seems to be worthwhile as there are good returns (higher profits) in the short term but this can only be ascertained by the long-term economic viability (a subject to be discussed later). This means that in the short term it will be more profitable to produce sunflower using the *IRWH* techniques as opposed to conventional production technique. As with the other techniques when compared to maize, sunflower still yields lower returns even though its price per ton is higher than that of maize.

**TABLE 5.8: ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION UNDER THE OBSR PRODUCTION TECHNIQUE IN GLEN DURING THE 1999/2000, 2000/2001 AND 2001/2002 – PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                  |                          |            |
|-----------------------------------------------------------------------|------|------------------|--------------------------|------------|
| SUNFLOWER                                                             |      |                  |                          |            |
| Country: South Africa                                                 |      |                  |                          |            |
| Province: Free State                                                  |      |                  |                          |            |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                  |                          |            |
| Clay (%) in A-horizon: 45%                                            |      |                  |                          |            |
| Plant Population: 33 333 plants per hectare                           |      |                  |                          |            |
| Cultivar: SNK 74                                                      |      |                  |                          |            |
| Glen - Organic mulch in the basins and stone mulch in runoff strip    |      |                  |                          |            |
| Farming area: Bloemfontein                                            |      |                  |                          |            |
| Target yield: 1 750Kg/ha                                              |      |                  |                          |            |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                  |                          |            |
|                                                                       | UNIT | PRICE OR         | Average over three years |            |
|                                                                       |      | COST PER UNIT(R) | Quantity                 | Cost/Value |
| Gross receipts from production                                        |      |                  |                          |            |
| Sunflower                                                             | Ton  | 1040.00          | 2.37                     | 2461.33    |
| VARIABLE COSTS                                                        |      |                  |                          |            |
| PREHARVEST:                                                           |      |                  |                          |            |
| Planting                                                              |      |                  |                          |            |
| Seed                                                                  | Kg   | 23.37            | 2.50                     | 58.43      |
| Labour                                                                | Days | 15.00            | 6.25                     | 93.75      |
| Fertilizers                                                           |      |                  |                          |            |
| Ammonium Nitrate                                                      | Kg   | 1.82             | 185.71                   | 337.99     |
| Superphosphate                                                        | Kg   | 1.79             | 39.21                    | 70.19      |
| Pest Control/Pesticides                                               |      |                  |                          |            |
| Bulldog                                                               | L    | 237.00           | 0.10                     | 23.70      |
| Application (labour)                                                  | Days | 15.00            | 5.78                     | 86.70      |
| Weed Control/Herbicides                                               |      |                  |                          |            |
| Hand weeding (labour)                                                 | Days | 15.00            | 4.07                     | 61.10      |
| Maintenance (labour)                                                  |      |                  |                          |            |
| Repair basins                                                         | Days | 15.00            | 2.79                     | 41.83      |
| HARVEST and POST HARVEST (labour)                                     |      |                  |                          |            |
| Hand harvesting                                                       | Days | 15.00            | 9.67                     | 145.05     |
| Threshing                                                             | Days | 15.00            | 4.22                     | 63.29      |
| Remove sunflower stems                                                | Days | 15.00            | 7.18                     | 107.72     |
| Total Allocatable Variable Costs                                      |      |                  |                          | 1089.74    |
| Margin Above Allocatable Variable costs                               |      |                  |                          | 1371.59    |
| Total Pre harvest Costs                                               |      |                  |                          | 773.69     |
| Total Harvest and Post harvest Costs                                  |      |                  |                          | 316.65     |
| Gross Margin Above Total Allocatable Costs                            |      |                  |                          | 1371.59    |
| FIXED COSTS                                                           |      |                  |                          |            |
| LAND PREPARATION                                                      |      |                  |                          |            |
| Energy                                                                |      |                  |                          | 90.00      |
| Repair and maintenance                                                |      |                  |                          | 114.35     |
| Construct basins (labour)                                             | Days | 15.00            | 10.35                    | 155.25     |
| Pack stones (labour)                                                  | Days | 15.00            | 8.72                     | 130.80     |
| Pack mulch (labour)                                                   | Days | 15.00            | 3.86                     | 57.85      |
| Total Fixed Costs                                                     |      |                  |                          | 548.25     |
| Prices are for the base year, 1999/2000                               |      |                  |                          |            |
| All activities done by hand and/or hand tools except soil preparation |      |                  |                          |            |
| Fertilisers applied by hand at time of planting                       |      |                  |                          |            |
| Chemical and hand control of weeds and pests                          |      |                  |                          |            |

**TABLE 5.9: ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION UNDER THE *BBR* PRODUCTION TECHNIQUE IN FELOANE DURING THE 2001/2002-PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                                       |      |                              |          |                      |
|-------------------------------------------------------------------------------|------|------------------------------|----------|----------------------|
| <b>SUNFLOWER</b>                                                              |      |                              |          |                      |
| Country: South Africa                                                         |      |                              |          |                      |
| Province: Free State                                                          |      |                              |          |                      |
| Ecotope: Glen/Bonheim-Onrus                                                   |      |                              |          |                      |
| Clay (%) in A-horizon: 45%                                                    |      |                              |          |                      |
| Plant Population: 33 333 plants per hectare                                   |      |                              |          |                      |
| Cultivar: SHK 74                                                              |      |                              |          |                      |
| Planting date: 29/11/2001                                                     |      |                              |          |                      |
| Season: 2001/2002                                                             |      |                              |          |                      |
| Feloane- Bare basins and runoff strip                                         |      |                              |          |                      |
| Farming area: Thaba Nchu/Bioemfontein                                         |      |                              |          |                      |
| Target yield: 1 750kg/ha                                                      |      |                              |          |                      |
|                                                                               | UNIT | PRICE OR<br>COST PER UNIT(R) | QUANTITY | Value or Cost per ha |
| Gross receipts from production<br>sunflower                                   | Ton  | 1040.00                      | 2.19     | 2277.60              |
| <b>VARIABLE COSTS</b>                                                         |      |                              |          |                      |
| <b>PREHARVEST :</b>                                                           |      |                              |          |                      |
| <b>Planting</b>                                                               |      |                              |          |                      |
| Seed                                                                          | Kg   | 23.37                        | 2.50     | 58.43                |
| Labour                                                                        | Days | 15.00                        | 6.25     | 93.75                |
| <b>Fertilisers</b>                                                            |      |                              |          |                      |
| Ammonium Nitrate                                                              | Kg   | 1.62                         | 189.28   | 344.49               |
| Superphosphate                                                                | Kg   | 1.79                         | 58.62    | 105.29               |
| <b>Pest Control</b>                                                           |      |                              |          |                      |
| Bulldog                                                                       | L    | 237.00                       | 0.10     | 23.70                |
| Application (labour)                                                          | Days | 15.00                        | 5.78     | 86.70                |
| <b>Weed Control</b>                                                           |      |                              |          |                      |
| Hand weeding (labour)                                                         | Days | 15.00                        | 5.32     | 79.80                |
| <b>Maintenance (labour)</b>                                                   |      |                              |          |                      |
| Repair basins                                                                 | Days | 15.00                        | 4.99     | 74.85                |
| <b>HARVEST AND POST HARVEST (labour)</b>                                      |      |                              |          |                      |
| Hand Harvest                                                                  | Days | 15.00                        | 8.97     | 134.48               |
| Threshing                                                                     | Days | 15.00                        | 3.90     | 58.51                |
| Remove sunflower stems                                                        | Days | 15.00                        | 6.66     | 99.83                |
| Total Allocatable Variable Costs                                              |      |                              |          | 1159.83              |
| Margin Above Allocatable Variable Costs                                       |      |                              |          | 1117.77              |
| <b>Total Pre harvest Costs</b>                                                |      |                              |          |                      |
|                                                                               |      |                              |          | 867.00               |
| <b>Total Harvest and Post Harvest Costs</b>                                   |      |                              |          |                      |
|                                                                               |      |                              |          | 292.82               |
| <b>Gross Margin Above Total Allocatable Costs</b>                             |      |                              |          |                      |
|                                                                               |      |                              |          | 1117.77              |
| <b>FIXED COSTS</b>                                                            |      |                              |          |                      |
| <b>LAND PREPARATION</b>                                                       |      |                              |          |                      |
| Construct basins (labour)                                                     | Days | 15.00                        | 10.35    | 155.25               |
| Energy                                                                        |      |                              |          | 90.00                |
| Repairs and maintenance                                                       |      |                              |          | 114.35               |
| Total Fixed Costs                                                             |      |                              |          | 359.60               |
| Prices are for the base year like in experimental plots, 1999/2000            |      |                              |          |                      |
| All activities done by hand and/or hand tools                                 |      |                              |          |                      |
| Construction of water harvesting system done with the help of other villagers |      |                              |          |                      |
| Fertilisers applied by hand at time of planting                               |      |                              |          |                      |
| Chemical and hand control of weeds and pests                                  |      |                              |          |                      |

On farm production of sunflower (Table 5.9) using *BbBr*, shows better returns than was the case with on station production. The gross margin from production is R1117 ha<sup>-1</sup> compared to R641 ha<sup>-1</sup> for the on station *BbBr* production. As pointed out earlier this discrepancy might be to the same reasons as above. It is worth mentioning that for the same production period as the one for on farm trials, sunflower actually yielded a better yield and hence returns than the on farm *BbBr*. This is not easily seen since the

on farm CEBs are an average for three seasons. For both on farm and on station *BbBr*, the costs of establishing the *IRWH* system are the same (R359 ha<sup>-1</sup>).

**TABLE 5.10: GROSS MARGINS (R HA<sup>-1</sup>) FOR SUNFLOWER UNDER DIFFERENT PRODUCTION TECHNIQUES FOR ON-STATION AND ON-FARM TRIALS FOR THREE PRODUCTION SEASONS**

| Place<br>Production technique | Gross Margin (R ha <sup>-1</sup> ) |
|-------------------------------|------------------------------------|
| Glen (On station)             |                                    |
| <i>CON</i>                    | 31                                 |
| <i>BbBr</i>                   | 641                                |
| <i>ObBr</i>                   | 762                                |
| <i>ObOr</i>                   | 881                                |
| <i>SbOr</i>                   | 983                                |
| <i>SbSr</i>                   | 985                                |
| <i>ObSr</i>                   | 1372                               |
| Feloane (field) (On farm)     |                                    |
| <i>CON</i>                    | -1                                 |
| <i>BbBr</i>                   | 1118                               |
| Paradys (field)               |                                    |
| <i>CON</i>                    | 227                                |
| <i>BbBr</i>                   | 1077                               |

Table 5.10 presents a summary of all the gross margins (to the nearest Rand) for all the techniques used in the on station and on farm trials. The trend is the same as that for maize. There are significant gains in profits as one moves from conventional to *IRWH*. This is showcased by the difference in profits between *CON* and *BbBr*, the simplest *IRWH* technique. The increase in profits is R610, which is equivalent to about twenty folds more than *CON*.

Amongst the *IRWH* techniques, significant gains in profitability are gained from *CON* to *ObSr*, but for the *IRWH* techniques in between the gains are not as drastic even though there are some exceptions. A move from *BbBr* to *ObBr* results in an increase of R121 ha<sup>-1</sup> while from *ObBr* to *SbOr* it is R221 ha<sup>-1</sup>. The difference between *SbOr* and *ObOr* is only R102 ha<sup>-1</sup>. Further significant gains in profits are made between *ObOr* and *SbSr* and between *SbSr* and *ObSr*. The latter is peculiar to sunflower, as in



the case of maize there was not such a drastic increase in profits between the two techniques.

For the on farm trials, there were drastic and significant gains in profits from *CON* to *BbBr*. In Feloane, *CON* yielded a loss of about R1 but *BbBr* yielded a gross margin of R1118 while in Paradys the techniques each yielded R227 and R1077, respectively

. On farm *BbBr* profits are close to those of on station *ObSr*. While these may be a positive indication, the on farm trials were only performed for one season (2001/2002) and the on farm trials were done over three seasons and the average used to determine the enterprise budgets. Secondly, the first two seasons prior to 2001/2002 resulted in poor yields for the on station trials whilst the 2001/2002 season experienced a drastic and significant increase in sunflower yields. From the foregoing, the results should be interpreted cautiously since in general the 2001/2002 season was favourable for sunflower compared to prior seasons.

Similar to maize, significant gains in profitability are made by the move from conventional to *IRWH* techniques, and *ObSr* increases profits the most (in the short term). Another important point to note is that the TDAVC do not differ a lot between the techniques, but the establishment costs do increase as we move from the simplest *IRWH* technique (*BbBr*) to the most complex (*ObSr*). The profits also tend to increase in the same direction as the establishment costs. Long-term economic analysis will show whether it will be worth investing in the establishment of the more complex *IRWH* techniques.

### 5.2.3 Dry beans

The results for dry beans production are also discussed in the same format as those for maize and sunflower above. Three average CEBs for on station dry beans production and one on farm CEB will be presented and a gross margin summary table is presented. The CEBs are for the same techniques as those for the other two crops above. Appendix A4 presents the rest of the crop enterprise budgets for the other *IRWH* techniques on farm and on station. The on station trials were also in Glen on the same ecotope and the on farm trial was on the same ecotope as the other on farm trial, the only difference will be the specific village in which the trial was performed. This means that in the discussion of the dry beans enterprise budgets only new information will be discussed.

Table 5.11 presents an average CEB for the production of dry beans using the *CON*. The gross margin from production is R658 ha<sup>-1</sup>, which is higher than that from sunflower. Total directly allocatable variable costs amounted to R1226 ha<sup>-1</sup> while the gross receipts were R1885 ha<sup>-1</sup>, thus giving a margin above total directly allocatable variable costs of R658 ha<sup>-1</sup>.

While the actual yield from production was very low (0.65 ton ha<sup>-1</sup>) compared to the target yield (1.5 ton ha<sup>-1</sup>), the higher price of beans R2900 ton<sup>-1</sup> helps to get the profits positive. This implies that even though dry beans have the potential to reward farmers better than sunflower and maize, conventional production may erode that potential.

**TABLE 5.11: ENTERPRISE BUDGET FOR DRY BEANS PRODUCTION UNDER THE CON PRODUCTION TECHNIQUE IN GLEN DURING THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                                |                      |         |
|-----------------------------------------------------------------------|------|--------------------------------|----------------------|---------|
| Glen- Conventional                                                    |      |                                |                      |         |
| Farming area: Bloemfontein                                            |      |                                |                      |         |
| Target yield: 1500kg/ha                                               |      |                                |                      |         |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                                |                      |         |
|                                                                       | UNIT | PRICE OR<br>(COST PER UNIT(R)) | Average over 3 years |         |
|                                                                       |      |                                | Quantity             | Cost    |
| Gross receipts from production                                        |      |                                |                      |         |
| Beans                                                                 | Ton  | 2960.00                        | 0.65                 | 1885.00 |
| =                                                                     |      |                                |                      |         |
| VARIABLE COSTS                                                        |      |                                |                      |         |
| PREHARVEST                                                            |      |                                |                      |         |
| PLANTING                                                              |      |                                |                      |         |
| Seed                                                                  | kg   | 11.76                          | 60.00                | 705.60  |
| Labour                                                                | Days | 15.00                          | 8.50                 | 127.50  |
| FERTILISERS                                                           |      |                                |                      |         |
| Ammonium Nitrate                                                      | kg   | 1.82                           | 62.96                | 114.58  |
| Superphosphate                                                        | kg   | 1.79                           | 39.21                | 70.19   |
| PEST CONTROL/PESTICIDES                                               |      |                                |                      |         |
| Metolachlor                                                           | L    | 87.80                          | 0.50                 | 43.90   |
| Application (labour)                                                  | Days | 15.00                          | 0.64                 | 9.60    |
| WEED CONTROL/HERBICIDES                                               |      |                                |                      |         |
| Hand weeding (labour)                                                 | Days | 15.00                          | 3.47                 | 52.05   |
| HARVEST and POST HARVEST (labour)                                     |      |                                |                      |         |
| Hand Harvesting                                                       | Days | 15.00                          | 1.75                 | 26.25   |
| Threshing                                                             | Days | 15.00                          | 1.15                 | 17.25   |
| Remove beans stems                                                    | Days | 15.00                          | 3.90                 | 58.50   |
|                                                                       |      |                                |                      |         |
| Total Directly Allocatable Variable Costs                             |      |                                |                      | 1226.55 |
| Margin above Directly Allocatable Variable Costs                      |      |                                |                      | 658.45  |
| Non Directly Allocatable variable Costs                               |      |                                |                      |         |
| Energy                                                                |      |                                |                      | 171.64  |
| Maintenance and Repairs                                               |      |                                |                      | 129.74  |
|                                                                       |      |                                |                      |         |
| Total Preharvest Costs                                                |      |                                |                      | 1123.70 |
| Total Harvest and Postharvest Costs                                   |      |                                |                      | 162.85  |
| Gross Margin Above Total Allocatable Costs                            |      |                                |                      | 658.45  |
| Prices are for the base year - 1999/2000                              |      |                                |                      |         |
| All activities done by hand and/or hand tools except soil preparation |      |                                |                      |         |
| Fertilisers applied by hand at time of planting                       |      |                                |                      |         |
| Chemical and hand control of weeds and pests                          |      |                                |                      |         |

By the use of *BbBr* (Table 5.12), the returns from dry beans production increased tremendously as opposed to the other two crops. *BbBr* gives a profit (GM) of R1191, the increase translates to almost two folds increase in profits above *CON*. The increase, however, is less than that observed for both maize and sunflower. As with the other crops (sunflower and maize), there is a significant increase in profits by moving from conventional to *IRWH*.

TABLE 5.12: ENTERPRISE BUDGET FOR DRY BEANS PRODUCTION UNDER THE *BBBr* PRODUCTION TECHNIQUE IN GLEN DURING THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASON.

| GROSS MARGIN PER HA (R)                                               |      |                            |                          |            |
|-----------------------------------------------------------------------|------|----------------------------|--------------------------|------------|
| Glen- Bare basins and runoff strip                                    |      |                            |                          |            |
| Farming area: Bloemfontein                                            |      |                            |                          |            |
| Target yield: 1500kg/ha                                               |      |                            |                          |            |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                            |                          |            |
| DRY BEANS                                                             | UNIT | PRICE OR COST PER UNIT (R) | Average over three years |            |
|                                                                       |      |                            | Quantity                 | Cost/Value |
| Gross receipts from production                                        |      |                            |                          |            |
| Beans                                                                 | Ton  | 2900.00                    | 0.63                     | 2397.43    |
| VARIABLE COSTS                                                        |      |                            |                          |            |
| PREHARVEST :                                                          |      |                            |                          |            |
| Planting                                                              |      |                            |                          |            |
| Seed                                                                  | Kg   | 11.76                      | 60.00                    | 705.60     |
| Labour                                                                | Days | 15.00                      | 8.50                     | 127.53     |
| Fertilisers                                                           |      |                            |                          |            |
| Ammonium Nitrate                                                      | Kg   | 1.82                       | 62.96                    | 114.58     |
| Superphosphate                                                        | Kg   | 1.79                       | 39.21                    | 70.19      |
| Pest Control/Pesticides                                               |      |                            |                          |            |
| Metasystox                                                            | L    | 87.80                      | 0.50                     | 43.90      |
| Application (labour)                                                  | Days | 15.00                      | 0.35                     | 5.30       |
| Weed Control                                                          |      |                            |                          |            |
| Hand weeding (labour)                                                 | Days | 15.00                      | 2.18                     | 32.67      |
| Maintenance (labour)                                                  |      |                            |                          |            |
| Repair basins                                                         | Days | 15.00                      | 2.34                     | 35.10      |
| HARVEST AND POST HARVEST (labour)                                     |      |                            |                          |            |
| Hand Harvesting                                                       | Days | 15.00                      | 2.68                     | 40.14      |
| Threshing                                                             | Days | 15.00                      | 1.46                     | 21.94      |
| Remove beans stems                                                    | Days | 15.00                      | 0.63                     | 9.43       |
| Total Allocatable Variable Costs                                      |      |                            |                          | 1206.35    |
| Gross Margin Above Allocatable Variable Costs                         |      |                            |                          | 1191.08    |
| Total Pre harvest Costs                                               |      |                            |                          | 1134.87    |
| Total Harvest and Post harvest Costs                                  |      |                            |                          | 71.48      |
| Gross Margin Above Total Allocatable Costs                            |      |                            |                          | 1191.08    |
| FIXED COSTS                                                           |      |                            |                          |            |
| LAND PREPARATION                                                      |      |                            |                          |            |
| Construct basins (labour)                                             | Days | 15.00                      | 10.35                    | 155.25     |
| Energy                                                                |      |                            |                          | 90.00      |
| Repairs and maintenance                                               |      |                            |                          | 114.35     |
| Total Fixed Costs                                                     |      |                            |                          | 359.60     |
| Prices are for the base year , 1999/2000                              |      |                            |                          |            |
| All activities done by hand and/or hand tools except soil preparation |      |                            |                          |            |
| Fertilisers applied by hand at time of planting                       |      |                            |                          |            |
| Chemical and hand control of weeds and pests                          |      |                            |                          |            |

The use of the *ObSr* technique (Table 5.13) also shows the same trend as with the other crops. In terms of the cost of setting up the system the costs are also the same as those for maize and sunflower. The gross margin from production is R1655 ha<sup>-1</sup> compared to *BbBr*'s R1191, an increase of about R500 ha<sup>-1</sup>.

**TABLE 5.13: ENTERPRISE BUDGET FOR DRY BEANS PRODUCTION UNDER THE *OBSR* PRODUCTION TECHNIQUE IN GLEN DURING THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                               |      |                           |          |                                     |
|-----------------------------------------------------------------------|------|---------------------------|----------|-------------------------------------|
| Glen: Organic mulch in the beans and stone mulch in runoff strips     |      |                           |          |                                     |
| Country: South Africa                                                 |      |                           |          |                                     |
| Province: Free State                                                  |      |                           |          |                                     |
| Ecotope: Glen/Bonhem-Onrus                                            |      |                           |          |                                     |
| Clay (% in A horizon): 45%                                            |      |                           |          |                                     |
| Plant Population: 13 333 plants per hectare                           |      |                           |          |                                     |
| Cultivar: PAN 140                                                     |      |                           |          |                                     |
| Target yield: 1500kg/ha                                               |      |                           |          |                                     |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                           |          |                                     |
|                                                                       | UNIT | PRICE OR COST PER UNIT(R) | Quantity | Average over three years Cost/Value |
| Gross receipts from production                                        |      |                           |          |                                     |
| Beans                                                                 | Ton  | 2400.00                   | 0.96     | 2362.47                             |
| VARIABLE COSTS                                                        |      |                           |          |                                     |
| PRE-HARVEST:                                                          |      |                           |          |                                     |
| Planting                                                              |      |                           |          |                                     |
| Seed                                                                  | kg   | 11.70                     | 60.00    | 702.00                              |
| Labour                                                                | Days | 16.00                     | 4.87     | 77.92                               |
| Fertilisers                                                           |      |                           |          |                                     |
| Ammonium Nitrate                                                      | kg   | 1.62                      | 42.96    | 114.58                              |
| Superphosphate                                                        | kg   | 1.79                      | 29.27    | 70.19                               |
| Pest Control/Pesticides                                               |      |                           |          |                                     |
| Molinate                                                              | L    | 27.80                     | 0.50     | 43.50                               |
| Application (labour)                                                  | Days | 10.00                     | 0.40     | 4.00                                |
| Weed Control/Herbicides                                               |      |                           |          |                                     |
| Hand weeding (labour)                                                 | Days | 15.00                     | 2.15     | 32.67                               |
| Maintenance (labour)                                                  |      |                           |          |                                     |
| Repair bulks                                                          | Days | 10.00                     | 2.27     | 22.70                               |
| HARVEST AND POST HARVEST (labour)                                     |      |                           |          |                                     |
| Harvest (labour)                                                      | Days | 10.00                     | 3.10     | 31.00                               |
| Threshing                                                             | Days | 10.00                     | 1.73     | 17.30                               |
| Remove beans stone                                                    | Days | 10.00                     | 0.74     | 7.40                                |
| Total Allocatable Variable Costs                                      |      |                           |          | 1186.97                             |
| Margin Above Allocatable Variable Costs                               |      |                           |          | 1655.50                             |
| Total Pre harvest Costs                                               |      |                           |          | 9381.29                             |
| Total Harvest and Post harvest Costs                                  |      |                           |          | 905.77                              |
| Gross Margin Above Total Allocatable Variable Costs                   |      |                           |          | 1655.50                             |
| FIXED COSTS                                                           |      |                           |          |                                     |
| LAND PREPARATION                                                      |      |                           |          |                                     |
| Energy                                                                |      |                           |          | 90.00                               |
| Repairs and maintenance                                               |      |                           |          | 114.29                              |
| Construct bulks (labour)                                              | Days | 10.00                     | 10.35    | 103.50                              |
| Rack stones (labour)                                                  | Days | 10.00                     | 8.72     | 87.20                               |
| Rack mulch (labour)                                                   | Days | 10.00                     | 3.66     | 36.60                               |
| Total Fixed Costs                                                     |      |                           |          | 548.25                              |
| Prices are for the base year - 1999/2000                              |      |                           |          |                                     |
| All activities done by hand and/or hand tools except soil preparation |      |                           |          |                                     |
| Fertilisers applied by hand at time of planting                       |      |                           |          |                                     |
| Chemicals and hand control of weeds and pests                         |      |                           |          |                                     |

On farm production, in Feloane, of dry beans under *BbBr* (Table 5.14), resulted in a gross margin of R1556 ha<sup>-1</sup>. The value is close to R400 more than for the same technique in the on station trials, even though most of the activities were the same for both trials. This implies that the technique avails the farmers an opportunity for better returns and thus an improved ability to provide for his/her family.

**TABLE 5.14: ENTERPRISE BUDGET FOR DRY BEANS PRODUCTION UNDER THE BBBR PRODUCTION TECHNIQUE IN FELOANE DURING THE 2001/2002-PRODUCTION SEASON**

| GROSS MARGIN PER HA (R)                                                       |      |                              |          |                      |
|-------------------------------------------------------------------------------|------|------------------------------|----------|----------------------|
| Feloane - Bare basins and hand till                                           |      |                              |          |                      |
| Farming area: Thaba Nchu/Bloemfontein                                         |      |                              |          |                      |
| Country: South Africa                                                         |      |                              |          |                      |
| Province: Free State                                                          |      |                              |          |                      |
| Ecotope: Gen/Bonhem-Onrus                                                     |      |                              |          |                      |
| Clay (% in A-horizon): 45%                                                    |      |                              |          |                      |
| Plant Population: 13 333 plants per hectare                                   |      |                              |          |                      |
| Target yield: 1500kg/ha                                                       |      |                              |          |                      |
| Cultivar: PAN 148                                                             |      |                              |          |                      |
| Planting date: 11/12/2001                                                     |      |                              |          |                      |
| Season: 2001/2002                                                             |      |                              |          |                      |
|                                                                               | UNIT | PRICE OR<br>COST PER UNIT(R) | QUANTITY | Value or Cost per ha |
| Gross receipts from production                                                |      |                              |          |                      |
| Beans                                                                         | Ton  | 2900.00                      | 1.03     | 2987.00              |
| ALLOCATABLE VARIABLE COSTS                                                    |      |                              |          |                      |
| PRE-HARVEST :                                                                 |      |                              |          |                      |
| Planting                                                                      |      |                              |          |                      |
| Seed                                                                          | Kg   | 11.76                        | 60.00    | 705.60               |
| Labour                                                                        | Days | 15.00                        | 8.13     | 121.95               |
| Fertilisers                                                                   |      |                              |          |                      |
| Ammonium Nitrate                                                              | Kg   | 1.82                         | 62.96    | 114.58               |
| Superphosphate                                                                | Kg   | 1.75                         | 35.21    | 70.19                |
| Pest Control                                                                  |      |                              |          |                      |
| Miconazole                                                                    | L    | 87.80                        | 0.50     | 43.90                |
| Application (labour)                                                          | Days | 15.00                        | 1.75     | 26.00                |
| Weed Control                                                                  |      |                              |          |                      |
| Hand weeding (labour)                                                         | Days | 15.00                        | 4.31     | 64.65                |
| Maintenance (labour)                                                          |      |                              |          |                      |
| Repair basins                                                                 | Days | 15.00                        | 10.56    | 158.33               |
| HARVEST and POST HARVEST (labour)                                             |      |                              |          |                      |
| Hand Harvesting                                                               | Days | 15.00                        | 4.83     | 72.49                |
| Threshing                                                                     | Days | 15.00                        | 1.82     | 27.33                |
| Remove beans stems                                                            | Days | 15.00                        | 1.68     | 25.20                |
| Total Allocatable Costs                                                       |      |                              |          | 1430.23              |
| Margin Above Allocatable Variable Costs                                       |      |                              |          | 1556.77              |
| Total Pre-harvest Costs                                                       |      |                              |          | 1305.21              |
| Total Post harvest Costs                                                      |      |                              |          | 125.02               |
| Gross Margin Above Total Allocatable Costs                                    |      |                              |          | 1556.77              |
| FIXED COSTS                                                                   |      |                              |          |                      |
| LAND PREPARATION                                                              |      |                              |          |                      |
| Construct basins (labour)                                                     | Days | 15.00                        | 10.33    | 155.25               |
| Energy                                                                        |      |                              |          | 90.00                |
| Repairs and maintenance                                                       |      |                              |          | 114.35               |
| Total Fixed Costs                                                             |      |                              |          | 359.60               |
| Prices are for the base year - 1999/2000                                      |      |                              |          |                      |
| All activities done by hand and/or hand tools except soil preparation         |      |                              |          |                      |
| Construction of water harvesting system done with the help of other villagers |      |                              |          |                      |
| Fertilisers applied by hand at time of planting                               |      |                              |          |                      |
| Chemical and hand control of weeds and pests                                  |      |                              |          |                      |

TABLE 5.15: GROSS MARGINS (R HA<sup>-1</sup>) FOR DRY BEANS UNDER DIFFERENT PRODUCTION TECHNIQUES FOR ON-STATION AND ON-FARM TRIALS FOR THREE PRODUCTION SEASONS

| Place<br>Production technique | Gross Margin (R ha <sup>-1</sup> ) |
|-------------------------------|------------------------------------|
| Glen (on station)             |                                    |
| <i>CON</i>                    | 658                                |
| <i>BbBr</i>                   | 1191                               |
| <i>ObBr</i>                   | 1216                               |
| <i>ObOr</i>                   | 1578                               |
| <i>SbOr</i>                   | 1558                               |
| <i>SbSr</i>                   | 1613                               |
| <i>ObSr</i>                   | 1656                               |
| Homestead gardens             |                                    |
| <i>BbBr</i>                   | 1557                               |
| Talla (on farm)               |                                    |
| <i>CON</i>                    | -545                               |
| <i>BbBr</i>                   | -167                               |

Table 5.15 shows the same trend for on station production as was the case with other crops. *ObSr* is the best performing technique as it gives the highest profits. However, the increase in profits is relatively larger than for the other crops. The increase from *CON* to *BbBr* as already stated is significant (R533) and that between *BbBr* and *ObSr* (R465) is slightly lower than the latter increase. The performance of the *IRWH* techniques follows the same order as was with maize and sunflower.

As for on farm trials, *BbBr* yielded negative profits as well as the *CON* for the field. However, positive results were obtained in Feloane from the homestead garden (R1557). Even though *BbBr* and *CON* gave negative returns in Talla, *BbBr* was still the superior technique in relative terms as it made a loss of R167 compared to R545 from *CON*. The reasons for the unexpected results might also have to do with the learning curve, but ARC scientists (Glen) had their doubts about the suitability of Talla soils for the production of cash crops using *IRWH*. One of their main concerns was that the soils were too shallow and may not be suitable for the cash crops. Nonetheless, the technique was employed with dry beans, a cash crop, since the farmer preferred that crop on his field.

To sum up the section on profitability, the results tend to show that the production of beans using the *IRWH* technique will be the most profitable, followed by maize and finally sunflower. However, one has to note that small scale resource poor farmers usually want to minimize risk by growing a mix of crops. This implies therefore that the results can be presented as is and the farmers will be able to determine which crop or crops they would like to produce. It was also observed in the study that the use of *IRWH* techniques increased profits significantly and thus enhancing the household income generating capacity. This will allow the farmers to be able to meet at least all the household food/income requirements making the household food secure.

### **5.3 Financial sustainability of IRWH techniques and risk analysis**

Enterprise budgets for three crops (sunflower, maize and dry beans) under different water harvesting techniques in the study area were linked to simulated yield data obtained from the CYP-SA model for an 81 year period and gross margins (R ha<sup>-1</sup>) were calculated. The simulation approach is used as it provides a time and cost-effective alternative to experimentation (Keating and McCown, 2001) as the approach has now become a legitimate way of evaluating policy as well as resource management issues (Silburn and Connolly, 1998 and Howden et al., 1999). It follows that the simulation approach makes available data that will take long periods and considerable resources outlay to generate.

The gross margins from the simulated yield data are presented in cumulative probability function format and stochastic dominance analysis is used to compare the CDFs and rank them. The Kolmogorov-Smirnov test is used to determine if the CDFs are significantly different from each other. The results are aimed at drawing comparison between conventional production and water harvesting techniques in order to make some recommendations on crop production practices for the study area.

The results are discussed according to each crop starting with maize, then sunflower and finally dry beans.



### 5.3.1 Maize

Cumulative probability distribution functions based on estimated gross margins ( $\text{R ha}^{-1}$ ) for maize over a period of 81 years are reported in Figure 5.1. The estimated gross margins were based on data from on station (Glen) trials as the data needed for the simulations was more readily available for Glen than for the on farm trials. It is assumed that, since the Thaba Nchu area is not very different from Glen in terms of rainfall and soils, the results will still have an important bearing on what is likely to happen with on farm applications of the *IRWH* techniques under investigation.

Conventional production lies to the left of all the water harvesting techniques and hence is stochastically dominated by the water harvesting techniques in the first order. The conventional production function shows that about 80 percent of the time, the technique will yield gross margins less or equal to zero. This implies that there is higher risk associated with conventional production of maize in the study area as opposed to the use of water harvesting techniques.

The simplest *IRWH* technique, *BbBr* has about a 36 percent chance of yielding a gross margin of zero or less. This is a considerable difference from the conventional production and it means that moving from *CON* to *IRWH* makes major gains. This is further shown by the differences in improvement between *BbBr* and *ObBr*, *ObOr* and *SbOr* and finally *ObSr* and *SbSr*. The differences between these pairs of water harvesting techniques are not as huge as that between *CON* and *BbBr*. *CON* carries the highest risk and may not be acceptable in terms of our assumed objective of maximizing profits from production.

*BbBr* is the least productive of the water harvesting techniques as it lies to the left of the other functions and *ObSr* lies to the right of all the functions and hence the most productive. This implies that *ObSr* is first order stochastically dominant to all the other techniques. The water harvesting techniques also have lower risks associated to them as opposed to *CON*. The *BbBr* technique has about 36 percent chance of a gross margin less than or equal to zero, and *ObSr* has a less than 12 percent of the above occurring as opposed to about 80 percent when *CON* is used. When using *ObSr*, there

is an 88 percent chance of getting a gross margin above zero whereas *BbBr* has a 64 percent chance of getting positive returns.

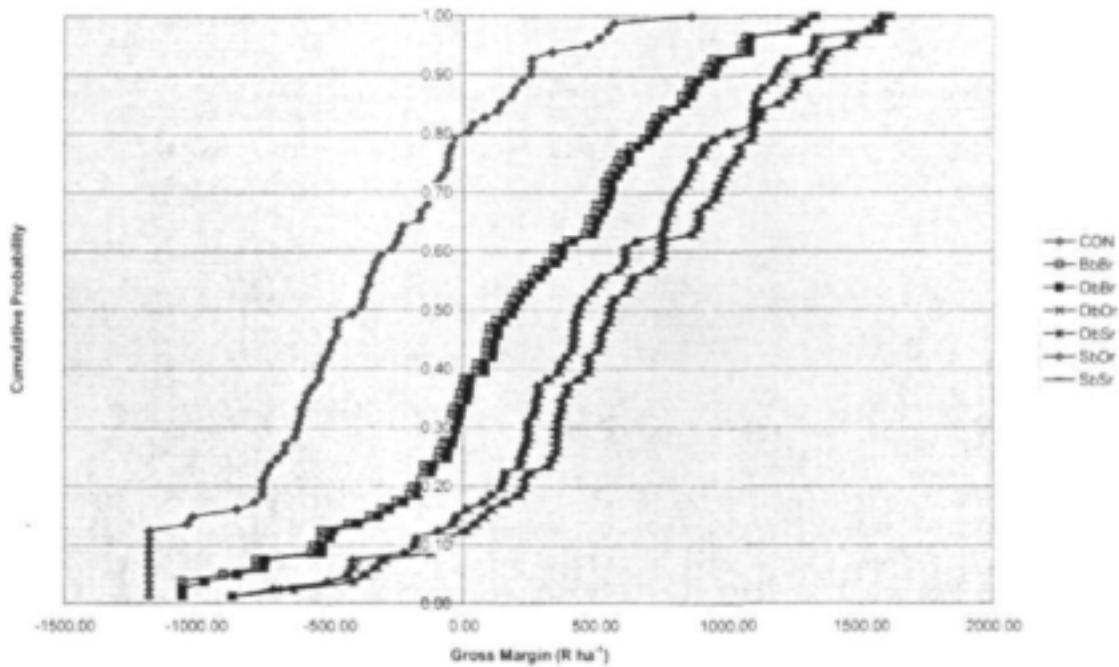


FIGURE 5.1: CUMULATIVE PROBABILITY DISTRIBUTION FUNCTIONS BASED ON ESTIMATED GROSS MARGINS ( $\text{R ha}^{-1}$ ) FOR MAIZE UNDER DIFFERENT PRODUCTION TECHNIQUES OVER A PERIOD OF 81 YEARS (1923-2003) IN THE STUDY AREA, PLANTED ON 17 DECEMBER WITH A HALF FULL SOIL PROFILE.

The differences between *ObOr* and *SbOr*, *ObSr* and *SbSr* are not as large as that between *CON* and *BbBr*. *ObSr* is first order stochastically dominant to all the other techniques for maize. As already stated the *BbBr* and *ObBr*, *ObSr* and *SbSr* as well as the *ObOr* and *SbOr* functions seem to be lying just on top of or close to each. To determine whether the functions are significantly different from each other the K-S test was used (Table 5.16).

According to the test, all the techniques are significantly different from the *CON* at the 99 percent ( $P < 0.01$ ) confidence level. *BbBr* is not significantly different from *ObBr* ( $P > 0.1$ ) but is significantly different to *ObOr*, *SbOr*, *SbSr* and *ObSr* at the 99 percent ( $P < 0.01$ ) confidence level. This implies that for the production of maize, the choice of either *BbBr* or *ObBr* will yield, in most cases, the same results. This has important bearings considering the establishment costs of the *IRWH* techniques. It will therefore be advisable for farmers to start off with the *BbBr* technique (this may also depend upon the farmers' ability to invest in the higher cost techniques). After

being competent with *BbBr* technique, they can then move to more complex *IRWH* techniques (*ObOr*, *SbOr*, *SbSr* or *ObSr*). A move from *BbBr* to the *ObBr* will result in almost the same results, in other words, a farmer can start with either *BbBr* or *ObBr* as a change from one to the other will not have any significant gains. *ObBr* is significantly different to *ObOr*, *SbOr*, *SbSr* and *ObSr* just like *BbBr*.

As the CDFs tend to show, the K-S test results also show that *ObOr*, *SbOr*, *SbSr* and *ObSr* are not significantly different from each for the production of maize. This implies that significant gains in profits will not be made by a move from one of these production techniques to the other as compared to moving from *CON*, to either *BbBr* or *ObBr*.

TABLE 5.16: K-S TEST RESULTS (D-VALUES<sup>A</sup>) FOR THE DIFFERENT WATER HARVESTING TECHNIQUES FOR MAIZE PLANTED ON 17 DECEMBER

| Technique   | <i>BbBr</i>          | <i>ObBr</i>          | <i>ObOr</i>          | <i>SbOr</i>          | <i>SbSr</i>          | <i>ObSr</i>          |
|-------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| <i>CON</i>  | 0.4815***<br>(0.000) | 0.5309***<br>(0.000) | 0.667***<br>(0.000)  | 0.6543***<br>(0.000) | 0.7037***<br>(0.000) | 0.7037***<br>(0.000) |
| <i>BbBr</i> |                      | 0.0617<br>(0.997)    | 0.3086***<br>(0.001) | 0.3806***<br>(0.000) | 0.3580***<br>(0.001) | 0.3580***<br>(0.000) |
| <i>ObBr</i> |                      |                      | 0.2963***<br>(0.001) | 0.2840**<br>(0.002)  | 0.3457***<br>(0.000) | 0.3457***<br>(0.000) |
| <i>ObOr</i> |                      |                      |                      | 0.0494<br>(1.000)    | 0.1481<br>(0.312)    | 0.1605<br>(0.226)    |
| <i>SbOr</i> |                      |                      |                      |                      | 0.1481<br>(0.312)    | 0.1605<br>(0.226)    |
| <i>SbSr</i> |                      |                      |                      |                      |                      | 0.0741<br>(0.975)    |

<sup>A</sup> values in parentheses are the respective p-values

\*\*\* Significant at 99%, \*\* significant at 95% and \* significant at 90%

Figure 5.2 presents the CDFs for maize production under *ObSr* planted on three different planting dates with a half-full soil profile. The planting dates are early planting (15 October), average planting time (17 December) and late planting (5 January). The CDFs are based on estimated gross margins based on simulated yield data over an 81-year period. The CYP-SA model as in Figure 5.1 estimated the yield data.

From the figure, early planting (15 October) lies to the left of both 5 January and 17 December and 5 January lies to the right of the other CDFs. Late planting seems to be

first order stochastically dominant to the early and average/middle planting. However, the two CDFs are touching and/or crossing each other. This means they can only be differentiated by second order stochastic dominance (SSD) but SSD is irrelevant to a resource poor risk avoiding/averse farmer for whom the techniques are meant.

For this farmer either of the two will be accepted as they yield more returns than early planting. Middle planting and late planting have both a 12 percent chance of negative returns as opposed to early planting which has a 36 percent chance of that occurring. This means that 64 percent of the time early planting will yield positive returns, while middle and late planting has an almost 88 percent chance of positive returns.

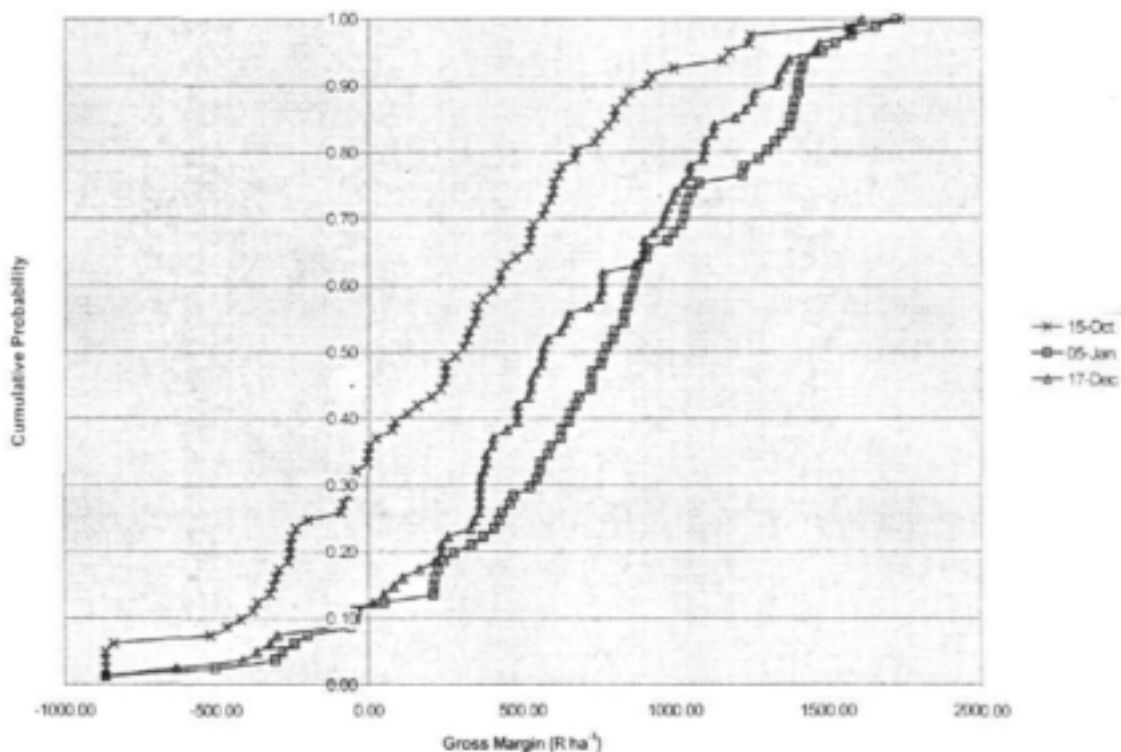


FIGURE 5.2: CUMULATIVE PROBABILITY FUNCTIONS BASED ON ESTIMATED GROSS MARGINS (R HA<sup>-1</sup>) FOR MAIZE USING THE *OBSR* PRODUCTION OVER A PERIOD OF 81 YEARS (1923-2003) IN THE STUDY AREA, PLANTED ON THREE DIFFERENT DATES<sup>6</sup> WITH A HALF FULL SOIL PROFILE.

To test for statistical difference between the functions, the K-S test is used (Table 5.17). According to the test, early planting is significantly different ( $P < 0.01$ ) to

<sup>6</sup> The dates are 15 October (early planting), 17 December (average planting) and 5 January (late planting)

middle and late planting but the latter two are not significantly different. This means any of the two can be used without necessarily forgoing better returns from the other.

**TABLE 5.17: K-S TEST RESULTS FOR DIFFERENT (D-VALUES<sup>^</sup>) MAIZE PLANTING DATES USING THE *ObsR* PRODUCTION TECHNIQUE**

| DATE   | 15 Oct               | 17 Dec            |
|--------|----------------------|-------------------|
| 17 Dec | 0.3210***<br>(0.000) |                   |
| 5 Jan  | 0.4074***<br>(0.000) | 0.1852<br>(0.110) |

<sup>^</sup> values in parentheses are the respective p-values

\*\*\* Significant at 99%, \*\* significant at 95% and \* significant at 90%

Figure 5.3 presents CDFs for maize production using the *ObsR* technique at different soil water contents and planted on 5 January. The figure shows that maize planted late on an empty profile will have a 36 percent chance of yielding negative profits whereas a full soil profile planted late will only have a 5 percent chance of negative returns. According to the figure, planting on a full soil profile is first order stochastically dominant to all the water levels. It is followed by a 75 percent full profile, then the 50 percent full profile and then 25 percent full followed lastly by the empty profile.

Figure 5.3 shows that late planting of maize will yield the highest returns but planting late on an empty profile also shows some positive returns. Planting on an empty profile has a 74 percent chance of still yielding profits when using the *ObsR* technique. This implies that the use of *IRWH* techniques will considerably reduce the risk due to inadequate moisture as a result of poor rainfall. The results are consistent with the fact that *IRWH* techniques conserve water in the root zone, which can be used for increased production and thus better crop yields.

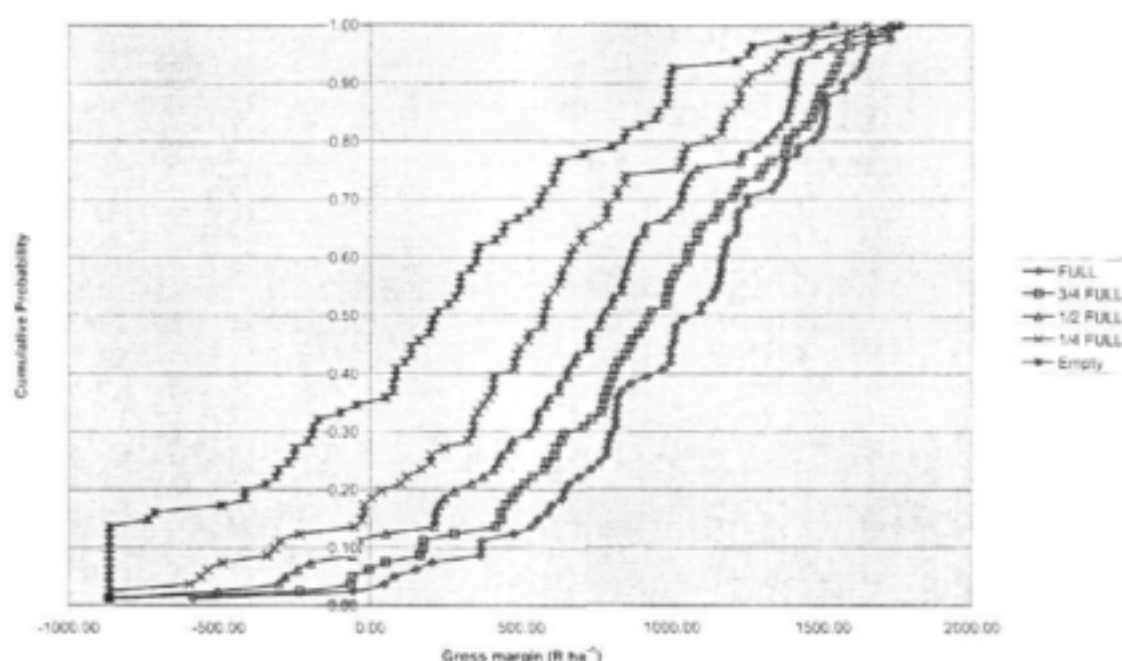


FIGURE 5.3: CUMULATIVE PROBABILITY DISTRIBUTION FUNCTIONS BASED ON ESTIMATED GROSS MARGINS FOR MAIZE USING THE *OBSR* PRODUCTION TECHNIQUE OVER A PERIOD OF 81 YEARS (1923-2003) IN THE STUDY AREA, PLANTED ON 5 JANUARY ON FIVE DIFFERENT SOIL WATER CONTENTS

According to Table 5.18, the soil water contents are significantly different to each other. However, the pairs of half (50%) full and three-quarter (75%) full as well as 75 percent full and full (100%) are not significantly different from each other. This implies planting on either a full profile or 75 percent full soil profile will result in almost the same returns when maize is planted late. The same is also true between half full and 75 percent full.

TABLE 5.18: K-S TEST RESULTS (D-VALUES<sup>A</sup>) FOR MAIZE PLANTED ON 5 JANUARY UNDER THE *OBSR* TECHNIQUE ON DIFFERENT SOIL WATER CONTENTS.

| Soil water content | Empty                | Quarter full         | Half full            | Three quarter full |
|--------------------|----------------------|----------------------|----------------------|--------------------|
| Quarter Full       | 0.2963***<br>(0.001) |                      |                      |                    |
| Half full          | 0.4074***<br>(0.000) | 0.2099**<br>(0.048)  |                      |                    |
| Three quarter full | 0.5062***<br>(0.000) | 0.3457***<br>(0.000) | 0.1728<br>(0.160)    |                    |
| Full               | 0.5926***<br>(0.000) | 0.4321***<br>(0.000) | 0.2716***<br>(0.004) | 0.1481<br>(0.312)  |

<sup>A</sup> values in parentheses are the respective p-values

\*\*\* Significant at 99%, \*\* significant at 95% and \* significant at 90%

### 5.3.2 Sunflower

Figure 5.4, shows the cumulative distribution functions based on estimated gross margins ( $\text{R ha}^{-1}$ ) for the period 1923-2003. The figure further compares the production techniques but also shows what has already been observed with maize.

*CON* production is inferior to all the *IRWH* techniques. The functions also show that there is a high risk of getting a negative gross margin when a farmer is using *CON*. The *CON* production technique has a 68 percent chance of yielding a gross margin of zero or less, which implies there is only a 32 percent chance of yielding a positive gross margin from production. In contrast, the simplest *IRWH* technique (*BbBr*) exposes the farmer to a risk of 27 percent of yielding a gross margin equal or less than zero, the highest performing (*ObSr*) only has a 11 percent chance of a gross margin of zero or less. This implies that *CON* exposes the farmer to a lot of risk and may not be acceptable in line with our assumed objective of maximizing profit (measured by GM) from production.

Comparing the *IRWH* techniques, *BbBr* is the least productive technique as it lies to the left of all the water harvesting techniques functions whereas *ObSr* is the most productive as it lies to the right of all the other water harvesting techniques functions. By implication, *ObSr* is stochastically dominant, in the first order, to all water harvesting techniques and conventional production technique. Secondly, water-harvesting techniques show low levels of risk, as shown by the case of *BbBr* as was earlier discussed. *ObBr* which lies to the immediate right of the *BbBr* function, shows that there is a 23 percent chance ( $P=0.23$ ) of getting a gross margin of zero or less as opposed to 27 percent in the case of *BbBr*. The risk reduces considerably as we move from *BbBr* to *ObSr*. This means that when using *ObBr*, a farmer has a 77 percent chance ( $P=0.77$ ) of getting a positive gross margin. *ObSr*, as might be expected, shows the lowest risk level of 11 percent chance of getting a gross margin of zero or less. This implies that a farmer using *ObSr* has an 89 percent chance of getting a positive gross margin.

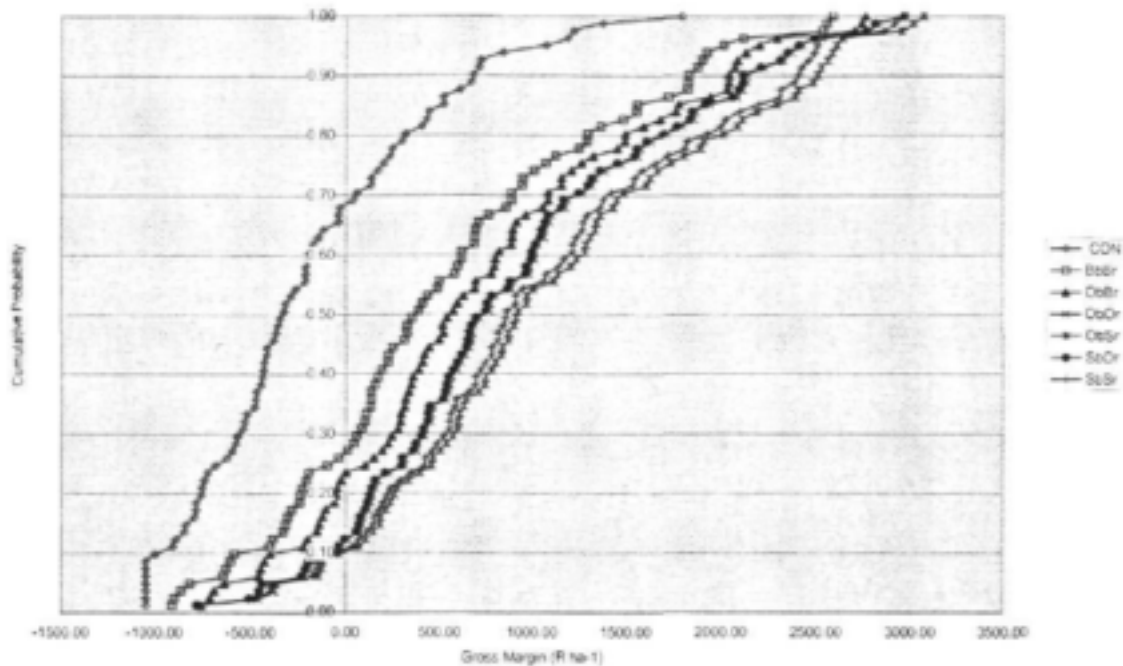


FIGURE 5.4: CUMULATIVE PROBABILITY FUNCTIONS BASED ON ESTIMATED GROSS MARGINS ( $\text{R ha}^{-1}$ ) FOR SUNFLOWER USING DIFFERENT WATER HARVESTING TECHNIQUES OVER A PERIOD OF 81 YEARS (1923-2003) IN THE STUDY AREA, PLANTED ON 17 DECEMBER WITH A HALF-FULL SOIL PROFILE.

*ObOr* is slightly superior to *SbOr* as shown by the closeness of the two functions to each other, however *ObOr* is distinctly to the right of *SbOr* and therefore stochastically dominates *SbOr* in the first order. Almost the same trend is shown between *SbSr* and *ObSr*, but its more distinguishable than the case of *ObOr* and *SbOr*.

According to Table 5.19, all the *IRWH* techniques are significantly different from the conventional production technique (*CON*). However, *BbBr* is not significantly different to *ObBr*, *ObOr* is also not significantly different to *ObBr*, as well as *SbOr* to *ObOr*. *SbSr* and *ObSr* are also not significantly different. The results imply that moving from *CON* to any of the *IRWH* techniques will result in significant gains in profits as opposed to moving among some of the *IRWH* techniques. For example a change from *BbBr* to *ObBr* will not yield significant gains but a move from *BbBr* to *ObOr* will result in gains in profitability.



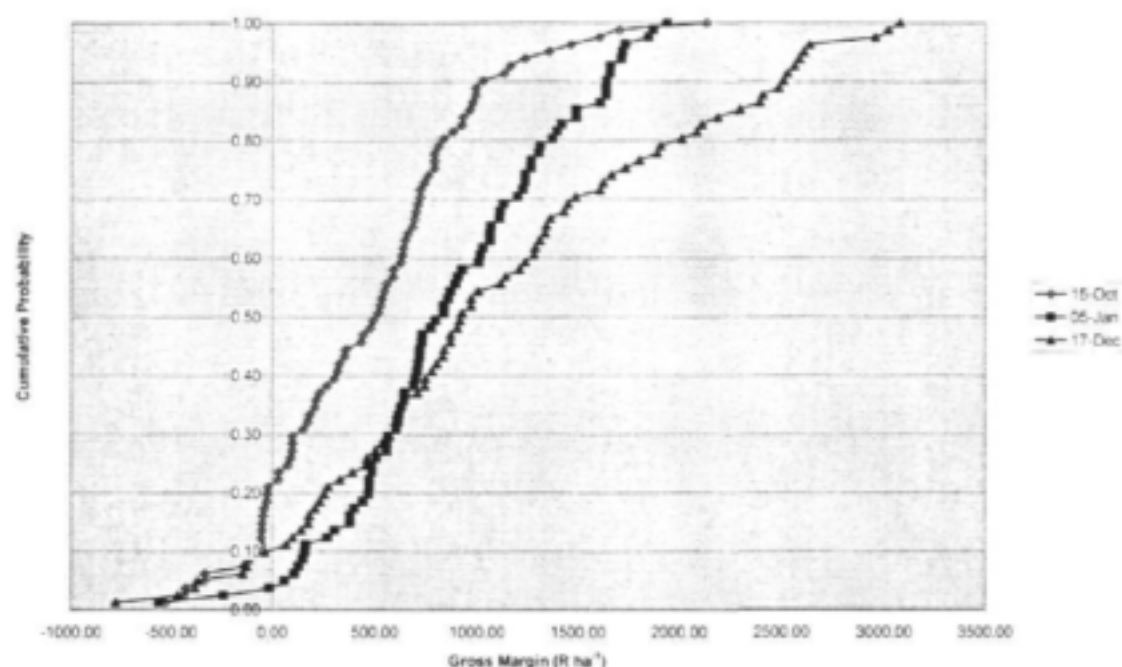
TABLE 5.19: K-S TEST RESULTS (D-VALUES<sup>A</sup>) FOR THE DIFFERENT WATER HARVESTING TECHNIQUES FOR SUNFLOWER PLANTED ON 17 DECEMBER

| Technique | BbBr                | ObBr                 | ObOr                 | SbOr                 | SbSr                 | ObSr                 |
|-----------|---------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| CON       | 0.4198**<br>(0.000) | 0.4938***<br>(0.000) | 0.5802***<br>(0.000) | 0.5802***<br>(0.000) | 0.5802***<br>(0.000) | 0.6049***<br>(0.000) |
| BbBr      |                     | 0.4181<br>(0.312)    | 0.2346**<br>(0.019)  | 0.2346**<br>(0.019)  | 0.2840***<br>(0.000) | 0.2963***<br>(0.001) |
| ObBr      |                     |                      | 0.1358<br>(0.417)    | 0.3158<br>(0.417)    | 0.1975*<br>(0.074)   | 0.2099*<br>(0.048)   |
| ObOr      |                     |                      |                      | 0.0370<br>(1.000)    | 0.1111<br>(0.674)    | 0.1235<br>(0.540)    |
| SbOr      |                     |                      |                      |                      | 0.1111<br>(0.674)    | 0.1358<br>(0.417)    |
| SbSr      |                     |                      |                      |                      |                      | 0.0617<br>(0.997)    |

<sup>A</sup> values in parentheses are the respective p-values

\*\*\* Significant at 99%, \*\* significant at 95% and \* significant at 90%

Figure 5.5 shows that all the planting dates cross and thus FSD cannot be used to rank them but second order stochastic dominance (SSD) can. Even though early planting has a higher probability of negative returns (21%), it also has a higher minimum profit than both late planting and middle planting. The latter two have minimum profits of negative R556 and negative R774, respectively as opposed to negative R527 from early planting. Based on this, farmers are most likely to plant early so as to avoid the higher losses from middle planting and late planting, since they will prefer more to less of an outcome.



**FIGURE 5.5: CUMULATIVE PROBABILITY DISTRIBUTION FUNCTIONS BASED ON ESTIMATED GROSS MARGINS (R HA<sup>-1</sup>) FOR SUNFLOWER USING *OBSR* OVER A PERIOD OF 81 YEARS (1923-2003) IN THE STUDY AREA, PLANTED ON THREE DIFFERENT DATES WITH A HALF FULL SOIL PROFILE.**

The K-S test results show that all the planting dates are significantly different from each other. This indicates that all the planting dates will result in significantly different returns to production.

**TABLE 5.20: K-S TEST RESULTS (D-VALUES<sup>A</sup>) FOR DIFFERENT PLANTING DATES OF SUNFLOWER UNDER THE *OBSR* TECHNIQUE IN THE STUDY AREA**

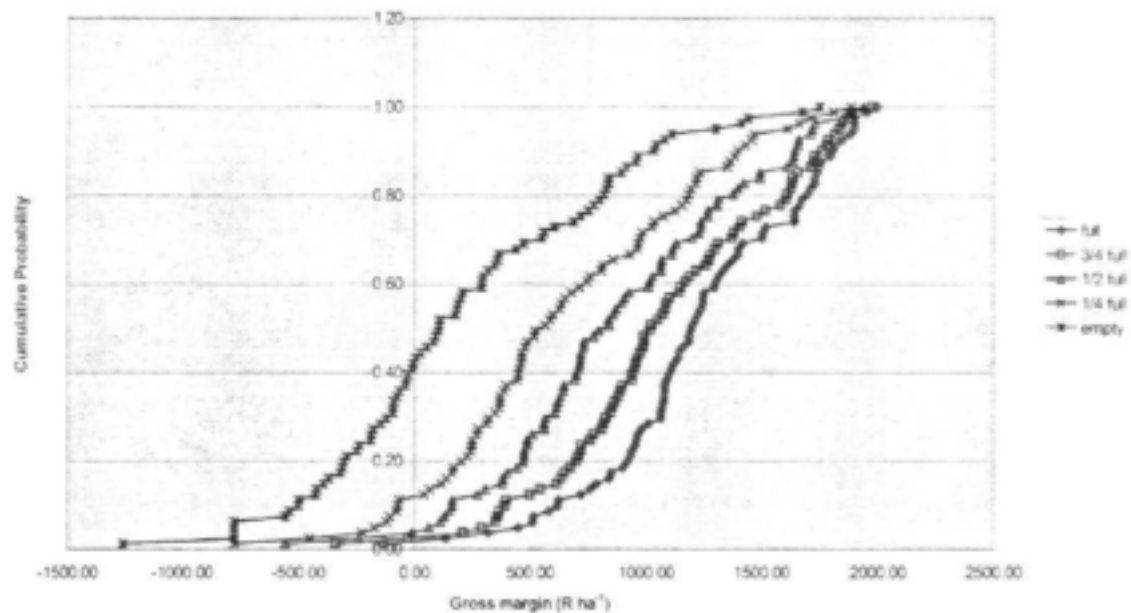
| DATE   | 15 Oct               | 17 Dec              |
|--------|----------------------|---------------------|
| 17 Dec | 0.3704***<br>(0.000) | 0.2222**<br>(0.031) |
| 5 Jan  | 0.3806***<br>(0.001) |                     |

<sup>A</sup> values in parentheses are the respective p-values

\*\*\* Significant at 99%, \*\* significant at 95% and \* significant at 90%

Figure 5.6 indicates that sunflower planted on a full soil profile will yield better profits than when planted on an empty profile. The soil water contents for sunflower are also the same as those for maize in terms of potential for returns. However, sunflower planted on an empty profile shows a higher risk of negative returns than maize. For sunflower the probability is 42 percent, compared to about 36 percent for maize.

Secondly sunflower also shows a 2 percent chance of negative returns under the full profile compared to about 5 percent for maize. The results also confirm that the use *IRWH* techniques will significantly reduce the risks of negative returns.



**FIGURE 5.6: CUMULATIVE PROBABILITY DISTRIBUTION FUNCTIONS BASED ON GROSSMARGINS ( $R\ ha^{-1}$ ) FOR SUNFLOWER USING *OBSR* OVER A PERIOD OF 81 YEARS (1923-2003) IN THE STUDY AREA, PLANTED ON 5 JANUARY ON FIVE DIFFERENT SOIL WATER CONTENTS**

Table 5.21 shows that all the soil water contents are significantly different from each other. This is also different from the case of maize where some of the soil water contents were not significantly different from each other. The results mean that all the water contents will result with significantly different results and a move from one water level to better soil water contents will improve profits. However, as in maize, planting late on a full profit will increase profits significantly than any of the other soil water contents.

TABLE 5.21: K-S TEST RESULTS (D-VALUES<sup>A</sup>) FOR SUNFLOWER PLANTED ON 5 JANUARY UNDER *OBSR* FOR DIFFERENT SOIL WATER CONTENTS

| Soil water content | Empty                | Quarter full         | Half full            | Three quarter full  |
|--------------------|----------------------|----------------------|----------------------|---------------------|
| Quarter Full       | 0.3827***<br>(0.000) |                      |                      |                     |
| Half full          | 0.5309***<br>(0.000) | 0.2593***<br>(0.007) |                      |                     |
| Three quarter full | 0.5926***<br>(0.000) | 0.3951***<br>(0.000) | 0.2346**<br>(0.019)  |                     |
| Full               | 0.6914***<br>(0.000) | 0.4938***<br>(0.000) | 0.3827***<br>(0.000) | 0.2346**<br>(0.019) |

<sup>A</sup> values in parentheses are the respective p-values

\*\*\* Significant at 99%, \*\* significant at 95% and \* significant at 90%

### 5.3.3 Dry beans

Figure 5.7 presents the cumulative probability functions for the production of dry beans using different *IRWH* techniques and the conventional production technique. The CDF for the conventional production of dry beans lies to the left of all the water harvesting techniques followed by *ObBr*. This implies that the *IRWH* techniques dominate *CON* by FSD and hence superior to conventional production.

The production of beans shows some distinct differences to that of the other two crops. The CDFs for dry beans show a lower risk for both *IRWH* and the conventional production techniques. In the production of dry beans under *CON*, the lowest possible expected gross margin is R179 ha<sup>-1</sup> while for the other crops this was negative. This might be attributed to the higher price of dry beans during the production year (1999/2000) on which the analysis is based. It follows therefore that, based on simulated data, there is no risk of making a negative profit in the long-term production of beans regardless of production technique, even though this was observed for the on farm trials (negative gross margins were observed). This is in contrast to the case of maize and sunflower, which showed higher risks of negative profits (80% and 68% for *CON*, respectively). Secondly, the CDF for *BbBr* dominates *ObBr* in the first order while *SbSr* also dominates *ObSr* in the first order while in the other crops, the former were dominated by the latter.

Apart from these peculiarities, the rest of the functions also follow the same trend as for the other crops with an even smaller difference between *SbOr* and *ObOr* and *SbSr* and *ObSr*. The figure shows that there are greater returns to *IRWH* than *CON* as shown by the difference between *CON* and *ObBr*, after which the increase in returns are not so large.

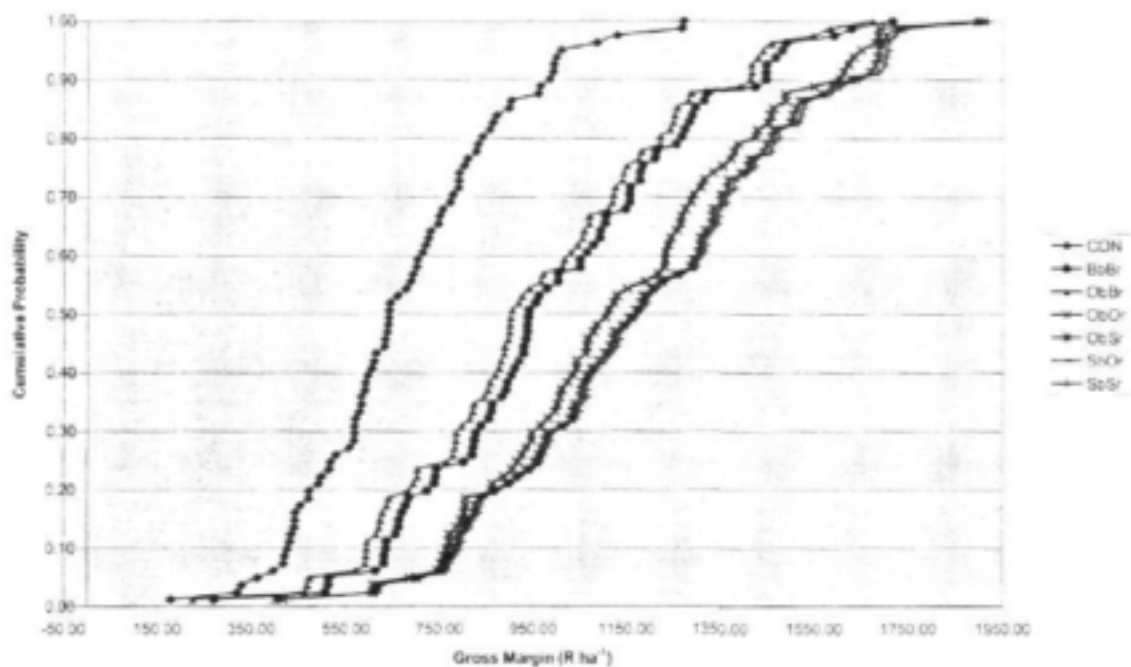


FIGURE 5.7: CUMULATIVE PROBABILITY DISTRIBUTION FUNCTIONS BASED ON ESTIMATED GROSS MARGINS (R HA<sup>-1</sup>) FOR DRY BEANS UNDER DIFFERENT PRODUCTION TECHNIQUES OVER A PERIOD OF 81 YEARS (1923-2003) IN THE STUDY AREA, PLANTED ON 17 DECEMBER WITH A HALF FULL SOIL PROFILE.

According to the K-S test results (Table 5.22), all the *IRWH* techniques are significantly different to *CON* at 99 percent ( $P < 0.01$ ). *BbBr* is also significantly different from all the other *IRWH* techniques, but not from *ObBr*. This means that significant gains in the long-term profitability will be achieved by the move from *CON* to the *IRWH* techniques and the move from *BbBr* to the more advanced techniques as opposed to moving from *BbBr* to *ObBr*. *ObBr* is significantly different from *ObOr*, *SbOr*, *SbSr* and *ObSr* while the latter three techniques are not significantly different from each other. This means that among the techniques, a move from either *BbBr* or *ObBr* to the other *IRWH* techniques will result in significant changes to the profits accrued from production. As in the stochastic dominance analysis for dry beans, the K-S test also shows some peculiar differences.

Like in the case of maize, *SbOr*, *SbSr* and *ObSr* are not significantly different from each other. This implies, statistically, that the functions are almost the same and thus there would not be any real gains in moving between the techniques.

**TABLE 5.22: K-S TEST RESULTS (D-VALUES<sup>A</sup>) FOR THE DIFFERENT WATER HARVESTING TECHNIQUES FOR DRY BEANS PLANTED ON 17 DECEMBER**

| Technique | BbBr                 | ObBr                 | ObOr                 | SbOr                 | SbSr                 | ObSr                 |
|-----------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| CON       | 0.5185***<br>(0.000) | 0.4568***<br>(0.000) | 0.6420***<br>(0.000) | 0.6543***<br>(0.000) | 0.6420***<br>(0.000) | 0.6667***<br>(0.000) |
| BbBr      |                      | 0.1111<br>(0.0674)   | 0.02346**<br>(0.019) | 0.2346***<br>(0.004) | 0.4321**<br>(0.019)  | 0.2963***<br>(0.001) |
| ObBr      |                      |                      | 0.2840**<br>(0.002)  | 0.2714**<br>(0.004)  | 0.3210***<br>(0.000) | 0.2716***<br>(0.004) |
| ObOr      |                      |                      |                      | 0.0370<br>(1.000)    | 0.1358<br>(0.417)    | 0.1358<br>(0.417)    |
| SbOr      |                      |                      |                      |                      | 0.1358<br>(0.417)    | 0.1481<br>(0.312)    |
| SbSr      |                      |                      |                      |                      |                      | 0.0370<br>(1.000)    |

<sup>A</sup> values in parentheses are the respective p-values

\*\*\* Significant at 99%, \*\* significant at 95% and \* significant at 90%

According to Figure 5.8, the CDFs are crossing each other and thus cannot be ranked by first order stochastic dominance. This means they have to be ranked by second order stochastic dominance. Middle planting (17 Dec) and late planting (5 Jan) have lower minimum gross margins than early planting, it means that early planting (15 Oct) dominates the other planting dates by SSD. This is so because farmers will prefer more to less and will likely choose that option which gives them a higher minimum return. For middle planting the minimum likely minimum gross margin is R401 ha<sup>-1</sup> while for late planting it is a loss of R1081 ha<sup>-1</sup> and early planting has a minimum likely gross margin of R433 ha<sup>-1</sup>. This indicates that early planting would be the likely desirable planting date for dry beans.

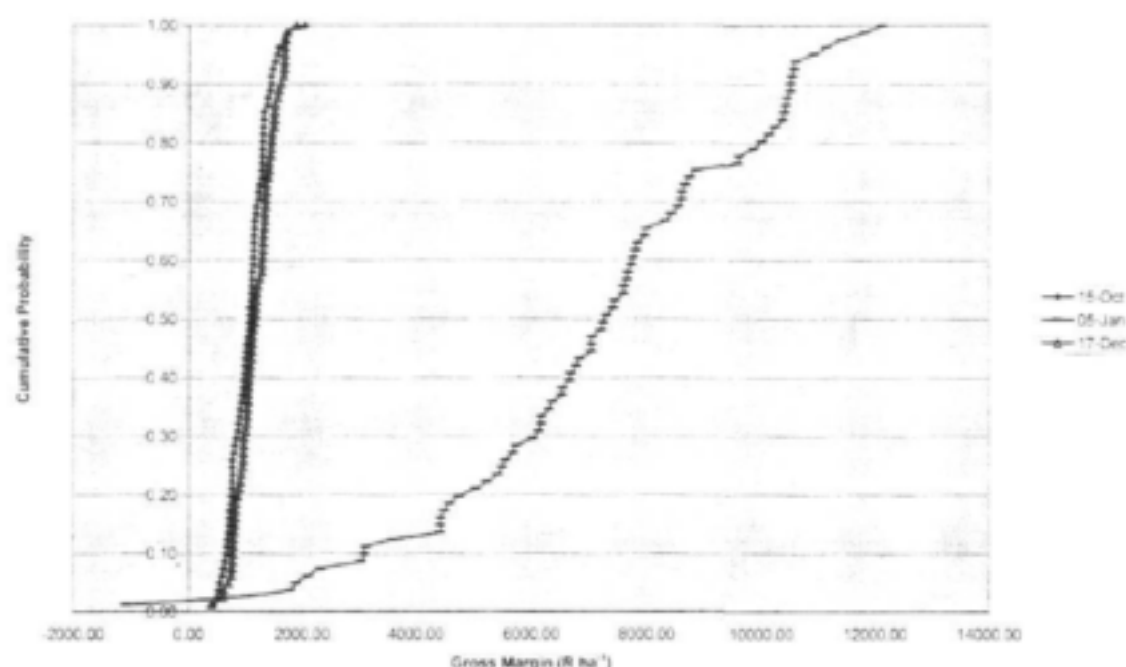


FIGURE 5.8: CUMULATIVE PROBABILITY DISTRIBUTION FUNCTIONS BASED ON GROSSMARGINS (R HA<sup>-1</sup>) FOR DRY BEANS UNDER *OBSR* TECHNIQUE FOR A PERIOD OF 81 YEARS IN THE STUDY AREA, PLANTED ON THREE DIFFERENT PLANTING DATES WITH A HALF FULL SOIL PROFILE.

In determining whether the functions for planting date are significantly different, the K-S test results (Table 5.23) show that the CDFs are significantly different from each other. Early planting and middle planting are significantly different at 95 percent ( $P < 0.05$ ) as well as late planting and early planting. Middle planting and late planting are significantly different at 99 percent ( $P < 0.01$ ).

The results imply that the use of a particular planting date will yield significantly different results than it would be the case with any of the other dates.

TABLE 5.23: K-S TEST RESULTS (D-VALUES<sup>A</sup>) FOR DIFFERENT PLANTING DATES OF DRY BEANS UNDER THE *OBSR* TECHNIQUE IN THE STUDY AREA

| Date   | 15 Oct              | 17 Dec               |
|--------|---------------------|----------------------|
| 17 Dec | 0.2099**<br>(0.048) |                      |
| 5 Jan  | 0.2099**<br>(0.048) | 0.9630***<br>(0.000) |

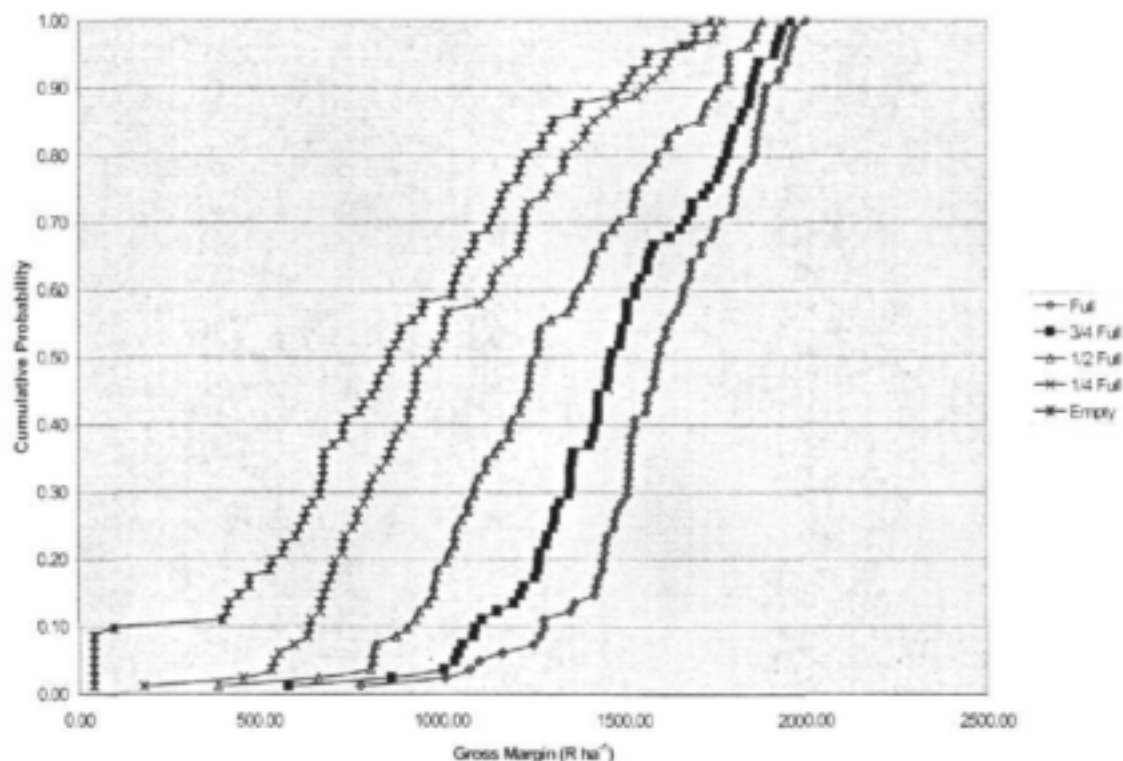
<sup>A</sup> values in parentheses are the respective p-values

\*\*\* Significant at 99%, \*\* significant at 95% and \* significant at 90%.

Figure 5.9 presents the CDFs for dry beans planted late (5 January) under the *ObSr* technique at different soil water content levels. The soil water levels were full, 75 percent full, 50 percent full, 25 percent full, and empty.

The figure shows that planting late on a full soil profile stochastically dominates all the other water content levels in the first order. This means it is the most productive water content level. This, however, is to be expected since a combination of late planting and full profile ensures that there is enough water in the rootzone to sustain plant growth.

Late planting under *ObSr* with an empty profile also yields returns even though they are less than for all other soil water contents. Similar to the other CDFs for beans, there is no part that falls below zero, that is, there is no chance of yielding negative profits like in other crops (maize and sunflower). The lowest expected profit is R42 that was achieved on an empty (dry) soil profile. This increases as the soil water content is increased. The highest possible minimum can be achieved by full profile (R778) and all the other soil water contents have gross margins within the range(R42-R778).



**FIGURE 5.9: CUMULATIVE PROBABILITY DISTRIBUTION FUNCTIONS BASED ON ESTIMATED GROSS MARGINS FOR DRY BEANS USING *ObSr* OVER A PERIOD OF 81 YEARS (1923-2003) IN THE STUDY AREA, PLANTED ON 5 JANUARY ON FIVE DIFFERENT SOIL WATER CONTENTS**



The soil water contents are significantly different from each other, (Table 5.24), as was the case with sunflower and maize. This means that the soil water contents will result in significantly different profits. Planting on a full profile will yield the highest profits while planting on an empty profile will result in less profit. The results also point out that planting late with *ObSr* has the potential to reduce risk significantly than planting on empty, 25 percent full, 50 percent full, or 75 percent full profile.

TABLE 5.24: K-S TEST RESULTS (D-VALUES<sup>A</sup>) FOR DRY BEANS UNDER *OBSR* PLANTED ON 5 JANUARY ON DIFFERENT SOIL WATER CONTENTS

| Soil water content | Empty                | Quarter full         | Half full            | Three quarter full   |
|--------------------|----------------------|----------------------|----------------------|----------------------|
| Quarter Full       | 0.2099**<br>(0.048)  |                      |                      |                      |
| Half full          | 0.4568***<br>(0.000) | 0.3704***<br>(0.000) |                      |                      |
| Three quarter full | 0.6420***<br>(0.000) | 0.5679***<br>(0.000) | 0.3457***<br>(0.000) |                      |
| Full               | 0.7407***<br>(0.000) | 0.7160***<br>(0.000) | 0.5185***<br>(0.000) | 0.2963***<br>(0.001) |

<sup>A</sup> values in parentheses are the respective p-values

\*\*\* Significant at 99%, \*\* significant at 95% and \* significant at 90%

In summing up the results for the long-term profitability and risk analysis, the *IRWH* techniques have shown that they have higher profits than the conventional dryland production for all the techniques. Significant gains in profits are made by just the move from the conventional production to the *BbBr* technique, which is the least productive *IRWH* technique for both on station and on farm trials. Among the crops maize yielded the highest profits even though it had the lowest price, at least for the on station trials followed by dry beans and then sunflower. This implies that the production of maize has a higher potential of enhancing household income generating capacity. The highest possible income from the production of maize is R2191 ha<sup>-1</sup> with the use of *ObSr*, compared to dry beans' R1703 ha<sup>-1</sup> and sunflower's R1372 ha<sup>-1</sup>. Sunflower had the lowest minimum profits of R31 ha<sup>-1</sup> with the use of the conventional production. However, it should be noted that the sunflower figures were generally lower during the first two seasons compared to the third season.

For the on station trials, sunflower with *BbBr* had the highest profits in Feloane (R1118 ha<sup>-1</sup>) while dry beans production showed the lowest profits (highest loss). Secondly, the conventional production for all the crops yielded some negative returns in almost all the on station trials except for sunflower production in Feloane. In Talla, both the *BbBr* and the *CON* production technique had negative returns but *BbBr* had lower losses than *CON*, therefore, confirming the superiority of the *IRWH* techniques.

Generally, *ObSr* is the most profitable *IRWH* technique for all the crops. There are drastic positive gains in profitability as a result of a move from *CON* to *BbBr*, but the magnitude of the gains reduces when moving among the rest of the *IRWH* techniques. The increase in profits from *ObBr* to *BbBr* is in the range of R500 – R700 while that from *ObBr* to *ObOr*, *SbOr*, and *SbSr* is in most cases less than R100 for sunflower and about R500 for maize and dry beans. The move from *SbOr* to *ObOr* (or vice versa), *SbOr* (*ObOr*) to *SbSr*, and *SbSr* to *ObSr* has positive but small increases in profits. The statistical analysis further shows that *CON* is significantly different to all the *IRWH* techniques. The analysis further shows that *BbBr* and *ObBr* are not significantly different but are to *ObOr*, *SbOr*, *SbSr*, *ObSr*. However, the latter techniques are not significantly different to each other.

In the risk analysis, all the *IRWH* techniques stochastically dominate *CON* in the first order. The *IRWH* techniques reduced risk considerably. In maize and sunflower production, the risk of crop failure was reduced by about 40 percent while for dry beans the risk was reduced to zero. Like in the profitability analysis, the *IRWH* techniques are significantly different from the conventional production. For all crops *BbBr* and *ObBr* were not significantly different but both were significantly different to *ObOr*, *SbOr*, *SbSr*, and *ObSr*. In the case of sunflower *ObBr* was also not significantly different to *ObOr*. The set of *ObOr*, *SbOr*, *SbSr*, and *ObSr* are not significantly different to each other.

The analysis of the effect of planting date shows that planting late will be the most preferred planting date. The statistical results confirm that planting date will have a significant effect on the returns, as the planting dates are significantly different to each other. This implies that the choice of planting date will be very important. Soil water content at the time of planting also proved to be very important. Planting late on

a full soil profile will yield the highest profits for all the crops. Late planting with *IRWH* on an empty soil profile using the *ObSr* production technique showed some positive returns, even more than the use of the conventional method. In maize production, the farmer has 36 percent chance of getting negative returns on an empty profile compared to about 80 percent when using the conventional method on a half full profile with middle planting date (17 December). The risk for sunflower and dry beans is 42 percent and 10 percent, respectively. The statistical analysis also shows that the planting dates are significantly different to each other, except in the case of maize where 50 percent full and 75 percent full are not significantly different as well as 75 percent full and 100 percent full.

From the results, it can be concluded that the choices of production technique, the planting date and soil moisture content has important implications on profitability and risk reduction in the study area. In general, planting late on a full soil profile using the *ObSr* technique has the potential to yield the highest profits.

#### **5.4 Financial sustainability of IRWH techniques**

The results that follow present the long-term economic analysis of the *IRWH* techniques. The analysis calculates the net present value, benefit cost ratio and the internal rate of return (where applicable). Gross enterprise income from production is discounted at three different rates: 5 percent, 10 percent and 15 percent over a period of 15 years. The values used in the analysis are from the last 15 years of the estimation period. The same is done for the total costs, which sums the total variable costs and the fixed costs. The difference between the gross income and the total costs gives the net margin, which is used as a measure of enterprise profit. The cumulative net margin is calculated as well as the internal rate of return, where applicable.

The results from the cost benefit analysis are presented in Tables 5.25 and 5.26. Table 5.25 presents an example of the procedure which was used to calculate the net present value, the B/C ratio and internal rate of return while Table 5.26 presents a summary of the results for all the crops and production techniques. The rest of the tables for the summarised information for each crop and production technique are presented in

TABLE 5.25: COMPARISON OF THE NET PRESENT VALUE AND BENEFIT COST RATIO FOR MAIZE PRODUCTION BETWEEN CONVENTIONAL AND *BBBR*, IN THE STUDY AREA OVER A PERIOD OF 15 YEARS.

| Enterprise level analysis (Maize)         |                     |            |          |           |          |          |           |           |           |           |           |           |          |            |            |            |
|-------------------------------------------|---------------------|------------|----------|-----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|------------|------------|------------|
|                                           | YEARS               | 1          | 2        | 3         | 4        | 5        | 6         | 7         | 8         | 9         | 10        | 11        | 12       | 13         | 14         | 15         |
| <b>Conventional</b>                       |                     |            |          |           |          |          |           |           |           |           |           |           |          |            |            |            |
| Gross Income                              |                     | 1578.98    | 871.33   | 1578.98   | 0        | 727.93   | 1686.83   | 360.81    | 1588.44   | 687.05    | 1689.1    | 0         | 5179.6   | 472.72     | 1956.51    | 1580.83    |
| Discounted Total Gross Income 10%         | <b>R 2,676.74</b>   | 1427.89    | 719.34   | 1432.18   | 0.00     | 651.43   | 819.28    | 174.85    | 1577.77   | 287.38    | 1575.27   | 0.00      | 374.58   | 136.93     | 288.84     | 258.80     |
| Discounted Total Gross Income 15%         | <b>R 2,445.31</b>   | 1369.72    | 658.70   | 1369.35   | 0.00     | 581.46   | 642.80    | 128.12    | 1353.81   | 195.33    | 1368.82   | 0.00      | 219.73   | 78.83      | 154.37     | 132.80     |
| Discounted Total Gross Income 5%          | <b>R 2,488.34</b>   | 1495.79    | 750.74   | 1488.74   | 0.00     | 789.85   | 1119.55   | 242.21    | 1738.70   | 442.58    | 1718.02   | 0.00      | 554.82   | 250.85     | 553.61     | 519.80     |
| Total Variable Costs                      |                     | 1252.81    | 1274.94  | 1294.82   | 1240.48  | 1289.21  | 1293.28   | 1215.97   | 1281.54   | 1287.88   | 1295.5    | 1287.48   | 1288.90  | 1289.18    | 1289.84    | 1283.22    |
| Fixed Cost                                |                     | 100        | 100      | 100       | 100      | 100      | 100       | 100       | 100       | 100       | 100       | 100       | 100      | 100        | 100        | 100        |
| Discounted Total Costs 10%                | <b>R 10,475.84</b>  | 1225.18    | 1128.21  | 1047.88   | 945.52   | 850.20   | 789.86    | 694.30    | 645.43    | 568.92    | 519.57    | 480.83    | 441.94   | 393.71     | 354.41     | 321.13     |
| Discounted Total Costs 15%                | <b>R 6,535.41</b>   | 1219.68    | 1019.05  | 917.52    | 785.43   | 680.78   | 604.95    | 519.01    | 452.28    | 388.77    | 345.03    | 288.13    | 235.24   | 220.91     | 195.58     | 169.89     |
| Discounted Total Costs 5%                 | <b>R 10,388.32</b>  | 1338.82    | 1247.31  | 1204.98   | 1102.82  | 1012.84  | 1044.17   | 952.24    | 836.43    | 693.81    | 589.57    | 493.78    | 372.33   | 270.81     | 198.93     | 165.38     |
| NET MARGIN                                |                     | 687.97     | -603.61  | -21.82    | -1340.48 | -642.22  | 87.54     | -1015.16  | -125.5    | -600.81   | -62.6     | -1340.48  | -251.30  | -895.47    | -157.33    | -102.8     |
| CUMULATIVE NET MARGIN                     | <b>R -29,186.85</b> | 687.97     | -535.24  | -556.86   | -1697.35 | -2339.57 | -2252.03  | -3265.19  | -3560.29  | -4240.5   | -4348.3   | -5488.78  | -5700.18 | -6595.65   | -6874.38   | -7176.58   |
| NET PRESENT VALUE (10%)                   | <b>R -4,397.63</b>  |            |          |           |          |          |           |           |           |           |           |           |          |            |            |            |
| NET PRESENT VALUE (15%)                   | <b>R -2,434.10</b>  |            |          |           |          |          |           |           |           |           |           |           |          |            |            |            |
| NET PRESENT VALUE (5%)                    | <b>R -6,516.93</b>  |            |          |           |          |          |           |           |           |           |           |           |          |            |            |            |
| <b>BB</b>                                 |                     |            |          |           |          |          |           |           |           |           |           |           |          |            |            |            |
| Gross Income                              |                     | 2184.28    | 1450.98  | 2019.88   | 0        | 1178.93  | 1828.72   | 723.8     | 1687.15   | 5180.4    | 2183.71   | 501.8     | 1583.93  | 862.53     | 1811.37    | 1871.78    |
| Discounted Total Gross Income 10%         | <b>R 10,332.42</b>  | 1985.71    | 1198.14  | 1922.43   | 0.00     | 732.84   | 1517.80   | 397.08    | 287.87    | 300.88    | 841.97    | 175.87    | 508.40   | 258.53     | 424.32     | 378.22     |
| Discounted Total Gross Income 15%         | <b>R 6,487.14</b>   | 1889.37    | 1057.13  | 1341.51   | 0.00     | 586.85   | 855.86    | 230.50    | 551.55    | 335.54    | 510.78    | 102.80    | 295.88   | 145.68     | 227.79     | 193.10     |
| Discounted Total Gross Income 5%          | <b>R 10,471.41</b>  | 2089.27    | 1518.08  | 1781.33   | 0.00     | 924.51   | 1407.28   | 549.32    | 1141.92   | 789.99    | 1345.51   | 293.28    | 885.49   | 472.33     | 813.88     | 788.86     |
| Total Variable Costs                      |                     | 1431.88    | 1102.84  | 1128.98   | 1045.25  | 1091.94  | 1123.59   | 1078.87   | 1122.51   | 1097.98   | 1131.88   | 1088.1    | 1107.89  | 1080.57    | 1109.21    | 1107.44    |
| Fixed Costs                               |                     | 353.8      | 0        | 0         | 114.35   | 0        | 0         | 114.35    | 0         | 0         | 114.35    | 0         | 0        | 114.35     | 0          | 0          |
| Discounted Total Costs 10%                | <b>R 6,432.31</b>   | 1355.70891 | 811.2828 | 845.91043 | 792.0224 | 818.0083 | 814.23728 | 813.77108 | 822.25362 | 803.09784 | 802.59978 | 773.31105 | 751.6079 | 748.12578  | 742.63894  | 735.12331  |
| Discounted Total Costs 15%                | <b>R 4,048.97</b>   | 1296.77    | 833.71   | 749.34    | 652.81   | 542.80   | 485.78    | 442.45    | 39.82     | 310.48    | 237.39    | 228.84    | 207.97   | 194.25     | 156.73     | 138.18     |
| Discounted Total Costs 5%                 | <b>R 10,332.73</b>  | 1420.27    | 1000.15  | 972.55    | 854.85   | 855.56   | 818.44    | 845.87    | 77.81     | 703.09    | 704.56    | 672.74    | 618.91   | 635.89     | 580.43     | 532.78     |
| NET MARGIN                                |                     | 685.09     | 348.30   | 953.70    | -1155.80 | 87.95    | 816.13    | -418.42   | 1155.14   | 88.48     | 937.70    | -583.50   | 475.14   | R -102.38  | R 622.38   | R 484.32   |
| CUMULATIVE NET MARGIN                     | <b>R 4,398.31</b>   | 685.09     | 1041.39  | 1055.09   | 795.49   | 883.39   | 1,729.52  | 1,321.10  | 2,898.24  | 2,986.88  | 3,924.38  | 3,340.88  | 3,816.02 | R 3,532.63 | R 4,035.09 | R 4,520.31 |
| NET PRESENT VALUE (10%)                   | <b>R 3,900.19</b>   |            |          |           |          |          |           |           |           |           |           |           |          |            |            |            |
| NET PRESENT VALUE (15%)                   | <b>R 1,898.81</b>   |            |          |           |          |          |           |           |           |           |           |           |          |            |            |            |
| NET PRESENT VALUE (5%)                    | <b>R 3,173.87</b>   |            |          |           |          |          |           |           |           |           |           |           |          |            |            |            |
| <b>INCREMENTAL: BB MINUS Conventional</b> |                     |            |          |           |          |          |           |           |           |           |           |           |          |            |            |            |
| Net Margin                                |                     | 525.03     | 852.11   | 934.72    | -180.80  | 736.21   | 788.59    | 936.74    | -1870.24  | 789.55    | 865.10    | 778.90    | 886.53   | 584.68     | 789.39     | 788.92     |
| Net Margin Increase                       |                     | 525.03     | 322.88   | 82.81     | -153.83  | 349.32   | 38.39     | -171.85   | 1,273.50  | -1,151.18 | 78.05     | -69.14    | 89.48    | -152.45    | 238.01     | -23.17     |
| Sum Net Margin                            | <b>R 10,872.88</b>  | 525.03     | 1,377.14 | 2,311.86  | 2,482.75 | 3,222.88 | 3,891.55  | 4,888.29  | 6,458.55  | 7,227.58  | 8,072.85  | 8,848.67  | 9,738.20 | 10,910.28  | 12,910.37  | 15,672.20  |
| Present value of Total NMI (10%)          | <b>884.70</b>       | 477.30     | 270.31   | 82.07     | -514.88  | 345.88   | 21.88     | -88.18    | 594.16    | -487.07   | 28.32     | -23.87    | -28.82   | -12.88     | 84.25      | -5.55      |
| Present value of Total NMI (15%)          | <b>864.44</b>       | 456.15     | 247.72   | 84.72     | -481.80  | 273.11   | 18.59     | -84.80    | 418.31    | -315.03   | 58.80     | -18.44    | -18.91   | -18.85     | 28.52      | -2.80      |
| Present value of Total NMI (5%)           | <b>233.88</b>       | 500.03     | 288.87   | 71.58     | -827.14  | 830.61   | 28.86     | -122.10   | 881.85    | -709.84   | 48.89     | -58.82    | -50.37   | -54.33     | 104.93     | -11.18     |

Appendices A5, A6 and A7. All the calculations are based on the comparison of the conventional technique and the *IRWH* techniques.

In the calculation of the NPV and BCR for the different techniques, the costs were accounted for somewhat differently depending on the technique. This was due to the inherent differences in the *IRWH* techniques' characteristics. As was discussed during the profitability analysis, the enterprise budget included investment costs (fixed costs). Generally these were incurred at the initial phase of the project, if the project is to be implemented, the costs will be incurred again (as replacement costs) but at different time intervals depending on the *IRWH* technique. It is against this background that a period of fifteen years was chosen since that was the longest period that was needed for one of the techniques (*SbSr*) to require that the system be replaced. One should also note that for most *IRWH* techniques, it was only a certain proportion of the total investment cost that has to be incurred and that depends on which part of the system needs to be replaced/revamped<sup>7</sup>.

For the period of analysis the different techniques needed a revamping of the system or a part thereof and this occurred at different intervals and costs. The simplest technique, *BbBr* needed that the basins be repaired every three years. This was equivalent the costs incurred in the initial phase to construct the basins only less all the other investment costs associated with that technique. *ObBr* unlike *BbBr* required that two-thirds of the cost of putting up mulches in initial investment cost be incurred every three years. This is used to replace the organic mulch, which is assumed to have a useful life of three years. For *ObOr*, the cost of replacing the organic mulch is equivalent to the initial cost of putting up the mulches. This means that this cost will be entered into the NPV calculation every three years. In the case of *SbMr*, only a third of the initial cost of putting up the mulch will be entered into the calculation every three years as a replacement cost for the organic mulches.

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<sup>7</sup> The parts that may need replacing might be the two-meter runoff strip or the one-meter cropped basin area. These each make up 2/3 and 1/3 of the system and thus accounts for a similar proportion of costs will depend on which part needs reworking replacing. For technique like *ObOr*, the replacement of the mulches will equal 100 percent the cost of the initial costs, while *ObBr* will only require 1/3 of the said costs.

For NPV analysis of *ObSr*, two thirds of the initial cost of putting up mulches will be required every three years whereas for *SbSr* there was no replacement costs incurred during the analysis period, as there was no part of the system that needed replacing. It is against this background that the NPV and B/C ratios are calculated and they need to be interpreted bearing this differential treatment in mind.

Table 5.26 shows the results from an enterprise level analysis of maize under conventional and *BbBr* (the rest of the results for each crop and technique are in Appendix A4). The analysis calculated the net present value (NPV) and the B/C ratio as well as the net margin for each production technique over a period of fifteen years. Three discount rates (5%, 10% and 15%) are used. The incremental net benefit was calculated from the difference between the net margin of *BbBr* and that of the *CON*.

The analysis starts with the calculation of the total discounted gross income and total discounted costs at different discount rates. The difference between the discounted income and the discounted costs gives the net present value. The B/C ratio is given by the ratio between the discounted income and costs for conventional production of maize, all the NPV values were negative. This implies that the costs for conventional production in the long-term are more than the gains from the investment in the system. The values were negative R4 819, R3 397, and R2 494 for 5 percent, 10 percent and 15 percent discount rates, respectively. The B/C ratios in the same order were 0.66, 0.68 and 0.69.

For *BbBr*, the NPVs were R3 173, R2 380 and R1 879 for 5 percent, 10 percent and 15 percent discount rates respectively. All the discount rates yielded positive NPVs, this implies that it might be advisable to invest in the *BbBr* technique as opposed to *CON*. The B/C ratios for the 5 percent and 10 percent discount rates were both 1.28, and for the 15 percent rate it was 1.29.

The net present values for net margin increase are positive at all discount rates. This implies that the investing in *BbBr* will yield better returns to investment than *CON*. From these criteria it can thus be recommended that *BbBr* be used in production of maize in the study area instead of *CON*.

This procedure is repeated for each *IRWH* technique and each crop, and the values are compared to the base scenario (conventional) to calculate the incremental net benefits. The results are presented in Appendix A4. However, Table 5.26 summarizes the results in terms of the net present value and benefit cost ratio for each crop and production technique.

Table 5.26 shows that maize production *ObOr* has the greatest NPVs and benefit cost ratios, followed by *SbOr*, *SbSr*, *ObSr*, *BbBr*, and finally *CON*. The results are almost in opposite order of the profitability analysis for *ObSr*, *SbSr*, *SbOr* and *ObOr* as well as between *BbBr* and *ObBr*. In the profit analysis *ObSr* was the most profitable and *BbBr* the least profitable of the *IRWH* techniques. The results imply that *ObOr* will bring the highest returns to investment when compared with the rest of the production techniques. While it would be profitable in the short term to use *ObSr*, it has lower long-term returns than *ObOr*.

TABLE 5.26: SUMMARY OF THE COST BENEFIT ANALYSIS FOR THE CROPS AND PRODUCTION TECHNIQUES IN THE STUDY AREA

| Crop<br>Production technique | Net Present Value<br>(R)'000 |       |       | Benefit –Cost Ratio |      |      |
|------------------------------|------------------------------|-------|-------|---------------------|------|------|
|                              | 5%                           | 10%   | 15%   | 5%                  | 10%  | 15%  |
| <b>Maize</b>                 |                              |       |       |                     |      |      |
| <i>CON</i>                   | -4.82                        | -3.40 | -2.49 | 0.66                | 0.68 | 0.69 |
| <i>BbBr</i>                  | 3.17                         | 2.38  | 1.88  | 1.28                | 1.28 | 1.29 |
| <i>ObBr</i>                  | 2.74                         | 2.06  | 1.64  | 1.23                | 1.23 | 1.23 |
| <i>ObOr</i>                  | 5.65                         | 4.14  | 3.21  | 1.55                | 1.54 | 1.54 |
| <i>ObSr</i>                  | 4.93                         | 3.61  | 2.79  | 1.41                | 1.40 | 1.40 |
| <i>SbOr</i>                  | 5.44                         | 3.89  | 3.09  | 1.52                | 1.52 | 1.51 |
| <i>SbSr</i>                  | 5.02                         | 3.67  | 2.84  | 1.42                | 1.41 | 1.41 |
| <b>Sunflower</b>             |                              |       |       |                     |      |      |
| <i>CON</i>                   | -1.26                        | -7.78 | -4.70 | 0.91                | 0.92 | 0.94 |
| <i>BbBr</i>                  | 8.35                         | 6.31  | 5.01  | 1.71                | 1.72 | 1.74 |
| <i>ObBr</i>                  | 8.80                         | 6.63  | 5.26  | 1.74                | 1.75 | 1.77 |
| <i>ObOr</i>                  | 9.85                         | 7.28  | 5.68  | 1.76                | 1.76 | 1.76 |
| <i>ObSr</i>                  | 12.86                        | 9.52  | 7.42  | 2.08                | 2.08 | 2.07 |
| <i>SbOr</i>                  | 10.91                        | 8.07  | 6.28  | 1.93                | 1.92 | 1.92 |
| <i>SbSr</i>                  | 12.93                        | 9.58  | 7.47  | 2.11                | 2.10 | 2.10 |
| <b>Dry beans</b>             |                              |       |       |                     |      |      |
| <i>CON</i>                   | 0.97                         | 0.75  | -1.50 | 1.05                | 1.05 | 0.86 |
| <i>BbBr</i>                  | 10.85                        | 7.95  | 6.12  | 1.85                | 1.85 | 1.84 |
| <i>ObBr</i>                  | 10.43                        | 7.63  | 5.87  | 1.79                | 1.78 | 1.77 |
| <i>ObOr</i>                  | 11.92                        | 8.67  | 6.64  | 1.94                | 1.92 | 1.91 |
| <i>ObSr</i>                  | 12.82                        | 9.32  | 7.13  | 2.03                | 2.01 | 1.99 |
| <i>SbOr</i>                  | 12.03                        | 8.75  | 6.69  | 1.96                | 1.94 | 1.93 |
| <i>SbSr</i>                  | 12.95                        | 9.42  | 7.20  | 2.06                | 2.04 | 2.02 |



Table 5.26 further shows that for sunflower production, the *IRWH* techniques have higher net returns than *CON* as in the profit and risk analysis. However, *SbSr* has the greatest NPVs and benefit cost ratios. The technique is followed by *ObSr*, *SbOr*, *ObOr*, *ObBr*, and *BbBr* in that order. In the profitability analysis and the risk analysis, *ObSr* performed better than *SbSr*, but the rest of the production techniques still rank the same in the cost benefit analysis. The observation is different from that for maize production where *ObOr* seems to be the technique with the highest net returns on investment.

For the production of dry beans, *SbSr*, as with sunflower production, has the greatest NPVs and benefit cost ratios. As in the case for maize production, dry beans production shows that *BbBr* has higher net returns than *ObBr*. Generally, dry beans production has relatively higher net return values than for all the other crops. Conventional production of dry beans shows positive values for the 5 percent and 10 percent discount rates except for the 15 percent discount rate. At the latter discount rate, there is a negative NPV and BCR less than 1. The observation is different from the other crops which all yielded negative net returns values and BCRs less 1 for the conventional production. This implies that dry beans production under the *CON* technique may bring positive net returns but more net returns will be achieved by the use of *IRWH* techniques.

## 5.5 Minimum area of land required for food security

The results that follow present the values used for the determination of the minimum household area required to ensure food/income security for an average household in the study area. The determination of minimum farm size uses two slightly different and complementary methods, the household income requirement and the household caloric requirement. The two methods will be explained further later in this section.

Table 5. 27 presents the average socio-economic characteristics of a household in the study area.

TABLE 5.27: AVERAGE SOCIO ECONOMIC CHARACTERISTICS OF AN AVERAGE HOUSEHOLD IN THE STUDY AREA, 2001

| Household Characteristics               | Average |
|-----------------------------------------|---------|
| Household Size                          | 5       |
| Adults                                  | 2       |
| Children                                | 3       |
| Adult Equivalent                        | 3       |
| Adult Income requirement (per month)    | R353    |
| Household Income requirement (per year) | R12 539 |
| Social Grants (per month)               | R328    |
| Remittances (per month)                 | R236    |
| Total off farm income (per year)        | R6 767  |

Table 5.27 shows that the average household size in the study area was 5 in 2001. On average each household had 2 adults and 3 children. This implies that on average each family is comprised of about two adults and three children. The average number of children and parents gave an average adult equivalent for the study area of 3, a figure which might be interpreted to mean that each household comprises about three adults. The poverty line as reported by May (1998) is used as a proxy for the minimum income requirement for an adult household member and the figure is R353 per month. The product of the poverty line, adult equivalent and the number of months in a year then give the household income requirement.

The household income requirement per year was calculated to be R12 539, and the social grants and remittances accounted for R6 767 per year. This implies that social grants and remittances make up a large proportion (53%) of the household income, therefore the other 47 percent should come from the household farm enterprise(s). The dependence on social grants and remittances is consistent with the fact that there is a high level of unemployment in the study area. It follows therefore that if the *IRWH* techniques are to prove worthwhile, they are more likely to be favoured by the farmers, as they will provide an alternative to total dependence on external income sources.

Another important observation from the table is that, for the survival of the families, at least one member receives a government social grant (old age pension, child support grant, and/or disability grant). This further necessitates the need for intervention to enable households to generate income or produce their own food if they are to have sustainable household livelihoods. Since arable farming should provide the shortfall in income requirement, there is a need to determine the minimum area that will be required to produce enough food/income to offset, at the least, the household food/income deficit. As already stated this is done with two approaches: the income requirement approach is discussed in the section that follows.

#### **5.5.1 Minimum farm area based on income requirement**

In the calculation of minimum area based on income requirement, the income deficit is divided by the per hectare production (total gross margin) of a combination of the crops used in the study for a given proportion of each. Given the importance of maize in the study area (as a staple food), the farmers are most likely to grow more maize than either sunflower or beans. To cater for this, it was assumed that the maize crop will at least take up 40 percent of the cropland and the other 60 percent were shared equally between sunflower and dry beans. Minimum farm sizes were calculated for the different production techniques and the results are presented in Table 5.29 together with those from the caloric requirement approach. The next section discusses the caloric requirement approach to determine minimum farm size.

#### **5.5.2 Minimum farm area based on household caloric requirement**

The approach is based on quantities of food expressed in terms of their caloric content and it uses factors that convert quantities of edible portions into calories. In this study a reference person is an adult person of age 30-60 years weighing 60 kg and involved in moderate activity thus requiring on average 2500 kilocalories per day (Rose *et al.*, 1999 and Hoddinott, 1999). According to the literature, 60 percent of the energy required is obtained from the edible portions of carbohydrates, 15 percent from proteins and the remaining 25 percent from fats and oils. The question then is to determine how much of each food type will be required to be able to meet the caloric needs of an average person

For this technique, typical meals for a household were determined as comprising maize porridge, milk, some vegetables and oils or fats. The quantities of each required per day for an average adult were calculated with the help of the food pyramid<sup>8</sup>. Table 5.28 shows the quantities required, for an adult person, of each food type in a typical meal for the study area and the way they are sourced. The sources of food are either own production or purchase.

**TABLE 5.28: HOUSEHOLD FOOD REQUIREMENTS TO MEET DAILY NUTRIENT AND ENERGY REQUIREMENT PER ADULT EQUIVALENT IN THE STUDY AREA, 2001**

| Item              | Quantity | Source         |
|-------------------|----------|----------------|
| Maize meal        | 400g     | Own production |
| Milk              | 0.5l     | Purchased      |
| Meat              | 60g      | Purchased      |
| Vegetables/fruits | 215g     | Purchased      |
| Fats and oils     | 69ml     | Purchased      |

As Table 5.28 clearly shows, the only food produced by the household is maize meal from maize production, all other items are sourced from outside the household (purchased). This then necessitates the need for the generation of enough income to enable the household to purchase all other items. To achieve that, the household has two options; either to produce maize in excess of the amount required for household income such that the surplus maize production can generate the required income or to produce a combination of the available crops (maize, sunflower and beans). In the second option, the maize production should at least be enough to meet the household demand for maize meal. This then raises the question of how much maize grain will be required to produce the daily requirement of 400g per adult person. Assuming, on average, a loss of 30 percent (Hoddinott, 1999) in processing maize grain to maize meal, then the amount of maize grain required to produce 400g was determined to be 520g. This implies that for an average household in the study area of 2.96 adult equivalents, the maize grain required totals 0.56 tons of maize grain per year. This means that households should at least produce 0.60 tons of maize grain to meet their yearly maize meal requirement.

<sup>8</sup> With the usual caveat, the advice of Danhausser and Lategan (Department of Human Nutrition, University of the Free State) on this issue is acknowledged.

After the required maize grain was determined, the income required to obtain the required quantities of the other food types was calculated. The total income required per adult equivalent per year was determined to be R3 314, and for the household was R9 811. Assuming that the household was to purchase the required maize grain, then they would require an extra R319 (at 1999/2000 prices of maize grain) which makes the required income to meet food needs to be R10 131. This figure together with the total income from social grants was used to determine the minimum farm size in the same way as was done with the income approach. The calculated areas of land for each technique are presented in Table 5.29 as well as those from the income approach.

**TABLE 5.29: CALCULATION OF THE MINIMUM AREA OF LAND REQUIRED TO ENSURE INCOME SECURITY FOR AN AVERAGE HOUSEHOLD IN THE STUDY AREA FOR DIFFERENT PRODUCTION TECHNIQUES**

| Technique   | Minimum area based on income requirement (ha) | Minimum area based on caloric requirement (ha) |
|-------------|-----------------------------------------------|------------------------------------------------|
| <i>CON</i>  | 14.49                                         | 8.45                                           |
| <i>BbBr</i> | 5.18                                          | 3.02                                           |
| <i>ObBr</i> | 4.87                                          | 2.84                                           |
| <i>ObOr</i> | 3.64                                          | 2.12                                           |
| <i>SbOr</i> | 3.51                                          | 2.05                                           |
| <i>SbSr</i> | 3.37                                          | 1.97                                           |
| <i>ObSr</i> | 3.21                                          | 1.87                                           |

Table 5.29 presents the minimum areas of land required to achieve household food/income security vary between the techniques and between the two approaches. The difference between the production techniques was however expected since they reflect the difference in productivity of the techniques. In the income approach, *CON* requires a minimum area of about 14.5 ha compared to about 3.2 ha for the *ObSr* technique. One should also note the sharp decrease in area from *CON* to *BbBr*, the simplest IRWH technique. The same trend is also shown in the caloric requirement approach, where *CON* requires 8.45 ha compared to *BbBr*'s 3.02, a decrease of 5.43 ha as opposed to 9.31 ha under the income approach for the two techniques. The differences in the two approaches are drastic, even though one would have expected the differences not to be so big. However, there are possible explanations for this.

The first likely explanation for the differences might be attributed to the figure used as the monthly income requirement for an adult equivalent. The value used is the poverty line (May, 1998) which is assumed to cater for all the basic needs (food, shelter and clothes) whereas in the caloric requirement, only the food component is catered for. This therefore might explain the differences in the areas of land required. The second explanation relates to the calculation of the daily caloric requirement, an average value was used (2500kcal). The caloric requirement in its strict sense is based on a number of factors like activity, age, weight, height, gender and individual characteristics and thus the use of an average may have overshadowed all this and led to an underestimation of the minimum farm size.

Based on this, it might be worth noting that the results of this analysis should be used cautiously as they are indicative and not prescriptive and they provide a starting point for further analysis of the required minimum area of land. However, if it is assumed that the household has other means to acquire income for non food household income, the caloric requirement criteria will be more relevant but the income approach will be important if all household needs are to be provided for by crop production. Another area that might need further research is the removal of social grants to see what will happen to the minimum amount of land required and whether it is feasible. Since social grants and remittances make up more than half of the income required, their removal is likely push up the land requirements by almost the same percentage as their contribution to household income. These numbers may prove very high and most probably not achievable, and under the current conditions of land scarcity there might be a preference towards the more costly *IRWH* techniques. Based on the above, it is evident that the farmers need some sort of institutional support if the *IRWH* techniques are to be sustainable. This is evidenced by the important role that the social grants play in the household livelihoods in the study area.

### **5.6 *IRWH* Economic simulation model**

Based on the different submodels that were developed for the economic analysis of the *IRWH* techniques, an overall economic model was developed. The model calculates the minimum farm size, total gross margin from a crop mix, and then determines enterprise budgets for a crop and production technique simultaneously

when some specified input variables are changed. The model combines the submodels for enterprise budget analysis and the minimum farm size determination. This allows for the changing of the variable input prices, the combination of crops and the household size. When such data is inputted, the model will calculate the minimum farm size required for each IRWH technique and the total gross margin thereof. In the calculation for the minimum farm size, a distinction is made between the income approach and caloric requirement approach. Figure 5.10 presents a diagrammatic representation of the spreadsheet linkages in the simulation model.



FIGURE 5.10: A DIAGRAMMATIC REPRESENTATION OF THE SPREADSHEET LINKAGES OF THE ECONOMIC SIMULATION MODEL

The model requires the specification<sup>9</sup> of the prices of variable inputs (seed, fertiliser, labour), household composition (children and adults), and the output prices (kg/ton). In addition, the model requires that the preferred crop mix be entered as a proportion



of the total land available. As the data is inputted, the total gross margin will be calculated for each technique and the enterprise budgets (per ha) will be developed. The enterprise budgets, the crop mix and the household composition are then linked to determine the minimum farm size that will be required by the household to achieve household food security. In the calculation of the household food security, the household composition is converted by the use of the adult equivalent approach. The model gives as output, the total gross margin per hectare, the enterprise budgets and the minimum farm size. Figure 5.11 below shows the input and output from the model, for an example run. For easy use of the model, all variables that are in blue are changeable and those in black are fixed values; they cannot be changed. Appendix 8 gives a description on how to operate the model. A diskette is also available from the Department of Agricultural Economics, University of the Free State, and the Water Research Commission (WRC).

| Irrigated Farmwater Harvesting Economic Model    |                               |                               |                               |                               |                               |                               |                               |                               |                               |
|--------------------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| INPUT                                            |                               |                               |                               |                               |                               |                               |                               |                               |                               |
| Area of Land Available (ha)                      | 1.00                          |                               |                               | Household labour availability |                               |                               |                               |                               |                               |
|                                                  |                               |                               |                               | Children (below 18 years)     |                               |                               |                               |                               |                               |
|                                                  |                               |                               |                               | Adults (above 18 years)       |                               |                               |                               |                               |                               |
| Crops                                            | Wheat, Sunflower, Beans       |                               |                               | 2.00                          |                               |                               |                               |                               |                               |
| Proportion of Land Cropped (%)                   | 0.00, 0.00, 0.00              |                               |                               | 5.00                          |                               |                               |                               |                               |                               |
| Input Prices                                     | 19.00                         |                               |                               |                               |                               |                               |                               |                               |                               |
| Inputs                                           | Current Prices                |                               |                               | 1999/2000 Prices              |                               |                               | Output Prices                 |                               |                               |
| Wheat                                            | 19.00                         | 19 kg                         |                               | 19.00                         | 19 kg                         |                               | 19.00                         | 19 kg                         |                               |
| Sunflower                                        | 25.00                         | 19 kg                         |                               | 25.00                         | 19 kg                         |                               | 25.00                         | 19 kg                         |                               |
| Dry Beans                                        | 27.50                         | 19 kg                         |                               | 27.50                         | 19 kg                         |                               | 27.50                         | 19 kg                         |                               |
| Chemicals                                        |                               |                               |                               |                               |                               |                               |                               |                               |                               |
| Fertiliser                                       | 27.50                         | 19 kg                         |                               | 27.50                         | 19 kg                         |                               | 27.50                         | 19 kg                         |                               |
| Turkey                                           | 27.50                         | 19 kg                         |                               | 27.50                         | 19 kg                         |                               | 27.50                         | 19 kg                         |                               |
| Machinery                                        | 27.50                         | 19 kg                         |                               | 27.50                         | 19 kg                         |                               | 27.50                         | 19 kg                         |                               |
| Ammonium Nitrate                                 | 1.00                          | 19 kg                         |                               | 1.00                          | 19 kg                         |                               | 1.00                          | 19 kg                         |                               |
| Superphosphate                                   | 1.75                          | 19 kg                         |                               | 1.75                          | 19 kg                         |                               | 1.75                          | 19 kg                         |                               |
| Labour                                           | 19.00                         | 19 days                       |                               | 19.00                         | 19 days                       |                               | 19.00                         | 19 days                       |                               |
| OUTPUT                                           |                               |                               |                               |                               |                               |                               |                               |                               |                               |
| Gross Margin per crop: Wheat                     | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         |
| Sunflower                                        | 25.00                         | 19.00                         | 19.00                         | 25.00                         | 19.00                         | 19.00                         | 25.00                         | 19.00                         | 19.00                         |
| Beans                                            | 27.50                         | 19.00                         | 19.00                         | 27.50                         | 19.00                         | 19.00                         | 27.50                         | 19.00                         | 19.00                         |
| Enterprise Budgets                               | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         |
| Crop enterprise Budgets (per hectare)            | Wheat_19.00, 19.00, 19.00     | Wheat_19.00, 19.00, 19.00     | Wheat_19.00, 19.00, 19.00     | Wheat_19.00, 19.00, 19.00     | Wheat_19.00, 19.00, 19.00     | Wheat_19.00, 19.00, 19.00     | Wheat_19.00, 19.00, 19.00     | Wheat_19.00, 19.00, 19.00     | Wheat_19.00, 19.00, 19.00     |
|                                                  | Sunflower_25.00, 19.00, 19.00 | Sunflower_25.00, 19.00, 19.00 | Sunflower_25.00, 19.00, 19.00 | Sunflower_25.00, 19.00, 19.00 | Sunflower_25.00, 19.00, 19.00 | Sunflower_25.00, 19.00, 19.00 | Sunflower_25.00, 19.00, 19.00 | Sunflower_25.00, 19.00, 19.00 | Sunflower_25.00, 19.00, 19.00 |
|                                                  | Beans_27.50, 19.00, 19.00     | Beans_27.50, 19.00, 19.00     | Beans_27.50, 19.00, 19.00     | Beans_27.50, 19.00, 19.00     | Beans_27.50, 19.00, 19.00     | Beans_27.50, 19.00, 19.00     | Beans_27.50, 19.00, 19.00     | Beans_27.50, 19.00, 19.00     | Beans_27.50, 19.00, 19.00     |
| Minimum Farm Size based Income (ha)              | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         |
| Minimum Farm Size based Calorie Requirement (ha) | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         | 19.00                         |

FIGURE 5.11: THE INPUT AND OUTPUT PAGE OF THE *IRWH* ECONOMIC SIMULATION

<sup>9</sup> If such prices are not available, base year (1999/2000) prices are provided as default prices.

## CHAPTER 6

### SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

#### 6.1 Introduction

Increasing agricultural productivity and production in smallholder agriculture can provide an opportunity to redress problems of poverty and food insecurity which are pervasive among rural households in South Africa. With adequate support from relevant institutions and organisations, such as improvements in access to land and other productive resources, the expansion of infrastructure and markets for inputs and outputs, agricultural production can help create employment and provide a means for generating income for households, thus helping to improve and secure rural livelihoods.

In order for a vibrant and productive smallholder agricultural sub-sector to emerge, there is need for a continual supply of new and improved production technologies and practices. The new technologies should be appropriate for the circumstances of smallholder farmers and address the constraints in their farming system. Also important, the new technologies must be economically, socially and environmentally sustainable. The fulfilment of these conditions requires that the processes by which new technologies are generated be responsive to such requirements. This starts with the way in which farming system problems are diagnosed and interventions to solve these constraints are carried out. There is a need for such technologies to be developed within a participatory framework to allow control and ownership of the processes and their outcomes by the intended end users of the technologies. Such an approach needs to be mainstreamed, and made an integral part of the way government departments and other organisations working with smallholder farmers operate.

This research was intended to make contributions in this direction by taking a technology trial process through a participatory process. Specifically the study examined the development of water conservation techniques and the development of crop production techniques based on these water conservation techniques. The specific water conservation and the related production techniques are called infield

rainwater harvesting techniques, which are based on inducing and collecting runoff during rainfall and collecting the water for use by plants in order to increase the amount of water available for plant use and thus increasing crop production. These techniques can improve crop production in semi-arid regions where rainfall is not only limited but the little available is irregularly distributed across time and space.

Rainwater harvesting for agricultural use in arid and semi-arid environments dates back to antiquity, and many societies have always practiced rainwater harvesting of one kind or another with the collected water used variously for agricultural production or for domestic purposes. In the recent past research and development efforts have resulted in the development of rainwater harvesting systems that are adapted to different conditions depending on the specific agro-ecological conditions in an effort to make available techniques for increasing agricultural production and minimising the impacts of droughts. Most of the techniques that were developed by agricultural scientists have been proven to increase crop yields, yet there has been no widespread use of the techniques by farmers. A possible reason for non-adoption by farmers is that there has been little investigation of the economic, and social impacts of these techniques. New technologies need to result in significant increase in farmers' income if they are to be deemed attractive. Farmers in marginal environments have evolved production practices that help minimise the risk of crop failure. Thus, new production techniques should be able to allow farmers to manage risk to household livelihood.

## **6.2 Social sustainability of IRWH techniques**

In the present study the broad goal of helping to increase agricultural production in smallholder agriculture by providing farmers with innovations to remove the constraints posed by inadequate water for crop production were developed and tested in a collaborative effort (in participatory framework) between farmers and researchers. Full and meaningful involvement of farmers in the entire process of diagnosing problems in the farming system and the development of appropriate interventions is key to the ensuring widespread use of new technologies. Participatory tools such as PRA and PAR can be important mechanisms for facilitating farmer involvement in the development process. In carrying out the study reported here PRA and PAR techniques were employed and the result was a greater involvement by farmers in Thaba Nchu in conducting trials of IRWH techniques. In the process all

members of the communities, including the poorest households, women and youths had an opportunity to participate since the process was open, not intimidating. The features of the IRWH were widely discussed among farmers ensuring that they did not conflict with local traditions and customs. The use of participatory approaches provided opportunities for learning to both farmers and researchers, thus all participants were empowered at the end of the process. Farmers selected a management committee to help manage trial plots and the committee took on the responsibility of mobilising fellow community members to undertake agricultural practices on the trial plots. With this newly acquired ability to cooperate in project work, in the subsequent period, farmers, in particular the ones in the village of Yoxford, were able to mobilise and form labour exchange cooperatives for the purpose of pulling labour to develop the rainwater harvesting infrastructure in each others' homestead gardens.

The active involvement of farmers in conducting the on-farm trials provided the farmers with an opportunity to gain practical experience working with IRWH techniques, enabling them to own the techniques and to acquire the ability to work with the techniques in the absence of assistance by researchers.

All the above advantages mean that farmers will be able to work with the techniques after the research phase is completed. The approach followed in carrying out the study promoted social acceptability of IRWH. Early indications, a season after the trials, testify to this claim as growing numbers of households in each of the villages were preparing to practice water harvesting in the following season. Although four villages were included in the research, growing numbers of farmers from non-participating villages were visiting the participating villages and asking if they too can learn about IRHW.

Sustainable development is as much about society as it is about the environment. Thriving regions, villages and neighbourhoods are fundamental to quality of life. If new technologies and production practices are to result in improvements in quality of life, they should maintain or lead to the attainment of a sense of social cohesion, cultural inclusion and people empowerment.

An assessment of the social acceptability of new technologies should consider both its effects on households in the current generation as well as some inter-generation concerns. For the current generation, an analysis of the impacts of new technologies among members of a household and across households should form part of the investigation of the likelihood of adoption and adaptation of new technologies. Sometimes the introduction of new technologies may lead to an alteration of the roles of members of the households. For example, some technological innovations may require that women spend more time working in the fields at the expense of other activities, such as food preparation and child care. This may have an overall negative effect on the well-being of the households. In some instances it may also be the case that new technologies affect the distribution of resources within the household. For example, new production practices designed to improve cash crop production are typically controlled by men in many farming systems in sub-Saharan Africa, but rely heavily on women and children's labour input, while it is not always the case that the benefits will be shared equally among members of the household.

In many communities households' livelihoods are based on social networks, among other factors. It is thus important that minimal disruptions in the networks should occur as a result of the introduction of new technologies. For example, new technologies that lead to intensification of production and the use of inputs may make it no longer possible for households to share draft power and labour.

The application of IRWH techniques allows farmers to increase production, thus improving the income earning potential and nutritional status of the households. The techniques enable households to utilise resources such as land which had up to now been lying idle, and also assures that the efforts of farmers are rewarded. In the villages where the IRWH techniques were tried, the skills of farmers, and the level of social capital was improved through farmers participating in the development and management of the trials.

### 6.3 Economic sustainability

In this study, economic sustainability was measured based on long term profitability and risk reduction. These two indicators are used to reflect the financial health and stability of the techniques. According to theory, an index of growth in total factor productivity, taking into account changes in levels of input use (including the changes in the quality of the natural environment) is useful in assessing economic sustainability. Different indices can be used to compare the growth in output and the growth in input use overtime. In this case, a similar approach was used where the net present value (NPV) of changes in income (output) is compared to the NPV of changes in costs (inputs) over a period of 15 years. However, the calculation of the NPVs does not take into account the impact of production on the natural environment. The riskiness of production using IRWH techniques was measured by cumulative distribution functions (CDFs) of farm income/gross margins obtained from projected production data using rainfall data for the past 81 years.

This was done to indicate whether the techniques were financially viable as well as contributed to reduction of the risk of crop failure or stabilization of profits from crop production in the study area. The argument is that financial viability and profit stabilization/risk reduction will be sufficient for the farmers to adopt the IRWH techniques. If the techniques do not provide sufficient profits, farmers will not adopt them regardless of the ecological benefits they might provide.

From the financial analysis, the techniques have shown that they have the potential to increase profits and reduce risk of crop failure considerably as opposed to conventional production. The analysis showed that the conventional production technique was not sustainable as it had negative financial returns and high levels of risk. The IRWH techniques showed positive net present values and benefit cost ratios above 1 and greater than the conventional. The least productive IRWH technique requires the farmers to expand their farms from 1.87 ha to 3.02 ha, using the caloric approach and to 5.18 ha using the minimum income approach; an increase of about 1.15 to 3.31 ha respectively to meet the households food requirement. The expansion of the cropping area can however, be limited by the use of more productive IRWH techniques. The analysis thus indicated that IRWH techniques can be economically

sustainable, as they are viable but other criteria need to be used to complement the economic analysis. This was accomplished through conducting social acceptability and ecological sustainability analyses.

In summary, the economic analyses show profitability and financial sustainability of IRWH techniques. The risk associated with production was reduced considerably by the use of IRWH techniques. Farmers can also produce adequate amounts of food or income with which they can purchase sufficient food to supply the medically recommended daily energy requirements to allow an average person to live a healthy and productive life from a smaller farm size using IRWH techniques, than with conventional techniques.

## **6.4 Environmental sustainability**

The natural environment is a crucial input in production systems and also acts as a support system for human and other life forms. The environment provides resources such as soil, water, metals and other living organisms. Sustainable management of basic natural resources for agriculture is a key issue in ensuring the continued productivity and the ability of the environment to continue providing the goods and services that are an input in human consumption. Thus, innovations and technologies that affect natural resources, such as the soil and water, among others should be carefully evaluated before they can be recommended for wide-spread use by farmers. In addition, where some degree of resource damage is unavoidable during production processes, mitigation measures should be developed to allow minimisation of such damages, as well as remedial measures to allow for resource recovery.

The IRWH techniques increase the amount of water available for crops on farmers' fields. As well, the amount of moisture in the soil profile at time of planting thus also increased. Mulching and construction of basins to stop off-field run-off helps reduce/eliminate soil erosion. In addition to organic mulches improving soil fertility and structure, they also reduced evaporation.

While IRWH techniques allow for intensification of production on agricultural lands, this should not come at the expense of the resource base. The IRWH techniques enable farmers to address the moisture constraint in agricultural production, but

typically the next bidding constraint is the fertility of the soil. It is recommended that farmers use fertiliser with IRWH if they are to receive the highest benefits from the moisture made available for plant use, an issue which requires further investigation.

## 6.5 Recommendations

The potential of water harvesting techniques to improve agricultural production are well known, but its application by farmers is surprisingly limited. In many parts of the world, various techniques of collecting rainwater and applying it to agriculture have been used for millennia with very high gains in output. There is a need to study these water-harvesting techniques in the areas where they have evolved and have been successful at increasing output levels. However, the choice of specific methods and designs of water harvesting practices to adopt and adapt for various farming areas depends of the specific ecotope in which they are going to be applied. In the present study, a design with 2-metre wide strips used as a micro-catchments, and 1-metre wide storage basins for collection of run-off was utilised. The basin area also serves as the planting area. Given the soil type and the rainfall pattern at the research station and the farming area in Thaba Nchu, this design has shown that it can collect adequate water to support crop growth.

The "2-metre wide run-off strip and 1-metre wide basin" developed by the researchers at ARC-ICSW is a basic design to which variations can be made in the form of adding of organic or stone mulches to either the basins or the run-off area separately or to both at the same time. The addition of the mulches has the advantage of eliminating soil movements, while organic mulches also improve the soil's structure and fertility and decrease evaporation from the soil's surface. The use of IRWH techniques for crop production does not seem to lead to a deterioration of the resource base suggesting these production techniques are environmentally sustainable.

The preliminary results reported in this study suggest that farmers are willing to apply IRWH techniques in their production activities, and that these techniques are economically viable and environmentally sustainable. Based on these findings it can be recommended that extension efforts should be undertaken to encourage adoption and adaptation by farmers. Extension officers from the Free State Department of Agriculture were involved in the development of on-station and on-farm trials of the



techniques and continue to work with farmers as they apply the rainwater harvesting to their gardens and fields. However, more information and support should be provided to them in order to increase their understanding of the techniques and to prepare them to carry on the work when the research project terminates. This information can be provided in the form of easy to use handbooks detailing the technical aspects of water harvesting and its economic and environmental benefits.

While the preliminary results reported here suggest that the use of IRWH techniques provides social, economic and environmental benefits, these findings come from assessment of the techniques in a short period. There is a need for continued monitoring of the impacts (environmental, economic and social) of these techniques. In this regard it would be necessary to conduct an impact assessment study in three to four seasons from now. This will allow one to have a better understanding of the role that IRWH can play in farming systems in semi-arid areas. Such a study will also include an assessment of the adoption patterns and their determinants, information which would be useful for guiding future work on water conservation efforts in other parts of the country.

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## **APPENDICES**

### **APPENDIX A1: QUESTIONNAIRE USED FOR COLLECTING HOUSEHOLD QUANTITATIVE DATA IN THE STUDY AREA**

## Questionnaire: Socio-Economic Impact of Water Harvesting Techniques among Smallholder Farmers in Semi-Arid Environments

*University of the Free State, Department of Agricultural Economics*

Name of Village -----

Household name -----

Household code -----

Interviewer's name -----

Date of Interview -----

Starting Time -----

Finishing Time -----

*Many households in South Africa are engaged in agricultural production (of crops and livestock) as their main source of livelihood. Several agencies are involved in helping small-scale farmers in the country to improve their productivity with the goal of trying to raise the standard of living of the people. However, to be effective more information is needed about the processes and ways in which farmers make production and land use decisions. A research team composed of researchers from the University of the Free State and the Agricultural Research Council would want to find out more about how farmers produce crops and raise livestock. To help us understand farmers' decisions making processes we would like to ask you some questions.*

### **Section A: Household Characteristics**

*The following questions are designed to tell us a little bit about you and your household. This information is important because it will allow us to compare and understand crop production, livestock husbandry practices and land use decisions of different groups of people. The information will be treated as confidential. Your name will not appear with your answers. Only a summary of the results will be published.*

1. Sex of respondent (*Observed - please circle appropriate answer*)

01 = Female

02 = Male

2. In which of the following age categories are you?

01. 18 - 29

02. 30 - 39

03. 40 - 49

04. over

50

3. What is your relation to the head of the household?

01 = head

02 = Spouse

03 = child

04 = other -----

4. What is your highest level of education?







7. Are any members of the household receiving income from the following sources?  
Please fill in the table below.

01 = Yes

02 = No

If **Yes**, please fill in table below. If **No**, please go to question 8.

| Source of income           | Number of members receiving income | Rand value per month (state amounts separately if more than one recipient in each category) |
|----------------------------|------------------------------------|---------------------------------------------------------------------------------------------|
| Pension                    |                                    |                                                                                             |
| Disability grant           |                                    |                                                                                             |
| Child grant                |                                    |                                                                                             |
| Other (Specify) -----<br>- |                                    |                                                                                             |
|                            |                                    |                                                                                             |

8. How long has the household been resident in this village?

01 = 1-5 years

02 = 6 – 10 years

03 = 11 – 15 years

04 = 16 – 20 years

05 = 21 – 25 years

06 = 26 or more years

9. Where did you (household) reside previously? (Describe if outside present village) -----

10. How many of the following assets (functional) does your household own?

| Asset  | Type | Quantity (number in working condition) | Date purchased | Purchase price |
|--------|------|----------------------------------------|----------------|----------------|
| Cart   |      |                                        |                |                |
| Plough |      |                                        |                |                |

|                    |  |  |  |  |
|--------------------|--|--|--|--|
| Cultivator         |  |  |  |  |
| Tractor            |  |  |  |  |
| Other<br>(specify) |  |  |  |  |
|                    |  |  |  |  |

### Section B: Crop Production

*The questions in this section are designed to provide us some information concerning your agricultural and homestead land, and the types of activities that you carry out on your land.*

11. Does the household have access to land for crop production?

01 = Yes

02 = No

12. If household has access to arable land, what is the size of the land? -----morgan

13. Did you grow crops in your field during the 2000/2001 season?

01 = Yes

02 = No

14. If No, why not? -----

-----

When was the last time you grew crops in your field? (year) -----

-----

Which crops did you grow then? -----

-----

15. If you grew crops this past season (2000/20001, which crops did you grow? Please fill in table below.

| Type of crop             | Area planted (morgan) | Methods of land preparation | Fertiliser type and quantity applied | Yield (bags) | Quantity kept for home consumption (bags) | Quantity sold (bags) | Price at which crop sold (Rand/bag) |
|--------------------------|-----------------------|-----------------------------|--------------------------------------|--------------|-------------------------------------------|----------------------|-------------------------------------|
| Maize                    |                       |                             |                                      |              |                                           |                      |                                     |
| Sunflower                |                       |                             |                                      |              |                                           |                      |                                     |
| Beans                    |                       |                             |                                      |              |                                           |                      |                                     |
| Sorghum                  |                       |                             |                                      |              |                                           |                      |                                     |
| Other (specify)<br>----- |                       |                             |                                      |              |                                           |                      |                                     |
|                          |                       |                             |                                      |              |                                           |                      |                                     |

16. How would you describe the quality of the soil in your field?

01 = Poor

02 = Fertile

03 = Very fertile

17. Which farmer-contact agencies provide you with advice on crop and livestock production? Please fill in the table below.

| Farmer-contact agency                | Frequency of contact<br>01 = once a week<br>02 = twice a month<br>03 = once a month<br>04 = Other (specify) ----- |
|--------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Agricultural Extension Officer       |                                                                                                                   |
| Veterinary Officer                   |                                                                                                                   |
| Bank/Financial Institution Personnel |                                                                                                                   |
| Input Suppliers                      |                                                                                                                   |
| Other (specify)                      |                                                                                                                   |

18. Do you grow crops in your backyard garden?

**01** = Yes

**02** = No

19. If **Yes**, which crops did you grow in your garden during the 2000/2001 season?

Please fill in the table below. If **No**, please go to question 20.

| Type of crop             | Main use of crop<br><b>01</b> = sale<br><b>02</b> = own consumption | Estimated Rand value of crop sold ( <b>where applicable</b> ) |
|--------------------------|---------------------------------------------------------------------|---------------------------------------------------------------|
| Tomatoes                 |                                                                     |                                                               |
| Spinach                  |                                                                     |                                                               |
| Garlic                   |                                                                     |                                                               |
| Potatoes                 |                                                                     |                                                               |
| Other ( <b>specify</b> ) |                                                                     |                                                               |
|                          |                                                                     |                                                               |

20. What is the main constraint in crop farming? -----

-----

21. Researchers from the Agricultural Research Council have developed a new water harvesting technique that increases maize; sunflower and beans harvests by up to 50 percent compared to conventional practices. If you were to begin field crop farming which crop would you prefer to start producing?

**01** = Maize

**02** = Sunflower

**03** = Beans

Why? -----

22. Do you have access to credit?

01 = Yes

02 = No

If **Yes**, please fill in the table below. If **No**, please go to question 21.

| Source of credit         | If obtained credit during 2000/2001<br><br>01 = Yes<br>02 = No | Purpose:<br>01 = Buy farm inputs<br>02 = Consumption<br>03 = Pay for medical expenses<br>04 = Other (specify) -----<br>----- |
|--------------------------|----------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Commercial bank          |                                                                |                                                                                                                              |
| Agricultural bank        |                                                                |                                                                                                                              |
| Local moneylenders       |                                                                |                                                                                                                              |
| Other (specify)<br>----- |                                                                |                                                                                                                              |
|                          |                                                                |                                                                                                                              |
|                          |                                                                |                                                                                                                              |

23. How many meals does the household normally have a day?

01 = 1

02 = 2

03 = 3

04 = 4 or more

Please fill in the table below.

| Type of meal           | Home produced meal constituents | Meal constituents purchased at market | Average expenditure on food per month (Rand) |
|------------------------|---------------------------------|---------------------------------------|----------------------------------------------|
| Breakfast/morning meal |                                 |                                       |                                              |
| Lunch/afternoon meal   |                                 |                                       |                                              |
| Supper/evening meal    |                                 |                                       |                                              |
| Other (specify)        |                                 |                                       |                                              |
|                        |                                 |                                       |                                              |

24. Where do you buy food items?

01 = local shops

02 = Thaba Nchu

03 = Bloemfontein

04 = Other (specify) -----

25. Do you think your family's food consumption is adequate to allow members to lead a healthy and productive life?

01 = Yes

02 = No

26. If **No**, in which way is food consumption inadequate?

-----

27. What mode of transport do you use for:

| Items transported | Estimated distance to market<br>(km) | Estimated cost ( <b>Rand</b> ) |
|-------------------|--------------------------------------|--------------------------------|
| Produce/Output    |                                      |                                |
| Inputs            |                                      |                                |
| Other (specify)   |                                      |                                |

**Section C: Livestock Inventory and Transactions**

*In this section we are asking for some information about the livestock owned by your household. This information will only be used for the purposes of this study, and when we write the results of our study, your name will not appear with your answers.*

28. Do you raise livestock?

**01 = Yes**

**02 = No**

29. If **Yes**, please fill in the table below concerning the **livestock you own**. If **No**, please go to question 30.

| Type of Livestock | Number owned to date | Number sold in 2000 | Reasons for sale<br><b>01 = buy grain</b><br><b>02 = school fees</b><br><b>03 = health care expenses</b><br><b>04 = lobola</b><br><b>05=Other</b><br><b>r</b><br><b>(Specify)</b><br>----- | Number bought 2000 | Reason for buying<br><b>01 = increase herd/flock</b><br><b>02 = herd/flock establishment</b><br><b>03 =fattening</b><br><b>04=Other (specify)</b><br>----- | Number received as gifts | Number gifted away |
|-------------------|----------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------|
| Cattle            |                      |                     |                                                                                                                                                                                            |                    |                                                                                                                                                            |                          |                    |
| Sheep             |                      |                     |                                                                                                                                                                                            |                    |                                                                                                                                                            |                          |                    |
| Goats             |                      |                     |                                                                                                                                                                                            |                    |                                                                                                                                                            |                          |                    |
| Pigs              |                      |                     |                                                                                                                                                                                            |                    |                                                                                                                                                            |                          |                    |
| Horses            |                      |                     |                                                                                                                                                                                            |                    |                                                                                                                                                            |                          |                    |
| Other (specify)   |                      |                     |                                                                                                                                                                                            |                    |                                                                                                                                                            |                          |                    |
|                   |                      |                     |                                                                                                                                                                                            |                    |                                                                                                                                                            |                          |                    |

30. What other sources of income are available to your household?

| Activity/Source of Income | Estimated monthly income (Rand) |
|---------------------------|---------------------------------|
| Produce and sell          |                                 |

|                          |  |
|--------------------------|--|
|                          |  |
| Selling mohair           |  |
| Taking care of livestock |  |
| Other (specify)          |  |

### Section D: Land Tenure

The questions in this section are designed to give us information about your ideas of what you think is the best way for allocating land and for controlling land. The arrangements under which land is held can affect farmers' production decisions and the way they look after their land.

31. At present, which of the following do you believe you have a right to do regarding your farmland? Please fill in the table below.

| Field           | Rights enjoyed:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                 | <b>01</b> = Sell without approval<br><b>02</b> = Sell with approval<br><b>03</b> = Rent out without approval<br><b>04</b> = Rent out with approval<br><b>05</b> = Bequeath without approval<br><b>06</b> = Bequeath with approval<br><b>07</b> = Gift away without approval<br><b>08</b> = Gift away with approval<br><b>09</b> = Mortgage without approval<br><b>10</b> = Mortgage with approval<br><b>11</b> = Pledge without approval<br><b>12</b> = Pledge with approval<br><b>13</b> = Prevent other villager's stock from grazing crop stubble |
| Main field      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Backyard garden |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

32. Does the current system of land tenure affect your decision to engage in crop production?

**01** = Yes

**02** = No

If Yes, how? .....

.....



33. What changes, **if any** would like to take place regarding the way access to and control of land are currently regulated in the village? Please fill in table below.

| Land Category | Desired Changes                                                                                                                                                                                                                           |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Crop land     | <b>01</b> = Have individual title to land (private ownership)<br><b>02</b> = Control farmland collectively<br><b>03</b> = Other ( <b>specify</b> ) -----                                                                                  |
| Grazing land  | <b>01</b> = Subdivide land and allocate parcels to individuals<br><b>02</b> = Allocate rights for grazing to each household so that those without stock can still benefit from grazing land<br><b>03</b> = Other ( <b>specify</b> ) ----- |

34. How do you think such changes in the land tenure system may affect your farming activities?

-----

#### Section E: Village Characteristics

35. Distance to major road ----- km

36. Distance to nearest town/city ----- km

37. Village population density -----

**APPENDIX A2: ENTERPRISE BUDGETS FOR MAIZE  
PRODUCTION**

**TABLE A2.1: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE OBBR PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                  |                      |         |
|-----------------------------------------------------------------------|------|------------------|----------------------|---------|
| Glen- Organic mulch in the basins and bare runoff strip               |      |                  |                      |         |
| Farming area: Thaba Nchu/Bloemfontein                                 |      |                  |                      |         |
| Target yield: 2 750 Kg/ha                                             |      |                  |                      |         |
| Seasons: 1999/2000, 2000/2001, 2001/2002                              |      |                  |                      |         |
| MAIZE                                                                 | UNIT | PRICE OR         | Average over 3 years |         |
| Country: South Africa                                                 |      | COST PER UNIT(R) | Quantity             | Cost    |
| Province: Free State                                                  |      |                  |                      |         |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                  |                      |         |
| Clay (%) in A-horizon: 45%                                            |      |                  |                      |         |
| Plant Population: 22 000 plants per hectare                           |      |                  |                      |         |
| Cultivar: PHI 3394                                                    |      |                  |                      |         |
| Gross receipts from production                                        |      |                  |                      |         |
| Maize grains                                                          | Ton  | 570.00           | 4.55                 | 2593.50 |
| VARIABLE COSTS                                                        |      |                  |                      |         |
| PREHARVEST :                                                          |      |                  |                      |         |
| Planting                                                              |      |                  |                      |         |
| Seed                                                                  | Kg   | 11.40            | 4.00                 | 45.60   |
| Labour                                                                | Days | 15.00            | 8.00                 | 120.00  |
| Fertilizers                                                           |      |                  |                      |         |
| Ammonium Nitrate                                                      | Kg   | 1.82             | 150.00               | 273.00  |
| Superphosphate                                                        | Kg   | 1.79             | 39.21                | 70.19   |
| Pest Control/Pesticides                                               |      |                  |                      |         |
| Bulldog                                                               | L    | 237.00           | 0.10                 | 23.70   |
| Application (labour)                                                  | Days | 15.00            | 5.73                 | 85.95   |
| Weed Control/Herbicides                                               |      |                  |                      |         |
| Turbo                                                                 | L    | 79.60            | 1.50                 | 119.40  |
| Application (labour)                                                  | Days | 15.00            | 5.79                 | 86.90   |
| Maintenance (labour)                                                  |      |                  |                      |         |
| Repair basins                                                         | Days | 15.00            | 14.70                | 220.50  |
| HARVEST and POST HARVEST (labour)                                     |      |                  |                      |         |
| Hand harvesting                                                       | Days | 15.00            | 2.56                 | 38.40   |
| Threshing                                                             | Days | 15.00            | 2.61                 | 39.15   |
| Remove maize stems                                                    | Days | 15.00            | 1.67                 | 25.05   |
| Total Allocatable Variable Costs                                      |      |                  |                      | 1147.85 |
| Margin Above Allocatable Variable Costs                               |      |                  |                      | 1445.65 |
| Total Pre harvest Costs                                               |      |                  |                      |         |
|                                                                       |      |                  |                      | 1045.25 |
| Total Harvest and Post harvest Costs                                  |      |                  |                      |         |
|                                                                       |      |                  |                      | 102.60  |
| Gross Margin Above Total Allocatable Costs                            |      |                  |                      |         |
|                                                                       |      |                  |                      | 1445.65 |
| FIXED COSTS                                                           |      |                  |                      |         |
| LAND PREPARATION                                                      |      |                  |                      |         |
| Energy                                                                |      |                  |                      | 90.00   |
| Repairs and maintenance                                               |      |                  |                      | 114.35  |
| Construct basins (labour)                                             | Days | 15.00            | 10.35                | 155.25  |
| Pack mulch (labour)                                                   | Days | 15.00            | 3.86                 | 57.90   |
| Total Fixed Costs                                                     |      |                  |                      | 417.50  |
| Prices are for the base year , 1999/2000                              |      |                  |                      |         |
| All activities done by hand and/or hand tools except soil preparation |      |                  |                      |         |
| Fertilisers applied by hand at time of planting                       |      |                  |                      |         |
| Chemical and hand control of weeds and pests                          |      |                  |                      |         |

**TABLE A2.2: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE OBOR PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                  |                      |         |
|-----------------------------------------------------------------------|------|------------------|----------------------|---------|
| Glen- Organic mulch in the basins and runoff strip                    |      |                  |                      |         |
| Farming area: Bloemfontein                                            |      |                  |                      |         |
| Target yield: 2 750 Kg/ha                                             |      |                  |                      |         |
| Seasons: 1999/2000, 2000/2001, 2001/2002                              |      |                  |                      |         |
| MAIZE                                                                 | UNIT | PRICE OR         | Average over 3 years |         |
| Country: South Africa                                                 |      | COST PER UNIT(R) | Quantity             | Cost    |
| Province: Free State                                                  |      |                  |                      |         |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                  |                      |         |
| Clay (%) in A-horizon: 45%                                            |      |                  |                      |         |
| Plant Population: 22 000 plants per hectare                           |      |                  |                      |         |
| Cultivar: PH 3394                                                     |      |                  |                      |         |
| Gross receipts from production                                        |      |                  |                      |         |
| Maize grains                                                          | Ton  | 570.00           | 5.41                 | 3083.70 |
| VARIABLE COSTS                                                        |      |                  |                      |         |
| PREHARVEST                                                            |      |                  |                      |         |
| Planting                                                              |      |                  |                      |         |
| Seed                                                                  | Kg   | 11.40            | 4.00                 | 45.60   |
| Labour                                                                | Days | 15.00            | 8.13                 | 121.95  |
| Fertilizers                                                           |      |                  |                      |         |
| Ammonium Nitrate                                                      | Kg   | 1.82             | 150.00               | 273.00  |
| Superphosphate                                                        | Kg   | 1.79             | 39.21                | 70.19   |
| Pest Control/Pesticides                                               |      |                  |                      |         |
| Bulldog                                                               | L    | 237.00           | 0.10                 | 23.70   |
| Application (labour)                                                  | Days | 15.00            | 5.73                 | 85.95   |
| Weed Control/Herbicides                                               |      |                  |                      |         |
| Turbo                                                                 | L    | 79.60            | 1.50                 | 119.40  |
| Application (labour)                                                  | Days | 15.00            | 5.79                 | 86.90   |
| Maintenance (labour)                                                  |      |                  |                      |         |
| Repair basins                                                         | Days | 15.00            | 2.28                 | 34.15   |
| HARVEST and POST HARVEST (labour)                                     |      |                  |                      |         |
| Labour                                                                | Days | 15.00            | 3.05                 | 45.75   |
| Threshing                                                             | Days | 15.00            | 3.11                 | 46.58   |
| Remove maize stems                                                    | Days | 15.00            | 1.98                 | 29.70   |
| Total Allocatable Variable Costs                                      |      |                  |                      | 982.84  |
| Margin Above Allocatable Variable Costs                               |      |                  |                      | 2100.86 |
| Total Pre harvest Costs                                               |      |                  |                      | 860.82  |
| Total Harvest and Post harvest Costs                                  |      |                  |                      | 122.03  |
| Gross Margin Above Total Allocatable Costs                            |      |                  |                      | 2100.86 |
| FIXED COSTS                                                           |      |                  |                      |         |
| LAND PREPARATION                                                      |      |                  |                      |         |
| Energy                                                                |      |                  |                      | 90.00   |
| Repairs and maintenance                                               |      |                  |                      | 114.35  |
| Construct basins (labour)                                             | Days | 15.00            | 10.35                | 155.25  |
| Pack mulch (labour)                                                   | Days | 15.00            | 11.57                | 173.55  |
| Total Fixed Costs                                                     |      |                  | 0.00                 | 460.84  |
| Prices are for the base year , 1999/2000                              |      |                  |                      |         |
| All activities done by hand and/or hand tools except soil preparation |      |                  |                      |         |
| Fertilisers applied by hand at time of planting                       |      |                  |                      |         |
| Chemical and hand control of weeds and pests                          |      |                  |                      |         |

**TABLE A2.3: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE SBOR PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                  |          |                      |
|-----------------------------------------------------------------------|------|------------------|----------|----------------------|
| Glen- Stone mulch in the basins and organic mulch in runoff strip     |      |                  |          |                      |
| Farming area: Bloemfontein                                            |      |                  |          |                      |
| Target yield: 2 750 Kg/ha                                             |      |                  |          |                      |
| Seasons: 1999/2000, 2000/2001, 2001/2002                              |      |                  |          |                      |
|                                                                       | UNIT | PRICE OR         | Quantity | Average over 3 years |
|                                                                       |      | COST PER UNIT(R) |          | Cost                 |
| Gross receipts from production                                        |      |                  |          |                      |
| Maize grains                                                          | Ton  | 570.00           | 5.37     | 3060.90              |
| <b>VARIABLE COSTS</b>                                                 |      |                  |          |                      |
| <b>PREHARVEST</b>                                                     |      |                  |          |                      |
| Planting                                                              |      |                  |          |                      |
| Seed                                                                  | Kg   | 11.40            | 4.00     | 45.60                |
| Labour                                                                | Days | 15.00            | 8.13     | 121.95               |
| Fertilizers                                                           |      |                  |          |                      |
| Ammonium Nitrate                                                      | Kg   | 1.82             | 150.00   | 273.00               |
| Superphosphate                                                        | Kg   | 1.79             | 39.21    | 70.19                |
| Pest Control/Pesticides                                               |      |                  |          |                      |
| Bulldog                                                               | L    | 237.00           | 0.10     | 23.70                |
| Application (labour)                                                  | Days | 15.00            | 5.73     | 85.95                |
| Weed Control/Herbicides                                               |      |                  |          |                      |
| Turbo                                                                 | L    | 79.60            | 1.50     | 119.40               |
| Application (labour)                                                  | Days | 15.00            | 5.79     | 86.90                |
| Maintenance (labour)                                                  |      |                  |          |                      |
| Repair basins                                                         | Days | 15.00            | 2.28     | 34.15                |
| <b>HARVEST and POST HARVEST (labour)</b>                              |      |                  |          |                      |
| Labour                                                                | Days | 15.00            | 3.02     | 45.30                |
| Threshing                                                             | Days | 15.00            | 3.08     | 46.20                |
| Remove maize stems                                                    | Days | 15.00            | 1.97     | 29.62                |
| Total Allocatable Variable Costs                                      |      |                  |          | 981.97               |
| Margin Above Allocatable Variable Costs                               |      |                  |          | 2078.93              |
| <b>FIXED COSTS</b>                                                    |      |                  |          |                      |
| <b>LAND PREPARATION</b>                                               |      |                  |          |                      |
| Energy                                                                |      |                  |          | 90.00                |
| Repairs and maintenance                                               |      |                  |          | 114.35               |
| Construct basins (labour)                                             | Days | 15.00            | 10.35    | 155.25               |
| Pack stones (labour)                                                  | Days | 15.00            | 3.69     | 55.35                |
| Pack mulch (labour)                                                   | Days | 15.00            | 7.71     | 115.65               |
| Total Fixed Costs                                                     |      |                  |          | 530.60               |
| Prices are for the base year, 1999/2000                               |      |                  |          |                      |
| All activities done by hand and/or hand tools except soil preparation |      |                  |          |                      |
| Fertilisers applied by hand at time of planting                       |      |                  |          |                      |
| Chemical and hand control of weeds and pests                          |      |                  |          |                      |

**TABLE A2.4: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE SBSR PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                  |                      |         |
|-----------------------------------------------------------------------|------|------------------|----------------------|---------|
| <b>MAIZE</b>                                                          |      |                  |                      |         |
| Country: South Africa                                                 |      |                  |                      |         |
| Province: Free State                                                  |      |                  |                      |         |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                  |                      |         |
| Clay (%) in A-horizon: 45%                                            |      |                  |                      |         |
| Plant Population: 22 000 plants per hectare                           |      |                  |                      |         |
| Cultivar: PH13394                                                     |      |                  |                      |         |
| Glen- Stone mulch in the basins and runoff strip                      |      |                  |                      |         |
| Farming area: Bloemfontein                                            |      |                  |                      |         |
| Target yield: 2 750 Kg/ha                                             |      |                  |                      |         |
| Seasons: 1999/2000, 2000/2001, 2001/2002                              |      |                  |                      |         |
|                                                                       | UNIT | PRICE OR         | Average over 3 years |         |
|                                                                       |      | COST PER UNIT(R) | Quantity             | Cost    |
| Gross receipts from production                                        |      |                  |                      |         |
| Maize grains                                                          | Ton  | 570.00           | 5.54                 | 3157.80 |
| VARIABLE COSTS                                                        |      |                  |                      |         |
| PREHARVEST                                                            |      |                  |                      |         |
| Planting                                                              |      |                  |                      |         |
| Seed                                                                  | Kg   | 11.40            | 4.00                 | 45.60   |
| Labour                                                                | Days | 15.00            | 8.13                 | 121.98  |
| Fertilisers                                                           |      |                  |                      |         |
| Ammonium Nitrate                                                      | Kg   | 1.62             | 150.00               | 273.00  |
| Superphosphate                                                        | Kg   | 1.79             | 39.21                | 70.19   |
| Pest Control/Pesticides                                               |      |                  |                      |         |
| Bulldoz                                                               | L    | 237.00           | 0.10                 | 23.70   |
| Application (labour)                                                  | Days | 15.00            | 5.73                 | 85.90   |
| Weed Control/Herbicides                                               |      |                  |                      |         |
| Turbo                                                                 | L    | 79.60            | 1.50                 | 119.40  |
| Application (labour)                                                  | Days | 15.00            | 5.79                 | 86.90   |
| Maintenance (labour)                                                  |      |                  |                      |         |
| Repair basins                                                         | Days | 15.00            | 2.28                 | 34.15   |
| HARVEST and POST HARVEST (labour)                                     |      |                  |                      |         |
| Labour                                                                | Days | 15.00            | 3.12                 | 46.77   |
| Threshing                                                             | Days | 15.00            | 3.18                 | 47.69   |
| Remove maize stems                                                    | Days | 15.00            | 2.04                 | 30.56   |
| Total Allocatable Variable Costs                                      |      |                  |                      | 985.82  |
| Margin Above Allocatable Variable Costs                               |      |                  |                      | 2171.98 |
| Total Pre harvest Costs                                               |      |                  |                      | 860.82  |
| Total Harvest and Post harvest Costs                                  |      |                  |                      | 125.61  |
| Gross Margin Above Total Allocatable Costs                            |      |                  |                      | 2152.14 |
| FIXED COSTS                                                           |      |                  |                      |         |
| LAND PREPARATION                                                      |      |                  |                      |         |
| Energy                                                                |      |                  |                      | 90.00   |
| Repairs and maintenance                                               |      |                  |                      | 114.35  |
| Construct basins (labour)                                             | Days | 15.00            | 10.35                | 155.25  |
| Pack stones (labour)                                                  | Days | 15.00            | 11.08                | 166.20  |
| Total Fixed Costs                                                     |      |                  |                      | 525.80  |
| Prices are for the base year, 1999/2000                               |      |                  |                      |         |
| All activities done by hand and/or hand tools except soil preparation |      |                  |                      |         |
| Fertilisers applied by hand at time of planting                       |      |                  |                      |         |
| Chemical and hand control of weeds and pests                          |      |                  |                      |         |

**TABLE A2.5: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE CON PRODUCTION TECHNIQUE IN FELOANE DURING THE 2001/2002- PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                                                                                                                                                                                                                                                                                                         |      |                              |          |                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------|----------|----------------------|
| <b>MAIZE</b><br>Country: South Africa<br>Province: Free State<br>Ecotope: Glen/Bonheim-Onrus<br>Clay (%) in A-horizon: 45%<br>Plant Population: 22 000 plants per hectare<br>Cultivar: PHI 3394<br>Planting date: 29/11/2001<br>Season: 2001/2002<br>Feloane- Conventional<br>Farming area: Thaba Nchu/Bloemfontein<br>Target yield: 2750 Kg/ha |      |                              |          |                      |
|                                                                                                                                                                                                                                                                                                                                                 | UNIT | PRICE OR<br>COST PER UNIT(R) | QUANTITY | Value or Cost per ha |
| Gross receipts from production                                                                                                                                                                                                                                                                                                                  |      |                              |          |                      |
| Maize grains                                                                                                                                                                                                                                                                                                                                    | Ton  | 570.00                       | 4.30     | 2451.57              |
| <b>VARIABLE COSTS</b>                                                                                                                                                                                                                                                                                                                           |      |                              |          |                      |
| <b>PREHARVEST :</b>                                                                                                                                                                                                                                                                                                                             |      |                              |          |                      |
| Planting                                                                                                                                                                                                                                                                                                                                        |      |                              |          |                      |
| Seed                                                                                                                                                                                                                                                                                                                                            | Kg   | 11.40                        | 4.00     | 45.60                |
| Labour                                                                                                                                                                                                                                                                                                                                          | Days | 15.00                        | 8.33     | 125.00               |
| <b>FERTILISERS</b>                                                                                                                                                                                                                                                                                                                              |      |                              |          |                      |
| Ammonium Nitrate                                                                                                                                                                                                                                                                                                                                | Kg   | 1.82                         | 142.85   | 259.99               |
| Superphosphate                                                                                                                                                                                                                                                                                                                                  | Kg   | 1.79                         | 117.65   | 210.59               |
| <b>Pest Control</b>                                                                                                                                                                                                                                                                                                                             |      |                              |          |                      |
| Bulldog                                                                                                                                                                                                                                                                                                                                         | L    | 237                          | 0.20     | 47.40                |
| Application (labour)                                                                                                                                                                                                                                                                                                                            | Days | 15.00                        | 3.35     | 50.30                |
| <b>Weed Control</b>                                                                                                                                                                                                                                                                                                                             |      |                              |          |                      |
| Hand weeding (labour)                                                                                                                                                                                                                                                                                                                           | Days | 15.00                        | 17.40    | 261.00               |
| <b>HARVEST and POST HARVEST (labour)</b>                                                                                                                                                                                                                                                                                                        |      |                              |          |                      |
| Hand Harvesting                                                                                                                                                                                                                                                                                                                                 | Days | 15.00                        | 2.37     | 35.54                |
| Threshing                                                                                                                                                                                                                                                                                                                                       | Days | 15.00                        | 2.48     | 37.15                |
| Remove bean stems                                                                                                                                                                                                                                                                                                                               | Days | 15.00                        | 1.56     | 23.67                |
| <b>Total directly Allocatable Costs</b>                                                                                                                                                                                                                                                                                                         |      |                              |          | <b>1096.24</b>       |
| <b>Margin above directly allocatable variable costs</b>                                                                                                                                                                                                                                                                                         |      |                              |          | <b>1355.33</b>       |
| <b>Non Directly Allocatable Variable Costs</b>                                                                                                                                                                                                                                                                                                  |      |                              |          | <b>446.85</b>        |
| Energy                                                                                                                                                                                                                                                                                                                                          |      |                              |          | 332.50               |
| Repairs and maintenance                                                                                                                                                                                                                                                                                                                         |      |                              |          | 114.35               |
| <b>Total Pre harvest Costs</b>                                                                                                                                                                                                                                                                                                                  |      |                              |          | <b>1446.73</b>       |
| <b>Total Post harvest Costs</b>                                                                                                                                                                                                                                                                                                                 |      |                              |          | <b>96.36</b>         |
| <b>Gross Margin Above Total Allocatable Costs</b>                                                                                                                                                                                                                                                                                               |      |                              |          | <b>908.48</b>        |
| Prices are for the base year like in experimental plots, 1999/2000<br>All activities done by hand and/or hand tools, except tillage which was done by tractor<br>Fertilisers applied by hand at time of planting<br>Chemical and hand control of weeds and pests                                                                                |      |                              |          |                      |

**TABLE A2.6: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE BBBR PRODUCTION TECHNIQUE IN FELOANE DURING THE 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                                       |      |                                   |          |                      |
|-------------------------------------------------------------------------------|------|-----------------------------------|----------|----------------------|
| Feloane- Water harvesting without mulch in the basins nor runoff strip        |      |                                   |          |                      |
| Farming area: Thaba Nchu/Bloemfontein                                         |      |                                   |          |                      |
| MAIZE                                                                         |      |                                   |          |                      |
| Country: South Africa                                                         |      |                                   |          |                      |
| Province: Free State                                                          |      |                                   |          |                      |
| Ecotope:                                                                      |      |                                   |          |                      |
| Clay (%) in A-horizon:                                                        |      |                                   |          |                      |
| Plant Population: 22 000 plants per hectare                                   |      |                                   |          |                      |
| Target yield: 2750 kg/ha                                                      |      |                                   |          |                      |
| Cultivar: PH4 3394                                                            |      |                                   |          |                      |
| Planting date: 26/11/2001                                                     |      |                                   |          |                      |
| Season: 2001/2002                                                             |      |                                   |          |                      |
|                                                                               | UNIT | PRICE OR<br>COST PER UNIT (R0.00) | QUANTITY | Value or Cost per ha |
| Gross receipts from production                                                |      |                                   |          |                      |
| Maize grain                                                                   | Ton  | 570.00                            | 4.03     | 2297.10              |
| VARIABLE COSTS                                                                |      |                                   |          |                      |
| PREHARVEST:                                                                   |      |                                   |          |                      |
| Planting                                                                      |      |                                   |          |                      |
| Seed                                                                          | kg   | 11.40                             | 4.00     | 45.60                |
| Labour                                                                        | Days | 15.00                             | 6.45     | 96.75                |
| FERTILISERS                                                                   |      |                                   |          |                      |
| Ammonium Nitrate                                                              | kg   | 1.82                              | 142.85   | 259.99               |
| Superphosphate                                                                | kg   | 1.79                              | 117.45   | 215.59               |
| Pest Control                                                                  |      |                                   |          |                      |
| Bulldoze                                                                      | L    | 237.00                            | 0.10     | 23.70                |
| Application (labour)                                                          | Days | 15.00                             | 2.44     | 36.50                |
| Weed Control                                                                  |      |                                   |          |                      |
| Turbo                                                                         | L    | 75.60                             | 1.50     | 113.40               |
| Application (labour)                                                          | Days | 15.00                             | 4.17     | 62.55                |
| Hand weeding (labour)                                                         | Days | 15.00                             | 4.57     | 68.55                |
| MAINTENANCE (labour)                                                          |      |                                   |          |                      |
| Repair basins                                                                 | Days | 15.00                             | 3.69     | 55.35                |
| HARVEST and POST HARVEST (labour)                                             |      |                                   |          |                      |
| Hand Harvesting                                                               | Days | 15.00                             | 2.22     | 33.30                |
| Threshing                                                                     | Days | 15.00                             | 2.32     | 34.80                |
| Remove maize stems                                                            | Days | 15.00                             | 1.48     | 22.20                |
| Total directly Allocatable Costs                                              |      |                                   |          |                      |
|                                                                               |      |                                   |          | 1069.38              |
| Margin above directly allocatable variable costs                              |      |                                   |          |                      |
|                                                                               |      |                                   |          | 1227.72              |
| Total Pre harvest Costs                                                       |      |                                   |          |                      |
|                                                                               |      |                                   |          | 979.08               |
| Total Post harvest Costs                                                      |      |                                   |          |                      |
|                                                                               |      |                                   |          | 90.30                |
| Gross Margin Above Total Allocatable Costs                                    |      |                                   |          |                      |
|                                                                               |      |                                   |          | 1227.72              |
| FIXED COSTS                                                                   |      |                                   |          |                      |
| LAND PREPARATION                                                              |      |                                   |          |                      |
| Construction basins (labour)                                                  | Days | 15.00                             | 10.33    | 154.95               |
| Energy                                                                        |      |                                   |          | 90.00                |
| Repair and maintenance                                                        |      |                                   |          | 114.35               |
| Total Fixed Costs                                                             |      |                                   |          |                      |
|                                                                               |      |                                   |          | 359.30               |
| Prices are for the base year like in experimental plots, 1999/2000            |      |                                   |          |                      |
| All activities done by hand and/or hand tools                                 |      |                                   |          |                      |
| Construction of water harvesting system done with the help of other villagers |      |                                   |          |                      |
| Fertilisers applied by hand at time of planting                               |      |                                   |          |                      |
| Chemical and hand control of weeds and pests                                  |      |                                   |          |                      |



**TABLE A2.7: ENTERPRISE BUDGET FOR HOMESTEAD MAIZE PRODUCTION USING THE BBBR PRODUCTION TECHNIQUE IN FELOANE DURING THE 2001/2002-PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                                       |      |                                   |          |                      |
|-------------------------------------------------------------------------------|------|-----------------------------------|----------|----------------------|
| <b>MAIZE</b>                                                                  |      |                                   |          |                      |
| Country: South Africa                                                         |      |                                   |          |                      |
| Province: Free State                                                          |      |                                   |          |                      |
| Ecotope:                                                                      |      |                                   |          |                      |
| Clay (%) in A-horizon:                                                        |      |                                   |          |                      |
| Plant Population: 22 000 plants per hectare                                   |      |                                   |          |                      |
| Cultivar: PH 3294                                                             |      |                                   |          |                      |
| Planting date: 29/11/2001                                                     |      |                                   |          |                      |
| Season: 2001/2002                                                             |      |                                   |          |                      |
| Target yield: 2750 Kg/ha                                                      |      |                                   |          |                      |
|                                                                               | UNIT | PRICE OR<br>COST PER UNIT (R0.00) | QUANTITY | Value or Cost per ha |
| Gross receipts from production                                                |      |                                   |          |                      |
| Maize grains                                                                  | Ton  | 570.00                            | 4.81     | 2741.78              |
| <b>VARIABLE COSTS</b>                                                         |      |                                   |          |                      |
| <b>PREHARVEST :</b>                                                           |      |                                   |          |                      |
| Planting                                                                      |      |                                   |          |                      |
| Seed                                                                          | Kg   | 11.40                             | 4.00     | 45.60                |
| Labour                                                                        | Days | 15.00                             | 6.53     | 97.95                |
| <b>FERTILISERS</b>                                                            |      |                                   |          |                      |
| Ammonium Nitrate                                                              | Kg   | 1.82                              | 142.85   | 261.99               |
| Superphosphate                                                                | Kg   | 1.79                              | 117.65   | 210.58               |
| <b>Pest Control</b>                                                           |      |                                   |          |                      |
| Bulding                                                                       | L    | 237.00                            | 0.10     | 23.70                |
| Application (labour)                                                          | Days | 15.00                             | 7.56     | 113.40               |
| <b>Weed Control</b>                                                           |      |                                   |          |                      |
| Turbo                                                                         | L    | 79.60                             | 1.50     | 119.40               |
| Application (labour)                                                          | Days | 15.00                             | 6.00     | 75.00                |
| Hand weeding (labour)                                                         | Days | 15.00                             | 3.52     | 52.80                |
| <b>MAINTENANCE</b>                                                            |      |                                   |          |                      |
| Repair basins                                                                 | Days | 15.00                             | 3.89     | 58.35                |
| <b>HARVEST and POST HARVEST (labour)</b>                                      |      |                                   |          |                      |
| Hand Harvesting                                                               | Days | 15.00                             | 2.65     | 39.75                |
| Threshing                                                                     | Days | 15.00                             | 2.77     | 41.55                |
| Remove maize stems                                                            | Days | 15.00                             | 1.77     | 26.55                |
| <b>Total directly Allocatable Costs</b>                                       |      |                                   |          | <b>1164.63</b>       |
| <b>Margin above directly allocatable variable costs</b>                       |      |                                   |          | <b>1577.87</b>       |
| <b>Total Pre harvest Costs</b>                                                |      |                                   |          | <b>1056.78</b>       |
| <b>Total Post harvest Costs</b>                                               |      |                                   |          | <b>107.85</b>        |
| <b>Gross margin of Total Allocatable Costs</b>                                |      |                                   |          | <b>1577.87</b>       |
| <b>FIXED COSTS</b>                                                            |      |                                   |          | <b>563.95</b>        |
| <b>LAND PREPARATION</b>                                                       |      |                                   |          |                      |
| Construct basins (labour)                                                     | Days | 15.00                             | 10.35    | 155.25               |
| Energy                                                                        |      |                                   |          | 50.00                |
| Repairs and maintenance                                                       |      |                                   |          | 114.35               |
| <b>Total Fixed Costs</b>                                                      |      |                                   |          | <b>359.60</b>        |
| Prices are for the base year like in experimental plots, 1999/2000            |      |                                   |          |                      |
| All activities done by hand and/or hand tools                                 |      |                                   |          |                      |
| Construction of water harvesting system done with the help of other villagers |      |                                   |          |                      |
| Fertilisers applied by hand at time of planting                               |      |                                   |          |                      |
| Chemical and hand control of weeds and pests                                  |      |                                   |          |                      |

**TABLE A2.8: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE CON PRODUCTION TECHNIQUE IN VOXFORD DURING THE 2001/2002- PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                                                                                                                                                                                                                                                                                                         |      |                              |          |                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------------------------------|----------|----------------------|
| <b>MAIZE</b><br>Country: South Africa<br>Province: Free State<br>Ecotope: Gey/Bonheim-Onrus<br>Clay (%) in A-horizon: 45%<br>Plant Population: 22 000 plants per hectare<br>Cultivar: PH6 33/94<br>Planting date: 29/11/2001<br>Season: 2001/2002<br>Target yield: 2750 Kg/ha<br>Yoxford- Conventional<br>Farming area: Thaba Nchu/Bloemfontein |      |                              |          |                      |
|                                                                                                                                                                                                                                                                                                                                                 | UNIT | PRICE OR<br>COST PER UNIT(R) | QUANTITY | Value or Cost per ha |
| Gross receipts from production                                                                                                                                                                                                                                                                                                                  |      |                              |          |                      |
| Maize grains                                                                                                                                                                                                                                                                                                                                    | Ton  | 570.00                       | 2.31     | 1316.70              |
| <b>VARIABLE COSTS</b>                                                                                                                                                                                                                                                                                                                           |      |                              |          |                      |
| <b>PREHARVEST :</b>                                                                                                                                                                                                                                                                                                                             |      |                              |          |                      |
| <b>Planting</b>                                                                                                                                                                                                                                                                                                                                 |      |                              |          |                      |
| Seed                                                                                                                                                                                                                                                                                                                                            | Kg   | 11.40                        | 4.00     | 45.60                |
| Labour                                                                                                                                                                                                                                                                                                                                          | Days | 15.00                        | 11.77    | 176.55               |
| <b>FERTILISERS</b>                                                                                                                                                                                                                                                                                                                              |      |                              |          |                      |
| Ammonium Nitrate                                                                                                                                                                                                                                                                                                                                | Kg   | 1.82                         | 142.85   | 259.99               |
| Superphosphate                                                                                                                                                                                                                                                                                                                                  | Kg   | 1.79                         | 117.65   | 210.59               |
| <b>Pest Control</b>                                                                                                                                                                                                                                                                                                                             |      |                              |          |                      |
| Bulldog                                                                                                                                                                                                                                                                                                                                         | L    | 23.7                         | 0.10     | 23.70                |
| Application (labour)                                                                                                                                                                                                                                                                                                                            | Days | 15.00                        | 6.25     | 93.75                |
| <b>Weed Control</b>                                                                                                                                                                                                                                                                                                                             |      |                              |          |                      |
| Turbo                                                                                                                                                                                                                                                                                                                                           | L    | 79.60                        | 1.50     | 119.40               |
| Application (labour)                                                                                                                                                                                                                                                                                                                            | Days | 15.00                        | 8.33     | 124.95               |
| Hand weeding (labour)                                                                                                                                                                                                                                                                                                                           | Days | 15.00                        | 17.40    | 261.00               |
| <b>HARVEST and POST HARVEST (labour)</b>                                                                                                                                                                                                                                                                                                        |      |                              |          |                      |
| Hand harvesting                                                                                                                                                                                                                                                                                                                                 | Days | 15.00                        | 1.27     | 19.05                |
| Threshing                                                                                                                                                                                                                                                                                                                                       | Days | 15.00                        | 1.33     | 19.95                |
| Remove beans stems                                                                                                                                                                                                                                                                                                                              | Days | 15.00                        | 0.85     | 12.75                |
| <b>Total directly Allocatable Costs</b>                                                                                                                                                                                                                                                                                                         |      |                              |          | <b>1367.28</b>       |
| <b>Margin above directly allocatable variable costs</b>                                                                                                                                                                                                                                                                                         |      |                              |          | <b>-50.58</b>        |
| <b>Non Directly Allocatable Variable Costs</b>                                                                                                                                                                                                                                                                                                  |      |                              |          | <b>446.85</b>        |
| Energy                                                                                                                                                                                                                                                                                                                                          |      |                              |          | 332.50               |
| Repairs and maintenance                                                                                                                                                                                                                                                                                                                         |      |                              |          | 114.35               |
| <b>Total Pre harvest Costs</b>                                                                                                                                                                                                                                                                                                                  |      |                              |          | <b>1518.03</b>       |
| <b>Total Post harvest Costs</b>                                                                                                                                                                                                                                                                                                                 |      |                              |          | <b>51.75</b>         |
| <b>Gross Margin Above Total Allocatable Costs</b>                                                                                                                                                                                                                                                                                               |      |                              |          | <b>-253.98</b>       |
| Prices are for the base year like in experimental plots, 1999/2000<br>All activities done by hand and/or hand tools, except tillage which was done by tractor<br>Fertilisers applied by hand at time of planting<br>Chemical and hand control of weeds and pests                                                                                |      |                              |          |                      |

**TABLE A2.9: ENTERPRISE BUDGET FOR MAIZE PRODUCTION USING THE BBBR PRODUCTION TECHNIQUE IN YOXFORD DURING THE 2001/2002-PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                                       |      |                                   |          |                      |
|-------------------------------------------------------------------------------|------|-----------------------------------|----------|----------------------|
| Yoxford - Bare basins and runoff strip                                        |      |                                   |          |                      |
| Farming area: Thaba Nchu/Bloemfontein                                         |      |                                   |          |                      |
| Target yield: 2 750 Kg/ha                                                     |      |                                   |          |                      |
| Cultivar: PH1 3394                                                            |      |                                   |          |                      |
| Planting date: 22/12/2001                                                     |      |                                   |          |                      |
| Season: 2001/2002                                                             |      |                                   |          |                      |
|                                                                               | UNIT | PRICE OR<br>COST PER UNIT (R0.00) | QUANTITY | Value or Cost per ha |
| Gross receipts from production                                                |      |                                   |          |                      |
| Maize grains                                                                  | Ton  | 570.00                            | 2.73     | 1556.10              |
| VARIABLE COSTS                                                                |      |                                   |          |                      |
| PREHARVEST :                                                                  |      |                                   |          |                      |
| Planting                                                                      |      |                                   |          |                      |
| Seed                                                                          | Kg   | 11.40                             | 4.00     | 45.60                |
| Labour                                                                        | Days | 15.00                             | 8.12     | 121.80               |
| FERTILISERS                                                                   |      |                                   |          |                      |
| Ammonium Nitrate                                                              | Kg   | 1.82                              | 142.86   | 260.01               |
| Superphosphate                                                                | Kg   | 1.79                              | 117.85   | 210.59               |
| Pest Control                                                                  |      |                                   |          |                      |
| Bulldog                                                                       | L    | 237.00                            | 0.10     | 23.70                |
| Application (labour)                                                          | Days | 15.00                             | 5.78     | 86.70                |
| Weed Control                                                                  |      |                                   |          |                      |
| Turbo                                                                         | L    | 79.60                             | 1.50     | 119.40               |
| Application (labour)                                                          | Days | 15.00                             | 3.20     | 48.00                |
| Hand weeding (labour)                                                         | Days | 15.00                             | 2.35     | 35.25                |
| MAINTENANCE (labour)                                                          |      |                                   |          |                      |
| Repair basins                                                                 | Days | 15.00                             | 2.16     | 32.40                |
| HARVEST and POST HARVEST (labour)                                             |      |                                   |          |                      |
| Hand Harvesting                                                               | Days | 15.00                             | 1.50     | 22.50                |
| Threshing                                                                     | Days | 15.00                             | 1.57     | 23.55                |
| Remove maize stems                                                            | Days | 15.00                             | 1.00     | 15.00                |
| Total Allocatable Costs                                                       |      |                                   |          | 1644.50              |
| Margin Above Allocatable Variable Costs                                       |      |                                   |          | 511.60               |
| Total Pre harvest Costs                                                       |      |                                   |          | 983.45               |
| Total Post harvest Costs                                                      |      |                                   |          | 61.05                |
| Gross Margin Above Total Allocatable Costs                                    |      |                                   |          | 511.60               |
| FIXED COSTS                                                                   |      |                                   |          |                      |
| LAND PREPARATION                                                              |      |                                   |          |                      |
| Construct basins (labour)                                                     | Days | 15.00                             | 10.35    | 155.25               |
| Energy                                                                        |      |                                   |          | 90.00                |
| Repairs and maintenance                                                       |      |                                   |          | 114.35               |
| Total Fixed Costs                                                             |      |                                   |          | 359.60               |
| Prices are for the base year like in experimental plots, 1999/2000            |      |                                   |          |                      |
| All activities done by hand and/or hand tools                                 |      |                                   |          |                      |
| Construction of water harvesting system done with the help of other villagers |      |                                   |          |                      |
| Fertilisers applied by hand at time of planting                               |      |                                   |          |                      |
| Chemical and hand control of weeds and pests                                  |      |                                   |          |                      |

**APPENDIX A3: ENTERPRISE BUDGETS FOR  
SUNFLOWER PRODUCTION**

**TABLE A3.1 ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION USING THE *OBRR* PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                              |                          |                |
|-----------------------------------------------------------------------|------|------------------------------|--------------------------|----------------|
| <b>SUNFLOWER</b>                                                      |      |                              |                          |                |
| Country: South Africa                                                 |      |                              |                          |                |
| Province: Free State                                                  |      |                              |                          |                |
| Ecotope: Glen/Bonheim-Onnus                                           |      |                              |                          |                |
| Clay (%) in A-horizon: 45%                                            |      |                              |                          |                |
| Plant Population: 33 333 plants per hectare                           |      |                              |                          |                |
| Cultivar: SHK 74                                                      |      |                              |                          |                |
| Glen - Organic mulch in basins and bare runoff strip                  |      |                              |                          |                |
| Farming area: Bloemfontein                                            |      |                              |                          |                |
| Target yield: 1 750kg/ha                                              |      |                              |                          |                |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                              |                          |                |
|                                                                       | UNIT | PRICE OR<br>COST PER UNIT(R) | Average over three years |                |
|                                                                       |      |                              | Quantity                 | Cost/Value     |
| Gross receipts from production                                        |      |                              |                          |                |
| Sunflower                                                             | Ton  | 1040.00                      | 1.75                     | 1820.00        |
| <b>VARIABLE COSTS</b>                                                 |      |                              |                          |                |
| <b>PREHARVEST :</b>                                                   |      |                              |                          |                |
| <b>Planting</b>                                                       |      |                              |                          |                |
| Seed                                                                  | Kg   | 23.37                        | 2.50                     | 58.43          |
| Labour                                                                | Days | 15.00                        | 6.25                     | 93.75          |
| <b>Fertilizers</b>                                                    |      |                              |                          |                |
| Ammonium Nitrate                                                      | Kg   | 1.82                         | 185.71                   | 337.99         |
| Superphosphate                                                        | Kg   | 1.79                         | 39.21                    | 70.19          |
| <b>Pest Control/Pesticides</b>                                        |      |                              |                          |                |
| Bulldog                                                               | L    | 237.00                       | 0.10                     | 23.70          |
| Application (labour)                                                  | Days | 15.00                        | 5.78                     | 86.70          |
| <b>Weed Control/Herbicides</b>                                        |      |                              |                          |                |
| Hand weeding (labour)                                                 | Days | 15.00                        | 5.24                     | 78.53          |
| <b>Maintenance (labour)</b>                                           |      |                              |                          |                |
| Repair basins                                                         | Days | 15.00                        | 4.99                     | 74.83          |
| <b>HARVEST and POST HARVEST (labour)</b>                              |      |                              |                          |                |
| Hand Harvesting                                                       | Days | 15.00                        | 7.15                     | 107.25         |
| Threshing                                                             | Days | 15.00                        | 3.11                     | 46.67          |
| Remove sunflower stems                                                | Days | 15.00                        | 5.30                     | 79.50          |
| <b>Total Allocatable Variable Costs</b>                               |      |                              |                          | <b>1057.59</b> |
| <b>Margin Above Total Allocatable Variable Costs</b>                  |      |                              |                          | <b>762.41</b>  |
| <b>Total Pre harvest Costs</b>                                        |      |                              |                          | <b>824.11</b>  |
| <b>Total Harvest and Post harvest Costs</b>                           |      |                              |                          | <b>233.48</b>  |
| <b>Gross Margin Above Total Allocatable Variable Costs</b>            |      |                              |                          | <b>762.41</b>  |
| <b>FIXED COSTS</b>                                                    |      |                              |                          |                |
| <b>LAND PREPARATION</b>                                               |      |                              |                          |                |
| Energy                                                                |      |                              |                          | 90.00          |
| Repairs and maintenance                                               |      |                              |                          | 114.35         |
| Construct basins (labour)                                             | Days | 15.00                        | 10.35                    | 155.25         |
| Pack mulch (labour)                                                   | Days | 15.00                        | 3.86                     | 57.90          |
| <b>Total Fixed Costs</b>                                              |      |                              |                          | <b>417.50</b>  |
| Prices are for the base year , 1999/2000                              |      |                              |                          |                |
| All activities done by hand and/or hand tools except soil preparation |      |                              |                          |                |
| Fertilisers applied by hand at time of planting                       |      |                              |                          |                |
| Chemical and hand control of weeds and pests                          |      |                              |                          |                |

**TABLE A3.2: ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION USING THE *OBOR* PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                  |                          |                |
|-----------------------------------------------------------------------|------|------------------|--------------------------|----------------|
| <b>SUNFLOWER</b>                                                      |      |                  |                          |                |
| Country: South Africa                                                 |      |                  |                          |                |
| Province: Free State                                                  |      |                  |                          |                |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                  |                          |                |
| Clay (%) in A-horizon: 45%                                            |      |                  |                          |                |
| Plant Population: 33 333 plants per hectare                           |      |                  |                          |                |
| Cultivar: SNK 74                                                      |      |                  |                          |                |
| Glen - Organic mulch in the basins and runoff strip                   |      |                  |                          |                |
| Farming area: Bloemfontein                                            |      |                  |                          |                |
| Target yield: 1 750Kg/ha                                              |      |                  |                          |                |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                  |                          |                |
|                                                                       | UNIT | PRICE OR         | Average over three years |                |
|                                                                       |      | COST PER UNIT(R) | Quantity                 | Cost/Value     |
| Gross receipts from production                                        |      |                  |                          |                |
| Sunflower                                                             | Ton  | 1040.00          | 1.83                     | 1896.69        |
|                                                                       |      |                  |                          |                |
| <b>VARIABLE COSTS</b>                                                 |      |                  |                          |                |
| <b>PREHARVEST :</b>                                                   |      |                  |                          |                |
| <b>Planting</b>                                                       |      |                  |                          |                |
| Seed                                                                  | Kg   | 23.37            | 2.50                     | 58.43          |
| Labour                                                                | Days | 15.00            | 6.25                     | 93.75          |
| <b>Fertilizers</b>                                                    |      |                  |                          |                |
| Ammonium Nitrate                                                      | Kg   | 1.82             | 185.71                   | 337.99         |
| Superphosphate                                                        | Kg   | 1.79             | 39.21                    | 70.19          |
| <b>Pest Control/Pesticides</b>                                        |      |                  |                          |                |
| Bulldog                                                               | L    | 237.00           | 0.10                     | 23.70          |
| Application (labour)                                                  | Days | 15.00            | 5.78                     | 86.70          |
| <b>Weed Control/Herbicides</b>                                        |      |                  |                          |                |
| Hand weeding (labour)                                                 | Days | 15.00            | 4.07                     | 61.10          |
|                                                                       |      |                  |                          |                |
| <b>Maintenance (labour)</b>                                           |      |                  |                          |                |
| Repair basins                                                         | Days | 15.00            | 2.79                     | 41.83          |
|                                                                       |      |                  |                          |                |
| <b>HARVEST and POST HARVEST (labour)</b>                              |      |                  |                          |                |
| Hand harvesting                                                       | Days | 15.00            | 7.47                     | 112.03         |
| Threshing                                                             | Days | 15.00            | 3.26                     | 48.86          |
| Remove sunflower stems                                                | Days | 15.00            | 5.54                     | 83.17          |
|                                                                       |      |                  |                          |                |
| <b>Total Allocatable Variable Costs</b>                               |      |                  |                          | <b>1017.72</b> |
| <b>Margin Above Allocatable Variable costs</b>                        |      |                  |                          | <b>880.97</b>  |
|                                                                       |      |                  |                          |                |
| <b>Total Pre harvest Costs</b>                                        |      |                  |                          | <b>773.69</b>  |
| <b>Total Harvest and Post harvest Costs</b>                           |      |                  |                          | <b>244.03</b>  |
| <b>Gross Margin Above Total Allocatable Costs</b>                     |      |                  |                          | <b>880.97</b>  |
|                                                                       |      |                  |                          |                |
| <b>FIXED COSTS</b>                                                    |      |                  |                          |                |
| <b>LAND PREPARATION</b>                                               |      |                  |                          |                |
| Energy                                                                |      |                  |                          | 90.00          |
| Repairs and maintenance                                               |      |                  |                          | 114.35         |
| Construct basins (labour)                                             | Days | 15.00            | 10.35                    | 155.25         |
| Pack mulch (labour)                                                   | Days | 15.00            | 11.57                    | 173.55         |
| <b>Total Fixed Costs</b>                                              |      |                  |                          | <b>533.15</b>  |
| Prices are for the base year , 1999/2000                              |      |                  |                          |                |
| All activities done by hand and/or hand tools except soil preparation |      |                  |                          |                |
| Fertilisers applied by hand at time of planting                       |      |                  |                          |                |
| Chemical and hand control of weeds and pests                          |      |                  |                          |                |

**TABLE A3.3: ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION USING THE SBOR PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                  |                          |                |
|-----------------------------------------------------------------------|------|------------------|--------------------------|----------------|
| Glen - Stone mulch in the basins and organic mulch in runoff strip    |      |                  |                          |                |
| Farming area: Bloemfontein                                            |      |                  |                          |                |
| Target yield: 1 750Kg/ha                                              |      |                  |                          |                |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                  |                          |                |
| SUNFLOWER                                                             | UNIT | PRICE OR         | Average over three years |                |
| Country: South Africa                                                 |      | COST PER UNIT(R) | Quantity                 | Cost/Value     |
| Province: Free State                                                  |      |                  |                          |                |
| Ecotope: Glen/Sonheims-Onrus                                          |      |                  |                          |                |
| Clay (%) in A-horizon: 45%                                            |      |                  |                          |                |
| Plant Population: 33 333 plants per hectare                           |      |                  |                          |                |
| Cultivar: SHK 74                                                      |      |                  |                          |                |
| Gross receipts from production                                        |      |                  |                          |                |
| Sunflower                                                             | Ton  | 1040.00          | 1.94                     | 2015.87        |
| <b>VARIABLE COSTS</b>                                                 |      |                  |                          |                |
| <b>PREHARVEST :</b>                                                   |      |                  |                          |                |
| Planting                                                              |      |                  |                          |                |
| Seed                                                                  | Kg   | 23.37            | 2.50                     | 58.43          |
| Labour                                                                | Days | 15.00            | 6.25                     | 93.75          |
| Fertilizers                                                           |      |                  |                          |                |
| Ammonium Nitrate                                                      | Kg   | 1.82             | 185.71                   | 337.99         |
| Superphosphate                                                        | Kg   | 1.79             | 39.21                    | 70.19          |
| Pest Control/Pesticides                                               |      |                  |                          |                |
| Bulldog                                                               | L    | 237.00           | 0.10                     | 23.70          |
| Application (labour)                                                  | Days | 15.00            | 5.78                     | 86.70          |
| Weed Control/Herbicides                                               |      |                  |                          |                |
| Hand weeding (labour)                                                 | Days | 15.00            | 4.07                     | 61.10          |
| Maintenance (labour)                                                  |      |                  |                          |                |
| Repair basins                                                         | Days | 15.00            | 2.79                     | 41.83          |
| <b>HARVEST and POST HARVEST (labour)</b>                              |      |                  |                          |                |
| Hand harvesting                                                       | Days | 15.00            | 7.92                     | 118.73         |
| Threshing                                                             | Days | 15.00            | 3.45                     | 51.80          |
| Remove sunflower stems                                                | Days | 15.00            | 5.68                     | 86.17          |
| <b>Total Allocatable Variable Costs</b>                               |      |                  |                          | <b>1032.39</b> |
| <b>Margin Above Allocatable Variable costs</b>                        |      |                  |                          | <b>983.47</b>  |
| <b>Total Pre harvest Costs</b>                                        |      |                  |                          | <b>773.69</b>  |
| <b>Total Harvest and Post harvest Costs</b>                           |      |                  |                          | <b>256.70</b>  |
| <b>Gross Margin Above Total Allocatable Costs</b>                     |      |                  |                          | <b>983.47</b>  |
| <b>FIXED COSTS</b>                                                    |      |                  |                          |                |
| <b>LAND PREPARATION</b>                                               |      |                  |                          |                |
| Energy                                                                |      |                  |                          | 90.00          |
| Repairs and maintenance                                               |      |                  |                          | 114.35         |
| Construct basins (labour)                                             | Days | 15.00            | 10.35                    | 155.25         |
| Pack stones (labour)                                                  | Days | 15.00            | 3.69                     | 55.35          |
| Pack mulch (labour)                                                   | Days | 15.00            | 7.71                     | 115.65         |
| <b>Total Fixed Costs</b>                                              |      |                  |                          | <b>530.60</b>  |
| Prices are for the base year, 1999/2000                               |      |                  |                          |                |
| All activities done by hand and/or hand tools except soil preparation |      |                  |                          |                |
| Fertilisers applied by hand at time of planting                       |      |                  |                          |                |
| Chemical and hand control of weeds and pests                          |      |                  |                          |                |

**TABLE A3.4: ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION USING THE SBSR PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                  |                      |         |
|-----------------------------------------------------------------------|------|------------------|----------------------|---------|
| SUNFLOWER                                                             |      |                  |                      |         |
| Country: South Africa                                                 |      |                  |                      |         |
| Province: Free State                                                  |      |                  |                      |         |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                  |                      |         |
| Clay (%) in A-horizon: 45%                                            |      |                  |                      |         |
| Plant Population: 33 333 plants per hectare                           |      |                  |                      |         |
| Cultivar: SNK 74                                                      |      |                  |                      |         |
| Glen - Stone mulch in the basins and runoff strip                     |      |                  |                      |         |
| Farming area: Bloemfontein                                            |      |                  |                      |         |
| Target yield: 1 750Kg/ha                                              |      |                  |                      |         |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                  |                      |         |
|                                                                       | UNIT | PRICE OR         | Average over 3 years |         |
|                                                                       |      | COST PER UNIT(R) | Quantity             | Cost    |
| Gross receipts from production                                        |      |                  |                      |         |
| Sunflower                                                             | Ton  | 1040.00          | 1.94                 | 2017.60 |
| VARIABLE COSTS                                                        |      |                  |                      |         |
| PREHARVEST :                                                          |      |                  |                      |         |
| Planting                                                              |      |                  |                      |         |
| Seed                                                                  | Kg   | 23.37            | 2.50                 | 58.43   |
| Labour                                                                | Days | 15.00            | 6.25                 | 93.75   |
| Fertilizers                                                           |      |                  |                      |         |
| Ammonium Nitrate                                                      | Kg   | 1.82             | 185.71               | 337.99  |
| Superphosphate                                                        | Kg   | 1.79             | 39.21                | 70.19   |
| Pest Control/Pesticides                                               |      |                  |                      |         |
| Bulldog                                                               | L    | 237.00           | 0.10                 | 23.70   |
| Application (labour)                                                  | Days | 15.00            | 5.78                 | 86.70   |
| Weed Control/Herbicides                                               |      |                  |                      |         |
| Hand weeding (labour)                                                 | Days | 15.00            | 4.07                 | 61.10   |
| Maintenance (labour)                                                  |      |                  |                      |         |
| Repair basins                                                         | Days | 15.00            | 2.79                 | 41.85   |
| HARVEST and POST HARVEST (labour)                                     |      |                  |                      |         |
| Hand harvesting                                                       | Days | 15.00            | 7.93                 | 118.91  |
| Threshing                                                             | Days | 15.00            | 3.45                 | 51.72   |
| Remove sunflower stems                                                | Days | 15.00            | 5.88                 | 88.19   |
| Total Allocatable Variable Costs                                      |      |                  |                      | 1032.50 |
| Margin Above Allocatable Variable costs                               |      |                  |                      | 985.10  |
| Total Pre harvest Costs                                               |      |                  |                      |         |
|                                                                       |      |                  |                      | 773.69  |
| Total Harvest and Post harvest Costs                                  |      |                  |                      |         |
|                                                                       |      |                  |                      | 258.81  |
| Gross Margin Above Total Allocatable Costs                            |      |                  |                      |         |
|                                                                       |      |                  |                      | 985.10  |
| FIXED COSTS                                                           |      |                  |                      |         |
| LAND PREPARATION                                                      |      |                  |                      |         |
| Energy                                                                |      |                  |                      | 90.00   |
| Repairs and maintenance                                               |      |                  |                      | 114.35  |
| Construct basins (labour)                                             | Days | 15.00            | 10.35                | 155.25  |
| Pack stones (labour)                                                  | Days | 15.00            | 11.08                | 166.20  |
| Total Fixed Costs                                                     |      |                  |                      | 525.80  |
| Prices are for the base year , 1999/2000                              |      |                  |                      |         |
| All activities done by hand and/or hand tools except soil preparation |      |                  |                      |         |
| Fertilisers applied by hand at time of planting                       |      |                  |                      |         |
| Chemical and hand control of weeds and pests                          |      |                  |                      |         |



**TABLE A3.5: ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION USING THE CON PRODUCTION TECHNIQUE IN FELOANE DURING THE 2001/2002-PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                                                |      |                              |                       |                                   |
|----------------------------------------------------------------------------------------|------|------------------------------|-----------------------|-----------------------------------|
| SUNFLOWER                                                                              |      |                              |                       |                                   |
| Country: South Africa                                                                  |      |                              |                       |                                   |
| Province: Free State                                                                   |      |                              |                       |                                   |
| Ecotope: Gen/Bonham-Onrus                                                              |      |                              |                       |                                   |
| Clay (%) in A-horizon: 45%                                                             |      |                              |                       |                                   |
| Plant Population: 33 333 plants per hectare                                            |      |                              |                       |                                   |
| Cultivar: SNK 74                                                                       |      |                              |                       |                                   |
| Planting date: 29/11/2001                                                              |      |                              |                       |                                   |
| Season: 2001/2002                                                                      |      |                              |                       |                                   |
| Target yield: 1 750kg/ha                                                               |      |                              |                       |                                   |
| Farming area: Thaba Nchu/Bloemfontein                                                  |      |                              |                       |                                   |
|                                                                                        | UNIT | PRICE OR<br>COST PER UNIT(R) | QUANTITY<br>2001/2002 | Value or Cost per ha<br>2001/2002 |
| Gross receipts from production                                                         |      |                              |                       |                                   |
| sunflower                                                                              | Ton  | 1040.00                      | 1.68                  | 1747.20                           |
| <b>VARIABLE COSTS</b>                                                                  |      |                              |                       |                                   |
| <b>PREHARVEST :</b>                                                                    |      |                              |                       |                                   |
| Planting                                                                               |      |                              |                       |                                   |
| Seed                                                                                   | Kg   | 23.37                        | 2.50                  | 58.43                             |
| Labour                                                                                 | Days | 15.00                        | 6.25                  | 93.75                             |
| <b>FERTILISERS</b>                                                                     |      |                              |                       |                                   |
| Ammonium Nitrate                                                                       | Kg   | 1.80                         | 186.28                | 344.49                            |
| Superphosphate                                                                         | Kg   | 1.75                         | 58.82                 | 105.29                            |
| Pest Control                                                                           |      |                              |                       |                                   |
| Building                                                                               | L    | 237.00                       | 0.20                  | 47.40                             |
| Application (labour)                                                                   | Days | 15.00                        | 3.65                  | 54.75                             |
| Weed Control                                                                           |      |                              |                       |                                   |
| Hand weeding (labour)                                                                  | Days | 15.00                        | 8.70                  | 130.50                            |
| <b>MAINTENANCE (labour)</b>                                                            |      |                              |                       |                                   |
| Regular burns                                                                          | Days | 15.00                        | 16.25                 | 243.75                            |
| <b>HARVEST and POST HARVEST (labour)</b>                                               |      |                              |                       |                                   |
| Hand Harvest                                                                           | Days | 15.00                        | 6.74                  | 101.10                            |
| Threshing                                                                              | Days | 15.00                        | 3.00                  | 44.94                             |
| Remove sunflower stems                                                                 | Days | 15.00                        | 5.11                  | 76.61                             |
| <b>Total directly Allocatable Costs</b>                                                |      |                              |                       | <b>1300.82</b>                    |
| <b>Margin above directly allocatable variable costs</b>                                |      |                              |                       | <b>446.28</b>                     |
| <b>Non Directly Allocatable Variable Costs</b>                                         |      |                              |                       | <b>446.85</b>                     |
| Energy                                                                                 |      |                              |                       | 332.50                            |
| Repairs and maintenance                                                                |      |                              |                       | 114.35                            |
| <b>Total Pre harvest Costs</b>                                                         |      |                              |                       | <b>1525.15</b>                    |
| <b>Total Post harvest Costs</b>                                                        |      |                              |                       | <b>222.62</b>                     |
| <b>Gross Margin Above Total Allocatable Costs</b>                                      |      |                              |                       | <b>-0.57</b>                      |
| Prices are for the base year like in experimental plots, 1989/2000                     |      |                              |                       |                                   |
| All activities done by hand and/or hand tools, except plough which was done by tractor |      |                              |                       |                                   |
| Fertilisers applied by hand at time of planting                                        |      |                              |                       |                                   |
| Chemical and hand control of weeds and pests                                           |      |                              |                       |                                   |

**TABLE A3.6: ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION USING THE CON PRODUCTION TECHNIQUE IN PARADYS DURING THE 2001/2002-PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                                                 |      |                              |          |                      |
|-----------------------------------------------------------------------------------------|------|------------------------------|----------|----------------------|
| <b>SUNFLOWER</b>                                                                        |      |                              |          |                      |
| Country: South Africa                                                                   |      |                              |          |                      |
| Province: Free State                                                                    |      |                              |          |                      |
| Ecotope: Glen/Bonheim-Onrus                                                             |      |                              |          |                      |
| Clay (%) in A-horizon: 45%                                                              |      |                              |          |                      |
| Plant Population: 33 333 plants per hectare                                             |      |                              |          |                      |
| Cultivar: SNK 74                                                                        |      |                              |          |                      |
| Planting date: 10/01/2002                                                               |      |                              |          |                      |
| Season: 2001/2002                                                                       |      |                              |          |                      |
| Target yield: 1 750Kg/ha                                                                |      |                              |          |                      |
|                                                                                         | UNIT | PRICE OR<br>COST PER UNIT(R) | QUANTITY | Value or Cost per ha |
| Gross receipts from production                                                          |      |                              |          |                      |
| sunflower                                                                               | Ton  | 1040.00                      | 1.63     | 1907.36              |
| <b>VARIABLE COSTS</b>                                                                   |      |                              |          |                      |
| <b>PREHARVEST :</b>                                                                     |      |                              |          |                      |
| Planting                                                                                |      |                              |          |                      |
| Seed                                                                                    | Kg   | 23.37                        | 2.50     | 58.43                |
| Labour                                                                                  | Days | 35.00                        | 6.25     | 218.75               |
| <b>FERTILISERS</b>                                                                      |      |                              |          |                      |
| Ammonium Nitrate                                                                        | Kg   | 1.82                         | 189.28   | 344.49               |
| Superphosphate                                                                          | Kg   | 1.79                         | 58.62    | 105.29               |
| <b>Pest Control</b>                                                                     |      |                              |          |                      |
| Bulldog                                                                                 | L    | 237.00                       | 0.10     | 23.70                |
| Application (labour)                                                                    | Days | 15.00                        | 6.45     | 96.80                |
| <b>Weed Control</b>                                                                     |      |                              |          |                      |
| Hand weeding (labour)                                                                   | Days | 15.00                        | 9.56     | 143.40               |
| <b>HARVEST and POST HARVEST (labour)</b>                                                |      |                              |          |                      |
| Hand Harvesting                                                                         | Days | 15.00                        | 7.34     | 110.07               |
| Threshing                                                                               | Days | 15.00                        | 3.27     | 49.00                |
| Remove sunflower stems                                                                  | Days | 15.00                        | 5.56     | 83.40                |
| <b>Total directly Allocatable Costs</b>                                                 |      |                              |          | <b>1233.32</b>       |
| <b>Margin above directly allocatable variable costs</b>                                 |      |                              |          | <b>674.04</b>        |
| <b>Non Directly Allocatable Variable Costs</b>                                          |      |                              |          | <b>446.85</b>        |
| Energy                                                                                  |      |                              |          | 332.50               |
| Repairs and maintenance                                                                 |      |                              |          | 114.35               |
| <b>Total Pre harvest Costs</b>                                                          |      |                              |          | <b>1437.70</b>       |
| <b>Total Post harvest Costs</b>                                                         |      |                              |          | <b>242.47</b>        |
| <b>Gross Margin Above Total Allocatable Costs</b>                                       |      |                              |          | <b>227.19</b>        |
| Prices are for the base year like in experimental plots, 1999/2000                      |      |                              |          |                      |
| All activities done by hand and/or hand tools, except tillage which was done by tractor |      |                              |          |                      |
| Fertilisers applied by hand at time of planting                                         |      |                              |          |                      |
| Chemical and hand control of weeds and pests                                            |      |                              |          |                      |

**TABLE A3.7: ENTERPRISE BUDGET FOR SUNFLOWER PRODUCTION USING THE BBBR PRODUCTION TECHNIQUE IN PARADYS DURING THE 2001/2002-PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                                       |      |                  |          |                      |
|-------------------------------------------------------------------------------|------|------------------|----------|----------------------|
| SUNFLOWER                                                                     |      |                  |          |                      |
| Country: South Africa                                                         |      |                  |          |                      |
| Province: Free State                                                          |      |                  |          |                      |
| Ecotope: Glen/Bonheims-Onrus                                                  |      |                  |          |                      |
| Clay (%) in A-horizon: 45%                                                    |      |                  |          |                      |
| Plant Population: 33 333 plants per hectare                                   |      |                  |          |                      |
| Cultivar: SNK 74                                                              |      |                  |          |                      |
| Planting date: 10/01/2002                                                     |      |                  |          |                      |
| Season: 2001/2002                                                             |      |                  |          |                      |
| Paradys- Bare basins and runoff strip                                         |      |                  |          |                      |
| Farming area: Thabo Nchu/Boemfontein                                          |      |                  |          |                      |
| Target yield: 1 750kg/ha                                                      |      |                  |          |                      |
|                                                                               | UNIT | PRICE OR         | QUANTITY | Value or Cost per ha |
|                                                                               |      | COST PER UNIT(R) |          |                      |
| Gross receipts from production                                                |      |                  |          |                      |
| Sunflower                                                                     | Ton  | 1040.00          | 2.13     | 2219.88              |
| <b>VARIABLE COSTS</b>                                                         |      |                  |          |                      |
| <b>PREHARVEST :</b>                                                           |      |                  |          |                      |
| Planting                                                                      |      |                  |          |                      |
| Seed                                                                          | Kg   | 23.37            | 2.50     | 58.43                |
| Labour                                                                        | Days | 15.00            | 6.25     | 93.75                |
| Fertilisers                                                                   |      |                  |          |                      |
| Ammonium Nitrate                                                              | Kg   | 1.82             | 189.28   | 344.49               |
| Superphosphate                                                                | Kg   | 1.79             | 58.82    | 105.29               |
| Pest Control                                                                  |      |                  |          |                      |
| Bulldog                                                                       | L    | 257.00           | 0.10     | 23.70                |
| Application (labour)                                                          | Days | 15.00            | 6.45     | 96.50                |
| Weed Control                                                                  |      |                  |          |                      |
| Hand weeding (labour)                                                         | Days | 15.00            | 5.73     | 85.95                |
| Maintenance (labour)                                                          |      |                  |          |                      |
| Repair basins                                                                 | Days | 15.00            | 3.25     | 46.75                |
| <b>HARVEST AND POST HARVEST (labour)</b>                                      |      |                  |          |                      |
| Labour                                                                        | Days | 15.00            | 8.74     | 131.07               |
| Threshing                                                                     | Days | 15.00            | 3.80     | 57.03                |
| Remove sunflower stems                                                        | Days | 15.00            | 6.49     | 97.30                |
| <b>Total Directly Allocatable Variable Costs</b>                              |      |                  |          | <b>1142.56</b>       |
| <b>Margin Above Total Directly Allocatable Variable Costs</b>                 |      |                  |          | <b>1077.32</b>       |
| <b>Total Pre harvest Costs</b>                                                |      |                  |          | <b>857.15</b>        |
| <b>Total Harvest and Post harvest Costs</b>                                   |      |                  |          | <b>285.40</b>        |
| <b>Gross Margin Above Total Allocatable Costs</b>                             |      |                  |          | <b>1077.32</b>       |
| <b>FIXED COSTS</b>                                                            |      |                  |          |                      |
| <b>LAND PREPARATION</b>                                                       |      |                  |          |                      |
| Construct basins (labour)                                                     | Days | 15.00            | 10.35    | 155.25               |
| Energy                                                                        |      |                  |          | 90.00                |
| Repairs and maintenance                                                       |      |                  |          | 114.35               |
| <b>Total Fixed Costs</b>                                                      |      |                  |          | <b>359.60</b>        |
| Prices are for the base year like in experimental plots, 1999/2000            |      |                  |          |                      |
| All activities done by hand and/or hand tools                                 |      |                  |          |                      |
| Construction of water harvesting system done with the help of other villagers |      |                  |          |                      |
| Fertilisers applied by hand at time of planting                               |      |                  |          |                      |
| Chemical and hand control of weeds and pests                                  |      |                  |          |                      |

**APPENDIX A4: ENTERPRISE BUDGETS FOR DRY  
BEANS PRODUCTION**

**TABLE A4.1: ENTERPRISE BUDGET FOR DRY BEANS PRODUCTION USING THE *OBBR* PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                  |                          |            |
|-----------------------------------------------------------------------|------|------------------|--------------------------|------------|
| Glen- Organic mulch in the basins and bare runoff strip               |      |                  |                          |            |
| Farming area: Bloemfontein                                            |      |                  |                          |            |
| Target yield: 1500Kg/ha                                               |      |                  |                          |            |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                  |                          |            |
| DRY BEANS                                                             | UNIT | PRICE OR         | Average over three years |            |
| Country: South Africa                                                 |      | COST PER UNIT(R) | Quantity                 | Cost/Value |
| Province: Free State                                                  |      |                  |                          |            |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                  |                          |            |
| Clay (%) in A-horizon: 45%                                            |      |                  |                          |            |
| Plant Population: 13 333 plants per hectare                           |      |                  |                          |            |
| Cultivar: PAN 148                                                     |      |                  |                          |            |
| Gross receipts from production                                        |      |                  |                          |            |
| Beans                                                                 | Ton  | 2900.00          | 0.85                     | 2475.00    |
| VARIABLE COSTS                                                        |      |                  |                          |            |
| PREHARVEST :                                                          |      |                  |                          |            |
| Planting                                                              |      |                  |                          |            |
| Seed                                                                  | Kg   | 11.76            | 60.00                    | 705.60     |
| Labour                                                                | Days | 15.00            | 8.50                     | 127.50     |
| Fertilisers                                                           |      |                  |                          |            |
| Ammonium Nitrate                                                      | Kg   | 1.82             | 62.96                    | 114.58     |
| Superphosphate                                                        | Kg   | 1.79             | 39.21                    | 70.18      |
| Pest Control/Pesticides                                               |      |                  |                          |            |
| Metasolox                                                             | L    | 87.80            | 0.50                     | 43.90      |
| Application (labour)                                                  | Days | 15.00            | 0.35                     | 5.25       |
| Weed Control (labour)                                                 |      |                  |                          |            |
| Hand weeding                                                          | Days | 15.00            | 2.18                     | 32.67      |
| Maintenance (labour)                                                  |      |                  |                          |            |
| Repair basins                                                         | Days | 15.00            | 0.94                     | 14.12      |
| HARVEST AND POST HARVEST (labour)                                     |      |                  |                          |            |
| Hand Harvesting                                                       | Days | 15.00            | 2.74                     | 41.11      |
| Threshing                                                             | Days | 15.00            | 1.51                     | 22.66      |
| Remove beans stems                                                    | Days | 15.00            | 0.64                     | 9.63       |
| Total Allocatable Variable Costs                                      |      |                  |                          | 1187.29    |
| Gross Margin Above Allocatable Variable Costs                         |      |                  |                          | 1289.31    |
| Total Pre harvest Costs                                               |      |                  |                          | 1187.29    |
| Total Harvest and Post harvest Costs                                  |      |                  |                          | 73.40      |
| Gross Margin Above Total Allocatable Costs                            |      |                  |                          | 1215.91    |
| FIXED COSTS                                                           |      |                  |                          |            |
| LAND PREPARATION                                                      |      |                  |                          |            |
| Energy                                                                |      |                  |                          | 90.00      |
| Repairs and maintenance                                               |      |                  |                          | 114.35     |
| Construct basins (labour)                                             | Days | 15.00            | 10.35                    | 155.25     |
| Pack mulch (labour)                                                   | Days | 15.00            | 3.86                     | 57.90      |
| Total Fixed Costs                                                     |      |                  |                          | 417.50     |
| Prices are for the base year , 1999/2000                              |      |                  |                          |            |
| All activities done by hand and/or hand tools except soil preparation |      |                  |                          |            |
| Fertilisers applied by hand at time of planting                       |      |                  |                          |            |
| Chemical and hand control of weeds and pests                          |      |                  |                          |            |

**TABLE A4.2: ENTERPRISE BUDGET FOR DRY BEANS PRODUCTION USING THE *OBOR* PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                  |                          |                |
|-----------------------------------------------------------------------|------|------------------|--------------------------|----------------|
| Glen- Organic mulch in the basins and runoff strip                    |      |                  |                          |                |
| Farming area: Bloemfontein                                            |      |                  |                          |                |
| Target yield: 1500Kg/ha                                               |      |                  |                          |                |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                  |                          |                |
| DRY BEANS                                                             | UNIT | PRICE OR         | Average over three years |                |
| Country: South Africa                                                 |      | COST PER UNIT(R) | Quantity                 | Cost/Value     |
| Province: Free State                                                  |      |                  |                          |                |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                  |                          |                |
| Clay (%) in A-horizon: 45%                                            |      |                  |                          |                |
| Plant Population: 13 333 plants per hectare                           |      |                  |                          |                |
| Cultivar: PAN 148                                                     |      |                  |                          |                |
| Gross receipts from production                                        |      |                  |                          |                |
| Beans                                                                 | Ton  | 2900.00          | 0.95                     | 2740.95        |
| <b>VARIABLE COSTS</b>                                                 |      |                  |                          |                |
| <b>PREHARVEST :</b>                                                   |      |                  |                          |                |
| Planting                                                              |      |                  |                          |                |
| Seed                                                                  | Kg   | 11.76            | 60.00                    | 705.60         |
| Labour                                                                | Days | 15.00            | 4.87                     | 72.98          |
| <b>Fertilisers</b>                                                    |      |                  |                          |                |
| Ammonium Nitrate                                                      | Kg   | 1.82             | 62.96                    | 114.58         |
| Superphosphate                                                        | Kg   | 1.79             | 39.21                    | 70.19          |
| <b>Pest Control/Pesticides</b>                                        |      |                  |                          |                |
| Metasystox                                                            | L    | 87.80            | 0.50                     | 43.90          |
| Application (labour)                                                  | Days | 15.00            | 0.48                     | 7.16           |
| <b>Weed Control/Herbicides</b>                                        |      |                  |                          |                |
| Hand weeding (labour)                                                 | Days | 15.00            | 2.18                     | 32.67          |
| <b>Maintenance (labour)</b>                                           | Days |                  |                          |                |
| Repair basins                                                         | Days | 15.00            | 2.27                     | 34.12          |
| <b>HARVEST AND POST HARVEST (labour)</b>                              |      |                  |                          |                |
| Harvest labour                                                        | Days | 15.00            | 3.06                     | 45.90          |
| Threshing                                                             | Days | 15.00            | 1.67                     | 25.08          |
| Remove beans stems                                                    | Days | 15.00            | 0.72                     | 10.76          |
| <b>Total Allocatable Variable Costs</b>                               |      |                  |                          | <b>1162.94</b> |
| <b>Margin Above Allocatable Variable Costs</b>                        |      |                  |                          | <b>1578.01</b> |
| <b>Total Pre harvest Costs</b>                                        |      |                  |                          | <b>1081.20</b> |
| <b>Total Harvest and Post harvest Costs</b>                           |      |                  |                          | <b>81.74</b>   |
| <b>Gross Margin Above Total Allocatable Variable Costs</b>            |      |                  |                          | <b>1578.01</b> |
| <b>FIXED COSTS</b>                                                    |      |                  |                          |                |
| <b>LAND PREPARATION</b>                                               |      |                  |                          |                |
| Energy                                                                |      |                  |                          | 90.00          |
| Repairs and maintenance                                               |      |                  |                          | 114.35         |
| Construct basins (labour)                                             | Days | 15.00            | 10.35                    | 155.25         |
| Pack mulch (labour)                                                   | Days | 15.00            | 11.57                    | 173.55         |
| <b>Total Fixed Costs</b>                                              |      |                  | <b>0.00</b>              | <b>533.15</b>  |
| Prices are for the base year : 1999/2000                              |      |                  |                          |                |
| All activities done by hand and/or hand tools except soil preparation |      |                  |                          |                |
| Fertilisers applied by hand at time of planting                       |      |                  |                          |                |
| Chemical and hand control of weeds and pests                          |      |                  |                          |                |

**TABLE A4.3: ENTERPRISE BUDGET FOR DRY BEANS PRODUCTION USING THE SBOR PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |      |                              |                          |                |
|-----------------------------------------------------------------------|------|------------------------------|--------------------------|----------------|
| <b>DRY BEANS</b>                                                      |      |                              |                          |                |
| Country: South Africa                                                 |      |                              |                          |                |
| Province: Free State                                                  |      |                              |                          |                |
| Ecotope: Glen/Bonheim-Onrus                                           |      |                              |                          |                |
| Clay (%) in A-horizon: 45%                                            |      |                              |                          |                |
| Plant Population: 13 333 plants per hectare                           |      |                              |                          |                |
| Cultivar: PAN 148                                                     |      |                              |                          |                |
| Glen- Stone mulch in the basins and organic mulch in runoff strip     |      |                              |                          |                |
| Farming area: Bloemfontein                                            |      |                              |                          |                |
| Target yield: 1500Kg/ha                                               |      |                              |                          |                |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |      |                              |                          |                |
|                                                                       | UNIT | PRICE OR<br>COST PER UNIT(R) | Average over three years |                |
|                                                                       |      |                              | Quantity                 | Cost/Value     |
| Gross receipts from production                                        |      |                              |                          |                |
| Beans                                                                 | Ton  | 2900.00                      | 0.94                     | 2720.26        |
| <b>VARIABLE COSTS</b>                                                 |      |                              |                          |                |
| <b>PREHARVEST :</b>                                                   |      |                              |                          |                |
| <b>Planting</b>                                                       |      |                              |                          |                |
| Seed                                                                  | Kg   | 11.76                        | 60.00                    | 705.60         |
| Labour                                                                | Days | 15.00                        | 4.87                     | 72.96          |
| <b>Fertilisers</b>                                                    |      |                              |                          |                |
| Ammonium Nitrate                                                      | Kg   | 1.82                         | 62.96                    | 114.58         |
| Superphosphate                                                        | Kg   | 1.79                         | 39.21                    | 70.19          |
| <b>Pest Control/Pesticides</b>                                        |      |                              |                          |                |
| Metasystox                                                            | L    | 67.80                        | 0.50                     | 43.90          |
| Application (labour)                                                  | Days | 15.00                        | 0.48                     | 7.16           |
| <b>Weed Control/Herbicides</b>                                        |      |                              |                          |                |
| Hand weeding (labour)                                                 | Days | 15.00                        | 2.18                     | 32.67          |
| <b>Maintenance (labour)</b>                                           | Days |                              |                          |                |
| Repair basins                                                         | Days | 15.00                        | 2.27                     | 34.12          |
| <b>HARVEST AND POST HARVEST (labour)</b>                              |      |                              |                          |                |
| Harvest labour                                                        | Days | 15.00                        | 3.03                     | 45.45          |
| Threshing                                                             | Days | 15.00                        | 1.66                     | 24.89          |
| Remove beans stems                                                    | Days | 15.00                        | 0.71                     | 10.65          |
| <b>Total Allocatable Variable Costs</b>                               |      |                              |                          | <b>1081.20</b> |
| <b>Margin Above Allocatable Variable Costs</b>                        |      |                              |                          | <b>1639.06</b> |
| <b>Total Pre harvest Costs</b>                                        |      |                              |                          | <b>1081.20</b> |
| <b>Total Harvest and Post harvest Costs</b>                           |      |                              |                          | <b>80.99</b>   |
| <b>Gross Margin Above Total Allocatable Variable Costs</b>            |      |                              |                          | <b>1558.07</b> |
| <b>FIXED COSTS</b>                                                    |      |                              |                          |                |
| <b>LAND PREPARATION</b>                                               |      |                              |                          |                |
| Energy                                                                |      |                              |                          | 90.00          |
| Repairs and maintenance                                               |      |                              |                          | 114.35         |
| Construct basins (labour)                                             | Days | 15.00                        | 10.35                    | 155.25         |
| Pack stones (labour)                                                  | Days | 15.00                        | 3.69                     | 55.35          |
| Pack mulch (labour)                                                   | Days | 15.00                        | 7.71                     | 115.65         |
| <b>Total Fixed Costs</b>                                              |      |                              |                          | <b>530.60</b>  |
| Prices are for the base year , 1999/2000                              |      |                              |                          |                |
| All activities done by hand and/or hand tools except soil preparation |      |                              |                          |                |
| Fertilisers applied by hand at time of planting                       |      |                              |                          |                |
| Chemical and hand control of weeds and pests                          |      |                              |                          |                |

**TABLE A4.4: ENTERPRISE BUDGET FOR DRY BEANS PRODUCTION USING THE SBSR PRODUCTION TECHNIQUE IN GLEN OVER THE 1999/2000, 2000/2001 AND 2001/2002-PRODUCTION SEASONS.**

| GROSS MARGIN PER HA (R)                                               |                  |                          |            |         |
|-----------------------------------------------------------------------|------------------|--------------------------|------------|---------|
| Glen- Stone mulch in the basins and runoff strip                      |                  |                          |            |         |
| Farming area: Bloemfontein                                            |                  |                          |            |         |
| Target yield: 1500Kg/ha                                               |                  |                          |            |         |
| Seasons: 1999/2000, 2000/2001 and 2001/2002                           |                  |                          |            |         |
| UNIT                                                                  | PRICE OR         | Average over three years |            |         |
|                                                                       | COST PER UNIT(R) | Quantity                 | Cost/Value |         |
| Gross receipts from production                                        |                  |                          |            |         |
| Beans                                                                 | Ton              | 2400.00                  | 0.96       | 2777.13 |
| <b>VARIABLE COSTS</b>                                                 |                  |                          |            |         |
| <b>PREHARVEST :</b>                                                   |                  |                          |            |         |
| <b>Planting</b>                                                       |                  |                          |            |         |
| Seed                                                                  | Kg               | 11.76                    | 60.00      | 705.60  |
| Labour                                                                | Days             | 15.00                    | 4.87       | 72.98   |
| <b>Fertilisers</b>                                                    |                  |                          |            |         |
| Ammonium Nitrate                                                      | Kg               | 1.62                     | 62.96      | 114.58  |
| Superphosphate                                                        | Kg               | 1.79                     | 39.21      | 70.19   |
| <b>Pest Control/Pesticides</b>                                        |                  |                          |            |         |
| Metasystox                                                            | L                | 87.80                    | 0.50       | 43.90   |
| Application (labour)                                                  | Days             | 15.00                    | 0.48       | 7.16    |
| <b>Weed Control/Herbicides</b>                                        |                  |                          |            |         |
| Hand weeding (labour)                                                 | Days             | 15.00                    | 2.18       | 32.67   |
| <b>Maintenance (labour)</b>                                           |                  |                          |            |         |
| Repair basins                                                         | Days             | 15.00                    | 2.27       | 34.12   |
| <b>HARVEST AND POST HARVEST (labour)</b>                              |                  |                          |            |         |
| Harvest labour                                                        | Days             | 15.00                    | 3.10       | 46.43   |
| Threshing                                                             | Days             | 15.00                    | 1.69       | 25.41   |
| Remove beans stems                                                    | Days             | 15.00                    | 0.72       | 10.67   |
| Total Allocatable Variable Costs                                      |                  |                          |            | 1163.92 |
| Margin Above Allocatable Variable Costs                               |                  |                          |            | 1613.21 |
| <b>FIXED COSTS</b>                                                    |                  |                          |            |         |
| <b>LAND PREPARATION</b>                                               |                  |                          |            |         |
| Energy                                                                |                  |                          |            | 90.00   |
| Repairs and maintenance                                               |                  |                          |            | 114.35  |
| Construct basins (labour)                                             | Days             | 15.00                    | 10.35      | 155.25  |
| Pack stones (labour)                                                  | Days             | 15.00                    | 11.06      | 166.20  |
| Total Fixed Costs                                                     |                  |                          |            | 525.80  |
| Prices are for the base year, 1999/2000                               |                  |                          |            |         |
| All activities done by hand and/or hand tools except soil preparation |                  |                          |            |         |
| Fertilisers applied by hand at time of planting                       |                  |                          |            |         |
| Chemical and hand control of weeds and pests                          |                  |                          |            |         |



**TABLE A4.5: ENTERPRISE BUDGET FOR DRY BEANS PRODUCTION USING THE CON PRODUCTION TECHNIQUE IN TALLA DURING THE 2001/2002-PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                            |      |                              |          |                      |
|--------------------------------------------------------------------|------|------------------------------|----------|----------------------|
| Talla- Conventional                                                |      |                              |          |                      |
| Farming area: Thaba Nchu/Bloemfontein                              |      |                              |          |                      |
| Target yield: 1500Kg/ha                                            |      |                              |          |                      |
| Cultivar: PAN 148                                                  |      |                              |          |                      |
| Planting date: 29/11/2001                                          |      |                              |          |                      |
| Season: 2001/2002                                                  |      |                              |          |                      |
|                                                                    | UNIT | PRICE OR<br>COST PER UNIT(R) | QUANTITY | Value or Cost per ha |
| Gross receipts from production                                     |      |                              |          |                      |
| beans                                                              | Ton  | 2900.00                      | 0.26     | 759.80               |
| <b>VARIABLE COSTS</b>                                              |      |                              |          |                      |
| <b>PREHARVEST :</b>                                                |      |                              |          |                      |
| Planting                                                           |      |                              |          |                      |
| Seed                                                               | kg   | 11.76                        | 60.00    | 705.60               |
| Labour                                                             | days | 15.00                        | 7.99     | 119.85               |
| Fertilisers                                                        |      |                              |          |                      |
| Ammonium Nitrate                                                   | kg   | 1.82                         | 53.57    | 97.50                |
| Superphosphate                                                     | kg   | 1.79                         | 141.18   | 252.71               |
| Pest Control                                                       |      |                              |          |                      |
| Metasystox                                                         | L    | 87.80                        | 0.50     | 43.90                |
| Application (labour)                                               | Days | 15.00                        | 0.56     | 8.40                 |
| Weed Control                                                       |      |                              |          |                      |
| Hand weeding (labour)                                              | Days | 15.00                        | 3.75     | 56.25                |
| <b>HARVEST and POST HARVEST (labour)</b>                           |      |                              |          |                      |
| Hand Harvesting                                                    | Days | 15.00                        | 0.69     | 10.35                |
| Threshing                                                          | Days | 15.00                        | 0.46     | 6.86                 |
| Remove beans stems                                                 | Days | 15.00                        | 0.24     | 3.60                 |
| <b>Total directly Allocatable Costs</b>                            |      |                              |          | <b>1305.02</b>       |
| <b>Margin above directly allocatable variable costs</b>            |      |                              |          | <b>-545.22</b>       |
| <b>Non Directly Allocatable Variable Costs</b>                     |      |                              |          | <b>341.03</b>        |
| Energy                                                             |      |                              |          | 183.04               |
| Repairs and maintenance                                            |      |                              |          | 157.99               |
| <b>Total Pre harvest Costs</b>                                     |      |                              |          | <b>1294.29</b>       |
| <b>Total Post harvest Costs</b>                                    |      |                              |          | <b>20.81</b>         |
| <b>Gross Margin Above Total Allocatable Costs</b>                  |      |                              |          | <b>-545.22</b>       |
| Prices are for the base year like in experimental plots, 1999/2000 |      |                              |          |                      |
| All activities done by hand and/or hand tools                      |      |                              |          |                      |
| Fertilisers applied by hand at time of planting                    |      |                              |          |                      |
| Chemical and hand control of weeds and pests                       |      |                              |          |                      |

**TABLE A4.6: ENTERPRISE BUDGET FOR DRY BEANS PRODUCTION USING THE BBBR PRODUCTION TECHNIQUE IN TALLA DURING THE 2001/2002-PRODUCTION SEASON.**

| GROSS MARGIN PER HA (R)                                               |      |                              |                       |                                   |
|-----------------------------------------------------------------------|------|------------------------------|-----------------------|-----------------------------------|
| <b>DRY BEANS</b>                                                      |      |                              |                       |                                   |
| Country: South Africa                                                 |      |                              |                       |                                   |
| Province: Free State                                                  |      |                              |                       |                                   |
| Ecotope: Glen/Bonheim-Orrus                                           |      |                              |                       |                                   |
| Clay (%) in A-horizon: 45%                                            |      |                              |                       |                                   |
| Plant Population: 13 3333 plants per hectare                          |      |                              |                       |                                   |
| Cultivar: PAN 148                                                     |      |                              |                       |                                   |
| Planting date: 29/11/2001                                             |      |                              |                       |                                   |
| Season: 2001/2002                                                     |      |                              |                       |                                   |
| Talla- Bare basins and runoff strip                                   |      |                              |                       |                                   |
| Farming area: Thaba Ncha/Bloemfontein                                 |      |                              |                       |                                   |
| Target yield: 1500Kg/ha                                               |      |                              |                       |                                   |
|                                                                       | UNIT | PRICE OR<br>COST PER UNIT(R) | QUANTITY<br>2001/2002 | Value or Cost per ha<br>2001/2002 |
| Gross receipts from production                                        |      |                              |                       |                                   |
| beans                                                                 | Ton  | 2900.00                      | 0.41                  | 1180.30                           |
| <b>VARIABLE COSTS</b>                                                 |      |                              |                       |                                   |
| <b>PREHARVEST :</b>                                                   |      |                              |                       |                                   |
| Planting                                                              |      |                              |                       |                                   |
| Seed                                                                  | Kg   | 11.76                        | 60.00                 | 705.60                            |
| Labour                                                                | Days | 15.00                        | 7.99                  | 119.85                            |
| <b>Fertilisers</b>                                                    |      |                              |                       |                                   |
| Ammonium Nitrate                                                      | Kg   | 1.82                         | 53.57                 | 97.50                             |
| Superphosphate                                                        | Kg   | 1.79                         | 141.18                | 252.71                            |
| <b>Pest Control</b>                                                   |      |                              |                       |                                   |
| Metasystox                                                            | L    | 87.80                        | 0.50                  | 43.90                             |
| Application (labour)                                                  | Days | 15.00                        | 0.56                  | 8.40                              |
| <b>Weed Control</b>                                                   |      |                              |                       |                                   |
| Hand weeding (labour)                                                 | Days | 15.00                        | 3.75                  | 56.25                             |
| <b>Maintenance (labour)</b>                                           |      |                              |                       |                                   |
| Repair basins                                                         | Days | 15.00                        | 2.00                  | 30.00                             |
| <b>HARVEST AND POST HARVEST (labour)</b>                              |      |                              |                       |                                   |
| Hand Harvesting                                                       | Days | 15.00                        | 1.25                  | 18.75                             |
| Threshing                                                             | Days | 15.00                        | 0.39                  | 5.87                              |
| Remove beans stems                                                    | Days | 15.00                        | 0.56                  | 8.40                              |
| <b>Total Allocatable Variable Costs</b>                               |      |                              |                       | <b>1347.22</b>                    |
| <b>Margin Above Allocatable Variable costs</b>                        |      |                              |                       | <b>-166.92</b>                    |
| <b>Total Pre harvest Costs</b>                                        |      |                              |                       | <b>1314.20</b>                    |
| <b>Total Harvest and Post harvest Costs</b>                           |      |                              |                       | <b>33.02</b>                      |
| <b>Gross Margin Above Total Allocatable Costs</b>                     |      |                              |                       | <b>-166.92</b>                    |
| <b>FIXED COSTS</b>                                                    |      |                              |                       |                                   |
| <b>LAND PREPARATION</b>                                               |      |                              |                       |                                   |
| Construct basins (labour)                                             | Days | 15.00                        | 10.35                 | 155.25                            |
| Energy                                                                |      |                              |                       | 90.00                             |
| Repairs and maintenance                                               |      |                              |                       | 114.35                            |
| <b>Total Fixed Costs</b>                                              |      |                              |                       | <b>359.60</b>                     |
| Prices are for the base year , 1999/2000                              |      |                              |                       |                                   |
| All activities done by hand and/or hand tools except soil preparation |      |                              |                       |                                   |
| Fertilisers applied by hand at time of planting                       |      |                              |                       |                                   |
| Chemical and hand control of weeds and pests                          |      |                              |                       |                                   |

**APPENDIX A5: COST BENEFIT ANALYSIS FOR MAIZE  
PRODUCTION**









TABLE A5.5: COMPARISON OF THE NET PRESENT VALUE AND BENEFIT COST RATIO FOR MAIZE PRODUCTION BETWEEN CONVENTIONAL PRODUCTION AND SBOR, IN THE STUDY AREA OVER A PERIOD OF 15 YEARS.

| Years                                   | 1                   | 2       | 3       | 4        | 5        | 6        | 7        | 8        | 9        | 10      | 11       | 12       | 13       | 14       | 15       |
|-----------------------------------------|---------------------|---------|---------|----------|----------|----------|----------|----------|----------|---------|----------|----------|----------|----------|----------|
| Conventional                            |                     |         |         |          |          |          |          |          |          |         |          |          |          |          |          |
| Gross Income                            | 1928.98             | 971.93  | 1922.8  | 0        | 787.23   | 1988.83  | 240.87   | 1888.44  | 987.93   | 1822.5  | 0        | 1178.5   | 822.22   | 1888.11  | 1888.83  |
| Discounted Total Gross Income 10%       | <b>\$ 7,878.73</b>  | 1427.89 | 719.94  | 1032.19  | 0.00     | 451.43   | 836.28   | 174.85   | 907.27   | 201.38  | 575.27   | 0.00     | 274.58   | 138.33   | 258.85   |
| Discounted Total Gross Income 15%       | <b>\$ 9,488.41</b>  | 1355.72 | 658.70  | 965.30   | 0.00     | 381.48   | 842.90   | 128.12   | 385.81   | 158.51  | 188.82   | 0.00     | 258.75   | 78.93    | 152.80   |
| Discounted Total Gross Income 5%        | <b>\$ 9,488.41</b>  | 1485.19 | 789.14  | 1185.78  | 0.00     | 588.85   | 1789.50  | 242.25   | 738.70   | 682.85  | 918.82   | 0.00     | 858.82   | 258.88   | 555.81   |
| Total Variable Costs                    | 1582.81             | 1278.84 | 1288.82 | 1248.48  | 1288.25  | 1288.25  | 1283.87  | 1283.84  | 1283.85  | 1288.5  | 1248.48  | 1288.38  | 1288.38  | 1283.84  | 1283.27  |
| Fixed Costs                             | 100                 | 100     | 100     | 100      | 100      | 100      | 100      | 100      | 100      | 100     | 100      | 100      | 100      | 100      | 100      |
| Discounted Total Costs 10%              | <b>\$ 18,478.81</b> | 1278.18 | 1138.31 | 1047.85  | 915.57   | 858.20   | 788.88   | 884.88   | 885.43   | 888.82  | 838.87   | 888.82   | 881.34   | 883.71   | 881.81   |
| Discounted Total Costs 15%              | <b>\$ 9,888.41</b>  | 1278.84 | 1038.85 | 817.12   | 788.43   | 888.78   | 838.88   | 888.81   | 882.28   | 888.77  | 838.83   | 888.13   | 838.24   | 838.81   | 838.88   |
| Discounted Total Costs 5%               | <b>\$ 18,478.81</b> | 1338.82 | 1247.11 | 1288.80  | 1182.82  | 1072.84  | 1048.17  | 982.24   | 938.83   | 881.81  | 888.17   | 788.78   | 772.33   | 728.81   | 688.81   |
| Net Margin                              | 167.87              | -803.81 | -23.82  | -1548.48 | -487.22  | 87.54    | -183.18  | -285.1   | -888.81  | 82.8    | -1588.48 | -251.38  | -888.47  | -287.73  | -188.8   |
| Cumulative Net Margin                   | <b>\$ 17,178.81</b> | 167.87  | -335.84 | -358.88  | -1487.33 | -1358.57 | -1252.83 | -1485.18 | -1588.28 | -828.8  | -4188.3  | -5488.78 | -5788.18 | -6888.81 | -7178.88 |
| Net Present Value (10%)                 | <b>\$ 1,387.88</b>  |         |         |          |          |          |          |          |          |         |          |          |          |          |          |
| Net Present Value (15%)                 | <b>\$ 1,488.18</b>  |         |         |          |          |          |          |          |          |         |          |          |          |          |          |
| Net Present Value (5%)                  | <b>\$ 1,488.81</b>  |         |         |          |          |          |          |          |          |         |          |          |          |          |          |
| SB                                      |                     |         |         |          |          |          |          |          |          |         |          |          |          |          |          |
| Gross Income                            | 2278.18             | 1588.12 | 2138.85 | 0        | 1288.87  | 2178.72  | 918.84   | 1738.87  | 1887.88  | 2188.88 | 718.28   | 1782.21  | 1881.83  | 1887.83  | 1788.38  |
| Discounted Total Gross Income 10%       | <b>\$ 11,888.81</b> | 2088.83 | 1278.85 | 1888.72  | 0.00     | 787.87   | 1227.80  | 488.28   | 811.82   | 558.88  | 882.45   | 218.15   | 571.27   | 881.88   | 488.81   |
| Discounted Total Gross Income 15%       | <b>\$ 9,888.81</b>  | 1978.88 | 1188.81 | 1488.42  | 0.00     | 638.88   | 948.21   | 343.81   | 588.87   | 371.72  | 555.77   | 188.83   | 338.46   | 178.88   | 288.48   |
| Discounted Total Gross Income 5%        | <b>\$ 18,888.41</b> | 2188.83 | 1387.84 | 1848.13  | 0.00     | 1088.87  | 1822.85  | 848.85   | 1327.81  | 882.34  | 1488.15  | 817.83   | 888.83   | 887.85   | 818.82   |
| Total Variable Costs                    | 858.28              | 828.81  | 848.85  | 888.87   | 881.88   | 848.88   | 887.81   | 888.87   | 812.87   | 881.45  | 888.88   | 881.78   | 882.84   | 812.85   | 818.27   |
| Fixed Costs                             | 118.88              | 0       | 0       | 118.88   | 0        | 0        | 118.88   | 0        | 0        | 118.88  | 0        | 0        | 118.88   | 0        | 0        |
| Discounted Total Costs 10%              | <b>\$ 7,888.81</b>  | 1388.72 | 781.81  | 778.28   | 688.88   | 638.88   | 638.88   | 638.88   | 638.88   | 638.88  | 638.88   | 638.88   | 638.88   | 638.88   | 638.88   |
| Discounted Total Costs 15%              | <b>\$ 9,888.81</b>  | 1288.17 | 687.82  | 621.88   | 558.20   | 488.27   | 488.27   | 488.27   | 488.27   | 488.27  | 488.27   | 488.27   | 488.27   | 488.27   | 488.27   |
| Discounted Total Costs 5%               | <b>\$ 18,888.81</b> | 1488.88 | 838.11  | 818.88   | 803.28   | 788.20   | 788.88   | 718.88   | 628.28   | 588.25  | 558.88   | 518.83   | 488.88   | 438.88   | 448.81   |
| Net Margin                              | 781.78              | 618.81  | 1188.88 | -578.47  | 372.28   | 522.88   | -88.72   | 888.88   | 888.81   | 1221.78 | -178.88  | 881.82   | 881.88   | 881.88   | 881.88   |
| Cumulative Net Margin                   | <b>\$ 7,888.81</b>  | 781.78  | 1418.10 | 2081.88  | 1628.27  | 2088.81  | 2228.33  | 3128.27  | 3088.87  | 4318.28 | 5558.88  | 6388.28  | 6281.88  | 6188.20  | 6188.27  |
| Net Present Value (10%)                 | <b>\$ 1,388.88</b>  |         |         |          |          |          |          |          |          |         |          |          |          |          |          |
| Net Present Value (15%)                 | <b>\$ 1,488.88</b>  |         |         |          |          |          |          |          |          |         |          |          |          |          |          |
| Net Present Value (5%)                  | <b>\$ 1,488.81</b>  |         |         |          |          |          |          |          |          |         |          |          |          |          |          |
| SBOR                                    |                     |         |         |          |          |          |          |          |          |         |          |          |          |          |          |
| Net Margin                              | 828.82              | 1128.12 | 1211.85 | 588.87   | 1088.81  | 1148.34  | 818.84   | 1188.88  | 1078.72  | 1128.18 | 1188.88  | 1072.81  | 918.81   | 1182.81  | 1078.87  |
| Net Margin Increase                     | 828.82              | 888.81  | 88.88   | -887.88  | 881.88   | 128.88   | -228.10  | 188.88   | -288.88  | 81.48   | 58.88    | -82.88   | -182.88  | 248.88   | -88.88   |
| Cum Net Margin                          | <b>\$ 18,888.81</b> | 828.82  | 1788.14 | 2088.85  | 3122.57  | 4388.88  | 4588.48  | 5788.48  | 5888.48  | 6088.48 | 6188.48  | 6188.48  | 6188.48  | 6188.48  | 6188.48  |
| Present Value of Total Net Margin (10%) | <b>\$ 18,888.81</b> | 887.11  | 812.84  | 88.88    | -1878.82 | 888.82   | 78.48    | -188.81  | 88.82    | -12.82  | 28.88    | -12.88   | -84.28   | 88.88    | -28.88   |
| Present Value of Total Net Margin (15%) | <b>\$ 18,888.81</b> | 882.48  | 372.84  | 88.18    | -1888.81 | 328.81   | 82.87    | -84.78   | 82.88    | -8.82   | 12.28    | 2.88     | -12.88   | 18.27    | -18.88   |
| Present Value of Total Net Margin (5%)  | <b>\$ 18,888.81</b> | 884.11  | 882.88  | 78.48    | -1887.33 | 818.48   | 88.18    | -188.12  | 82.87    | -18.87  | 32.82    | 21.38    | -81.72   | 81.28    | -122.88  |





**APPENDIX A6: COST BENEFIT ANALYSIS FOR  
SUNFLOWER PRODUCTION**

TABLE A6.1: COMPARISON OF THE NET PRESENT VALUE AND BENEFIT COST RATIO FOR SUNFLOWER PRODUCTION BETWEEN CONVENTIONAL PRODUCTION AND *BBBR*, IN THE STUDY AREA OVER A PERIOD OF 15 YEARS.

| Estimated Net Present Value (USD)       |                    |         |         |          |          |         |         |          |         |         |          |          |         |         |         |         |  |
|-----------------------------------------|--------------------|---------|---------|----------|----------|---------|---------|----------|---------|---------|----------|----------|---------|---------|---------|---------|--|
|                                         | Years              | 1       | 2       | 3        | 4        | 5       | 6       | 7        | 8       | 9       | 10       | 11       | 12      | 13      | 14      | 15      |  |
| <b>Conventional</b>                     |                    |         |         |          |          |         |         |          |         |         |          |          |         |         |         |         |  |
| Gross Income                            |                    | 2195.93 | 255.55  | 1992.85  | 0        | 865     | 2425.88 | 252.38   | 1420.35 | 957.51  | 1993.18  | 222.88   | 1828.88 | 824     | 1602.5  | 1355.88 |  |
| Discounted Total Gross Income 10%       | <b>\$ 3,222.44</b> | 1995.93 | 199.52  | 1622.85  | 0.00     | 800.52  | 2274.45 | 249.22   | 1400.85 | 218.88  | 1993.18  | 222.88   | 1828.88 | 824.00  | 1602.50 | 1355.88 |  |
| Discounted Total Gross Income 15%       | <b>\$ 3,128.12</b> | 1995.93 | 172.10  | 1622.85  | 0.00     | 820.58  | 2052.42 | 259.84   | 1402.20 | 198.51  | 1993.18  | 222.88   | 1828.88 | 824.00  | 1602.50 | 1355.88 |  |
| Discounted Total Gross Income 5%        | <b>\$ 3,278.12</b> | 2092.72 | 257.22  | 1943.78  | 0.00     | 908.55  | 2412.88 | 267.88   | 1422.45 | 922.84  | 1993.18  | 222.88   | 1828.88 | 824.00  | 1602.50 | 1355.88 |  |
| Total Variable Costs                    |                    | 1525.85 | 1525.21 | 1467.8   | 1285.45  | 1844.95 | 1127.87 | 1397.91  | 1082.8  | 1228.55 | 1128.15  | 1289.72  | 1074.97 | 1235.88 | 1040.82 | 1244.52 |  |
| Fixed Costs                             |                    | 100     | 100     | 100      | 100      | 100     | 100     | 100      | 100     | 100     | 100      | 100      | 100     | 100     | 100     | 100     |  |
| Discounted Total Costs 10%              | <b>\$ 3,033.14</b> | 1294.85 | 1128.21 | 952.52   | 768.89   | 116.80  | 893.10  | 747.73   | 551.60  | 565.45  | 475.07   | 460.40   | 324.28  | 288.28  | 215.70  | 125.25  |  |
| Discounted Total Costs 15%              | <b>\$ 2,728.21</b> | 1218.18 | 1028.15 | 815.90   | 784.49   | 508.58  | 552.88  | 547.78   | 580.51  | 577.80  | 525.88   | 580.88   | 218.58  | 218.58  | 182.52  | 108.00  |  |
| Discounted Total Costs 5%               | <b>\$ 3,178.41</b> | 1554.18 | 1208.89 | 1055.17  | 1143.07  | 807.92  | 918.28  | 1935.54  | 850.20  | 858.48  | 754.71   | 818.20   | 464.18  | 707.18  | 507.90  | 453.52  |  |
| Net Margin                              |                    | 722.92  | 1428.68 | 535.88   | -1199.21 | -458.88 | 1293.81 | -1104.23 | 348.85  | -671.04 | 755.82   | -1567.97 | 238.18  | 1589.88 | 470.50  | 2.58    |  |
| Conventional Net Margin                 | <b>\$ 3,033.14</b> | 722.92  | 1428.68 | 535.88   | -1199.21 | -458.88 | 1293.81 | -1104.23 | 348.85  | -671.04 | 755.82   | -1567.97 | 238.18  | 1589.88 | 470.50  | 2.58    |  |
| Net Present Value (10%)                 | <b>\$ -178.88</b>  |         |         |          |          |         |         |          |         |         |          |          |         |         |         |         |  |
| Net Present Value (15%)                 | <b>\$ -158.88</b>  |         |         |          |          |         |         |          |         |         |          |          |         |         |         |         |  |
| Net Present Value (5%)                  | <b>\$ -128.88</b>  |         |         |          |          |         |         |          |         |         |          |          |         |         |         |         |  |
| <b>BBBR</b>                             |                    |         |         |          |          |         |         |          |         |         |          |          |         |         |         |         |  |
| Gross Income                            |                    | 2195.93 | 255.55  | 1992.85  | 0        | 865     | 2425.88 | 252.38   | 1420.35 | 957.51  | 1993.18  | 222.88   | 1828.88 | 824     | 1602.5  | 1355.88 |  |
| Discounted Total Gross Income 10%       | <b>\$ 3,222.44</b> | 1995.93 | 199.52  | 1622.85  | 0.00     | 800.52  | 2274.45 | 249.22   | 1400.85 | 218.88  | 1993.18  | 222.88   | 1828.88 | 824.00  | 1602.50 | 1355.88 |  |
| Discounted Total Gross Income 15%       | <b>\$ 3,128.12</b> | 1995.93 | 172.10  | 1622.85  | 0.00     | 820.58  | 2052.42 | 259.84   | 1402.20 | 198.51  | 1993.18  | 222.88   | 1828.88 | 824.00  | 1602.50 | 1355.88 |  |
| Discounted Total Gross Income 5%        | <b>\$ 3,278.12</b> | 2092.72 | 257.22  | 1943.78  | 0.00     | 908.55  | 2412.88 | 267.88   | 1422.45 | 922.84  | 1993.18  | 222.88   | 1828.88 | 824.00  | 1602.50 | 1355.88 |  |
| Total Variable Costs                    |                    | 1525.85 | 1525.21 | 1467.8   | 1285.45  | 1844.95 | 1127.87 | 1397.91  | 1082.8  | 1228.55 | 1128.15  | 1289.72  | 1074.97 | 1235.88 | 1040.82 | 1244.52 |  |
| Fixed Costs                             |                    | 100     | 100     | 100      | 100      | 100     | 100     | 100      | 100     | 100     | 100      | 100      | 100     | 100     | 100     | 100     |  |
| Discounted Total Costs 10%              | <b>\$ 3,033.14</b> | 1294.85 | 1128.21 | 952.52   | 768.89   | 116.80  | 893.10  | 747.73   | 551.60  | 565.45  | 475.07   | 460.40   | 324.28  | 288.28  | 215.70  | 125.25  |  |
| Discounted Total Costs 15%              | <b>\$ 2,728.21</b> | 1218.18 | 1028.15 | 815.90   | 784.49   | 508.58  | 552.88  | 547.78   | 580.51  | 577.80  | 525.88   | 580.88   | 218.58  | 218.58  | 182.52  | 108.00  |  |
| Discounted Total Costs 5%               | <b>\$ 3,178.41</b> | 1554.18 | 1208.89 | 1055.17  | 1143.07  | 807.92  | 918.28  | 1935.54  | 850.20  | 858.48  | 754.71   | 818.20   | 464.18  | 707.18  | 507.90  | 453.52  |  |
| Net Margin                              |                    | 722.92  | 1428.68 | 535.88   | -1199.21 | -458.88 | 1293.81 | -1104.23 | 348.85  | -671.04 | 755.82   | -1567.97 | 238.18  | 1589.88 | 470.50  | 2.58    |  |
| BBBR Net Margin                         | <b>\$ 3,178.41</b> | 722.92  | 1428.68 | 535.88   | -1199.21 | -458.88 | 1293.81 | -1104.23 | 348.85  | -671.04 | 755.82   | -1567.97 | 238.18  | 1589.88 | 470.50  | 2.58    |  |
| Net Present Value (10%)                 | <b>\$ -178.88</b>  |         |         |          |          |         |         |          |         |         |          |          |         |         |         |         |  |
| Net Present Value (15%)                 | <b>\$ -158.88</b>  |         |         |          |          |         |         |          |         |         |          |          |         |         |         |         |  |
| Net Present Value (5%)                  | <b>\$ -128.88</b>  |         |         |          |          |         |         |          |         |         |          |          |         |         |         |         |  |
| <b>BBBR Margin Increase</b>             |                    |         |         |          |          |         |         |          |         |         |          |          |         |         |         |         |  |
| Net Margin                              |                    | 51.74   | 240.28  | 1,179.92 | 499.35   | 999.72  | 1999.44 | 899.24   | 999.44  | 999.24  | 1,140.20 | 1,050.88 | 798.38  | 608.48  | 508.20  | 448.48  |  |
| Net Margin Increase                     |                    | 51.74   | 240.28  | 1,179.92 | 499.35   | 999.72  | 1999.44 | 899.24   | 999.44  | 999.24  | 1,140.20 | 1,050.88 | 798.38  | 608.48  | 508.20  | 448.48  |  |
| BBBR Net Margin                         | <b>\$ 3,178.41</b> | 51.74   | 240.28  | 1,179.92 | 499.35   | 999.72  | 1999.44 | 899.24   | 999.44  | 999.24  | 1,140.20 | 1,050.88 | 798.38  | 608.48  | 508.20  | 448.48  |  |
| Present value of Total Net Margin (10%) | <b>\$19.88</b>     | 722.92  | 1428.68 | 24.23    | -187.87  | 173.88  | -18.18  | 7.74     | 18.88   | -18.18  | 18.88    | -18.18   | 18.88   | -18.18  | 18.88   | -18.18  |  |
| Present value of Total Net Margin (15%) | <b>\$19.88</b>     | 722.92  | 1428.68 | 24.23    | -187.87  | 173.88  | -18.18  | 7.74     | 18.88   | -18.18  | 18.88    | -18.18   | 18.88   | -18.18  | 18.88   | -18.18  |  |
| Present value of Total Net Margin (5%)  | <b>\$19.88</b>     | 722.92  | 1428.68 | 24.23    | -187.87  | 173.88  | -18.18  | 7.74     | 18.88   | -18.18  | 18.88    | -18.18   | 18.88   | -18.18  | 18.88   | -18.18  |  |





**TABLE A6-4: COMPARISON OF THE NET PRESENT VALUE AND BENEFIT COST RATIO FOR SUNFLOWER PRODUCTION BETWEEN CONVENTIONAL PRODUCTION AND *ORSR*, IN THE STUDY AREA OVER A PERIOD OF 15 YEARS.**

| Economic Benefit Analysis (US\$ Million)  |                    |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
|-------------------------------------------|--------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
|                                           | Years              | 1       | 2       | 3       | 4       | 5       | 6       | 7       | 8       | 9       | 10      | 11      | 12      | 13      | 14      | 15      |
| <b>Conventional Production</b>            |                    |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Grain Income                              |                    | 2335.55 | 2335.55 | 2335.55 | 0       | 0       | 2335.55 | 2335.55 | 1828.55 | 1828.55 | 1828.55 | 212.55  | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Discounted Grain Income (10%)             | <b>R 3,333.33</b>  | 2335.55 | 2335.55 | 2335.55 | 0       | 0       | 2335.55 | 2335.55 | 1828.55 | 1828.55 | 1828.55 | 212.55  | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Discounted Grain Income (15%)             | <b>R 3,333.33</b>  | 2335.55 | 2335.55 | 2335.55 | 0       | 0       | 2335.55 | 2335.55 | 1828.55 | 1828.55 | 1828.55 | 212.55  | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Discounted Grain Income (20%)             | <b>R 3,333.33</b>  | 2335.55 | 2335.55 | 2335.55 | 0       | 0       | 2335.55 | 2335.55 | 1828.55 | 1828.55 | 1828.55 | 212.55  | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Total Variable Costs                      |                    | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Fixed Costs                               |                    | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Variable Costs (10%)           | <b>R 18,285.55</b> | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Discounted Variable Costs (15%)           | <b>R 18,285.55</b> | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Discounted Variable Costs (20%)           | <b>R 18,285.55</b> | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Net Margin                                |                    | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (10%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (15%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (20%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| <b>ORSR Production</b>                    |                    |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Grain Income                              |                    | 2335.55 | 2335.55 | 2335.55 | 0       | 0       | 2335.55 | 2335.55 | 1828.55 | 1828.55 | 1828.55 | 212.55  | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Discounted Grain Income (10%)             | <b>R 3,333.33</b>  | 2335.55 | 2335.55 | 2335.55 | 0       | 0       | 2335.55 | 2335.55 | 1828.55 | 1828.55 | 1828.55 | 212.55  | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Discounted Grain Income (15%)             | <b>R 3,333.33</b>  | 2335.55 | 2335.55 | 2335.55 | 0       | 0       | 2335.55 | 2335.55 | 1828.55 | 1828.55 | 1828.55 | 212.55  | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Discounted Grain Income (20%)             | <b>R 3,333.33</b>  | 2335.55 | 2335.55 | 2335.55 | 0       | 0       | 2335.55 | 2335.55 | 1828.55 | 1828.55 | 1828.55 | 212.55  | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Total Variable Costs                      |                    | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Fixed Costs                               |                    | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Variable Costs (10%)           | <b>R 18,285.55</b> | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Discounted Variable Costs (15%)           | <b>R 18,285.55</b> | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Discounted Variable Costs (20%)           | <b>R 18,285.55</b> | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 | 1828.55 |
| Net Margin                                |                    | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (10%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (15%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (20%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| <b>ORSR Production - Net Margin</b>       |                    |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Net Margin                                |                    | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (10%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (15%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (20%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| <b>ORSR Production - Net Margin (10%)</b> |                    |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Net Margin                                |                    | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (10%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (15%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (20%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| <b>ORSR Production - Net Margin (15%)</b> |                    |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Net Margin                                |                    | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (15%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (20%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| <b>ORSR Production - Net Margin (20%)</b> |                    |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Net Margin                                |                    | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Discounted Net Margin (20%)               | <b>R 5,069.99</b>  | 506.99  | 506.99  | 506.99  | 0       | 0       | 506.99  | 506.99  | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |

**TABLE A6.5: COMPARISON OF THE NET PRESENT VALUE AND BENEFIT COST RATIO FOR SUNFLOWER PRODUCTION BETWEEN CONVENTIONAL PRODUCTION AND SBOR, IN THE STUDY AREA OVER A PERIOD OF 15 YEARS.**

| CONVENTIONAL PRODUCTION                             | 1                  | 2       | 3        | 4        | 5        | 6        | 7        | 8        | 9        | 10       | 11       | 12       | 13       | 14       | 15       |
|-----------------------------------------------------|--------------------|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| CONVENTIONAL                                        |                    |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| Grain Income                                        | 2195.93            | 556.55  | 1002.85  | 0        | 440      | 2422.69  | 232.18   | 1422.35  | 487.51   | 1983.18  | 222.66   | 1470.88  | 588      | 1663.5   | 1358.28  |
| Discounted Total Grain Income 10%                   | <b>R 2322.44</b>   | 500.09  | 750.52   | 3420.80  | 0.00     | 401.12   | 1375.49  | 149.52   | 868.81   | 228.88   | 768.97   | 81.74    | 408.50   | 88.50    | 248.22   |
| Discounted Total Grain Income 15%                   | <b>R 2388.74</b>   | 488.42  | 722.26   | 3251.17  | 0.00     | 327.18   | 1255.42  | 128.54   | 457.22   | 188.91   | 490.21   | 49.89    | 274.51   | 49.47    | 168.55   |
| Discounted Total Grain Income 5%                    | <b>R 18318.92</b>  | 2082.70 | 867.71   | 1003.70  | 0.00     | 509.19   | 1813.96  | 207.55   | 867.45   | 423.80   | 1212.50  | 155.88   | 819.51   | 183.27   | 949.18   |
| Total Variable Costs                                | 1223.91            | 1349.21 | 1107.9   | 1288.81  | 1088.95  | 1127.87  | 1057.11  | 1082.4   | 1228.55  | 1120.95  | 1490.10  | 1074.51  | 1233.88  | 1061.02  | 1258.54  |
| Fixed Costs                                         | 500                | 500     | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      |
| Discounted Total Costs 10%                          | <b>R 12481.14</b>  | 1244.46 | 1176.21  | 852.52   | 548.59   | 750.85   | 693.10   | 747.72   | 551.83   | 553.43   | 473.97   | 400.40   | 374.26   | 388.38   | 311.76   |
| Discounted Total Costs 15%                          | <b>R 12481.14</b>  | 1244.46 | 1176.21  | 852.52   | 548.59   | 750.85   | 693.10   | 747.72   | 551.83   | 553.43   | 473.97   | 400.40   | 374.26   | 388.38   | 311.76   |
| Discounted Total Costs 5%                           | <b>R 12481.14</b>  | 1244.46 | 1176.21  | 852.52   | 548.59   | 750.85   | 693.10   | 747.72   | 551.83   | 553.43   | 473.97   | 400.40   | 374.26   | 388.38   | 311.76   |
| NET MARGIN                                          | 762.02             | -892.66 | 895.95   | -1388.81 | -1088.95 | 1205.82  | -1154.02 | -245.95  | -621.04  | 762.23   | -1167.47 | -208.60  | -1023.88 | -879.58  | -2.58    |
| CUMULATIVE NET MARGIN                               | <b>R 762.02</b>    | 762.02  | 275.35   | 970.30   | 418.87   | -971.72  | 228.09   | -845.84  | -622.88  | -1154.02 | -615.80  | -1178.16 | -1492.51 | -2512.45 | -2514.87 |
| NET PRESENT VALUE (10%)                             | <b>R 1773.30</b>   |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| NET PRESENT VALUE (15%)                             | <b>R 1682.92</b>   |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| NET PRESENT VALUE (5%)                              | <b>R 1133.81</b>   |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| SBOR                                                |                    |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| Grain Income                                        | 2422.81            | 2010.24 | 3117.43  | 0        | 1438.31  | 3745.84  | 1028.4   | 2408.31  | 1566.54  | 5566.31  | 1122.5   | 2502.50  | 578.42   | 2512.25  | 4721.57  |
| Discounted Total Grain Income 10%                   | <b>R 18388.21</b>  | 3111.40 | 1677.88  | 2422.42  | 0.00     | 472.52   | 2114.40  | 515.37   | 1120.83  | 408.10   | 1382.52  | 595.52   | 848.36   | 183.41   | 555.22   |
| Discounted Total Grain Income 15%                   | <b>R 18388.21</b>  | 2970.18 | 1515.55  | 2181.20  | 0.00     | 408.70   | 1810.47  | 444.84   | 785.87   | 454.88   | 885.41   | 122.42   | 401.55   | 75.02    | 180.42   |
| Discounted Total Grain Income 5%                    | <b>R 18388.21</b>  | 3259.40 | 1841.40  | 2485.72  | 0.00     | 1137.14  | 2705.28  | 727.80   | 1427.33  | 1511.04  | 2257.51  | 459.40   | 1482.50  | 518.89   | 1410.88  |
| Total Variable Costs                                | 1212.82            | 1334.24 | 1130.42  | 1279.92  | 1059.04  | 1258.41  | 1015.08  | 1089.24  | 1188.99  | 1253.86  | 1518.48  | 1115.38  | 880.22   | 1117.20  | 1071.81  |
| Fixed Costs                                         | 500                | 500     | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      | 500      |
| Discounted Total Costs 10%                          | <b>R 12481.14</b>  | 1244.46 | 1176.21  | 852.52   | 548.59   | 750.85   | 693.10   | 747.72   | 551.83   | 553.43   | 473.97   | 400.40   | 374.26   | 388.38   | 311.76   |
| Discounted Total Costs 15%                          | <b>R 12481.14</b>  | 1244.46 | 1176.21  | 852.52   | 548.59   | 750.85   | 693.10   | 747.72   | 551.83   | 553.43   | 473.97   | 400.40   | 374.26   | 388.38   | 311.76   |
| Discounted Total Costs 5%                           | <b>R 12481.14</b>  | 1244.46 | 1176.21  | 852.52   | 548.59   | 750.85   | 693.10   | 747.72   | 551.83   | 553.43   | 473.97   | 400.40   | 374.26   | 388.38   | 311.76   |
| NET MARGIN                                          | 1210.00            | 676.00  | 2187.00  | 888.51   | 479.27   | 2487.43  | 1103.32  | 1319.07  | 3076.55  | 2312.45  | 200.02   | 756.12   | 693.12   | 1395.05  | 1649.76  |
| CUMULATIVE NET MARGIN                               | <b>R 1210.00</b>   | 1210.00 | 2187.00  | 3075.51  | 3554.78  | 6042.21  | 7145.53  | 8464.60  | 11541.15 | 13853.60 | 14053.62 | 14809.74 | 15502.86 | 16897.91 | 18547.67 |
| NET PRESENT VALUE (10%)                             | <b>R 8488.99</b>   |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| NET PRESENT VALUE (15%)                             | <b>R 8488.99</b>   |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| NET PRESENT VALUE (5%)                              | <b>R 10,888.99</b> |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| CONVENTIONAL PRODUCTION - SBOR MARGINS DISADVANTAGE |                    |         |          |          |          |          |          |          |          |          |          |          |          |          |          |
| Net Margin                                          | 927.07             | 1482.56 | 1482.56  | 508.07   | 950.17   | 1482.56  | 1482.56  | 1482.56  | 1482.56  | 1482.56  | 1482.56  | 1482.56  | 1482.56  | 1482.56  | 1482.56  |
| Net Margin Increase                                 | 927.07             | 528.99  | 20.37    | -102.80  | 450.10   | 330.55   | -121.72  | -92.80   | 216.51   | 105.94   | 105.94   | -126.51  | -126.51  | 27.89    | 27.89    |
| Sum Net Margin                                      | <b>R 12,742.92</b> | 927.07  | 2,355.53 | 2,052.73 | 4,382.93 | 5,313.48 | 5,021.76 | 4,828.96 | 5,045.47 | 5,151.41 | 5,257.35 | 5,130.80 | 4,904.29 | 5,032.18 | 5,159.07 |
| Present value of Total Net (10%)                    | <b>1274.92</b>     | 851.85  | 434.24   | 55.50    | -175.31  | 229.49   | 199.67   | -52.44   | 43.33    | 81.82    | 73.95    | -36.90   | -46.20   | -74.81   | 9.55     |
| Present value of Total Net (15%)                    | <b>1274.92</b>     | 814.80  | 507.55   | 53.50    | -160.55  | 223.74   | 149.80   | -46.74   | -50.37   | 81.55    | 47.22    | -23.69   | -23.69   | 34.51    | 4.55     |
| Present value of Total Net (5%)                     | <b>1274.92</b>     | 892.45  | 474.53   | 57.60    | -160.60  | 352.82   | 253.34   | -84.50   | -82.87   | 139.56   | 117.24   | -61.70   | -76.24   | -138.59  | -18.21   |





**APPENDIX A7: COST BENEFIT ANALYSIS FOR DRY BEANS  
PRODUCTION**



TABLE A7.2: COMPARISON OF THE NET PRESENT VALUE AND BENEFIT COST RATIO FOR DRY BEANS PRODUCTION BETWEEN CONVENTIONAL PRODUCTION AND *QBBR* IN THE STUDY AREA OVER A PERIOD OF 15 YEARS.

| Category Item Analysis (Row 1) |          |        |        |        |        |        |        |        |        |        |         |         |         |         |
|--------------------------------|----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|---------|
|                                | Category | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      | 10      | 11      | 12      | 13      |
| Category Item 1                |          | 1.2345 | 2.3456 | 3.4567 | 4.5678 | 5.6789 | 6.7890 | 7.8901 | 8.9012 | 9.0123 | 10.1234 | 11.2345 | 12.3456 | 13.4567 |
| Category Item 2                |          | 1.3456 | 2.4567 | 3.5678 | 4.6789 | 5.7890 | 6.8901 | 7.9012 | 8.0123 | 9.1234 | 10.2345 | 11.3456 | 12.4567 | 13.5678 |
| Category Item 3                |          | 1.4567 | 2.5678 | 3.6789 | 4.7890 | 5.8901 | 6.9012 | 7.0123 | 8.1234 | 9.2345 | 10.3456 | 11.4567 | 12.5678 | 13.6789 |
| Category Item 4                |          | 1.5678 | 2.6789 | 3.7890 | 4.8901 | 5.9012 | 6.0123 | 7.1234 | 8.2345 | 9.3456 | 10.4567 | 11.5678 | 12.6789 | 13.7890 |
| Category Item 5                |          | 1.6789 | 2.7890 | 3.8901 | 4.9012 | 5.0123 | 6.1234 | 7.2345 | 8.3456 | 9.4567 | 10.5678 | 11.6789 | 12.7890 | 13.8901 |
| Category Item 6                |          | 1.7890 | 2.8901 | 3.9012 | 4.0123 | 5.1234 | 6.2345 | 7.3456 | 8.4567 | 9.5678 | 10.6789 | 11.7890 | 12.8901 | 13.9012 |
| Category Item 7                |          | 1.8901 | 2.9012 | 3.0123 | 4.1234 | 5.2345 | 6.3456 | 7.4567 | 8.5678 | 9.6789 | 10.7890 | 11.8901 | 12.9012 | 13.0123 |
| Category Item 8                |          | 1.9012 | 2.0123 | 3.1234 | 4.2345 | 5.3456 | 6.4567 | 7.5678 | 8.6789 | 9.7890 | 10.8901 | 11.9012 | 12.0123 | 13.1234 |
| Category Item 9                |          | 1.0123 | 2.1234 | 3.2345 | 4.3456 | 5.4567 | 6.5678 | 7.6789 | 8.7890 | 9.8901 | 10.9012 | 11.0123 | 12.1234 | 13.2345 |
| Category Item 10               |          | 1.1234 | 2.2345 | 3.3456 | 4.4567 | 5.5678 | 6.6789 | 7.7890 | 8.8901 | 9.9012 | 10.0123 | 11.1234 | 12.2345 | 13.3456 |
| Category Item 11               |          | 1.2345 | 2.3456 | 3.4567 | 4.5678 | 5.6789 | 6.7890 | 7.8901 | 8.9012 | 9.0123 | 10.1234 | 11.2345 | 12.3456 | 13.4567 |
| Category Item 12               |          | 1.3456 | 2.4567 | 3.5678 | 4.6789 | 5.7890 | 6.8901 | 7.9012 | 8.0123 | 9.1234 | 10.2345 | 11.3456 | 12.4567 | 13.5678 |
| Category Item 13               |          | 1.4567 | 2.5678 | 3.6789 | 4.7890 | 5.8901 | 6.9012 | 7.0123 | 8.1234 | 9.2345 | 10.3456 | 11.4567 | 12.5678 | 13.6789 |
| Category Item 14               |          | 1.5678 | 2.6789 | 3.7890 | 4.8901 | 5.9012 | 6.0123 | 7.1234 | 8.2345 | 9.3456 | 10.4567 | 11.5678 | 12.6789 | 13.7890 |
| Category Item 15               |          | 1.6789 | 2.7890 | 3.8901 | 4.9012 | 5.0123 | 6.1234 | 7.2345 | 8.3456 | 9.4567 | 10.5678 | 11.6789 | 12.7890 | 13.8901 |
| Category Item 16               |          | 1.7890 | 2.8901 | 3.9012 | 4.0123 | 5.1234 | 6.2345 | 7.3456 | 8.4567 | 9.5678 | 10.6789 | 11.7890 | 12.8901 | 13.9012 |
| Category Item 17               |          | 1.8901 | 2.9012 | 3.0123 | 4.1234 | 5.2345 | 6.3456 | 7.4567 | 8.5678 | 9.6789 | 10.7890 | 11.8901 | 12.9012 | 13.0123 |
| Category Item 18               |          | 1.9012 | 2.0123 | 3.1234 | 4.2345 | 5.3456 | 6.4567 | 7.5678 | 8.6789 | 9.7890 | 10.8901 | 11.9012 | 12.0123 | 13.1234 |
| Category Item 19               |          | 1.0123 | 2.1234 | 3.2345 | 4.3456 | 5.4567 | 6.5678 | 7.6789 | 8.7890 | 9.8901 | 10.9012 | 11.0123 | 12.1234 | 13.2345 |
| Category Item 20               |          | 1.1234 | 2.2345 | 3.3456 | 4.4567 | 5.5678 | 6.6789 | 7.7890 | 8.8901 | 9.9012 | 10.0123 | 11.1234 | 12.2345 | 13.3456 |
| Category Item 21               |          | 1.2345 | 2.3456 | 3.4567 | 4.5678 | 5.6789 | 6.7890 | 7.8901 | 8.9012 | 9.0123 | 10.1234 | 11.2345 | 12.3456 | 13.4567 |
| Category Item 22               |          | 1.3456 | 2.4567 | 3.5678 | 4.6789 | 5.7890 | 6.8901 | 7.9012 | 8.0123 | 9.1234 | 10.2345 | 11.3456 | 12.4567 | 13.5678 |
| Category Item 23               |          | 1.4567 | 2.5678 | 3.6789 | 4.7890 | 5.8901 | 6.9012 | 7.0123 | 8.1234 | 9.2345 | 10.3456 | 11.4567 | 12.5678 | 13.6789 |
| Category Item 24               |          | 1.5678 | 2.6789 | 3.7890 | 4.8901 | 5.9012 | 6.0123 | 7.1234 | 8.2345 | 9.3456 | 10.4567 | 11.5678 | 12.6789 | 13.7890 |
| Category Item 25               |          | 1.6789 | 2.7890 | 3.8901 | 4.9012 | 5.0123 | 6.1234 | 7.2345 | 8.3456 | 9.4567 | 10.5678 | 11.6789 | 12.7890 | 13.8901 |
| Category Item 26               |          | 1.7890 | 2.8901 | 3.9012 | 4.0123 | 5.1234 | 6.2345 | 7.3456 | 8.4567 | 9.5678 | 10.6789 | 11.7890 | 12.8901 | 13.9012 |
| Category Item 27               |          | 1.8901 | 2.9012 | 3.0123 | 4.1234 | 5.2345 | 6.3456 | 7.4567 | 8.5678 | 9.6789 | 10.7890 | 11.8901 | 12.9012 | 13.0123 |
| Category Item 28               |          | 1.9012 | 2.0123 | 3.1234 | 4.2345 | 5.3456 | 6.4567 | 7.5678 | 8.6789 | 9.7890 | 10.8901 | 11.9012 | 12.0123 | 13.1234 |
| Category Item 29               |          | 1.0123 | 2.1234 | 3.2345 | 4.3456 | 5.4567 | 6.5678 | 7.6789 | 8.7890 | 9.8901 | 10.9012 | 11.0123 | 12.1234 | 13.2345 |
| Category Item 30               |          | 1.1234 | 2.2345 | 3.3456 | 4.4567 | 5.5678 | 6.6789 | 7.7890 | 8.8901 | 9.9012 | 10.0123 | 11.1234 | 12.2345 | 13.3456 |
| Category Item 31               |          | 1.2345 | 2.3456 | 3.4567 | 4.5678 | 5.6789 | 6.7890 | 7.8901 | 8.9012 | 9.0123 | 10.1234 | 11.2345 | 12.3456 | 13.4567 |
| Category Item 32               |          | 1.3456 | 2.4567 | 3.5678 | 4.6789 | 5.7890 | 6.8901 | 7.9012 | 8.0123 | 9.1234 | 10.2345 | 11.3456 | 12.4567 | 13.5678 |
| Category Item 33               |          | 1.4567 | 2.5678 | 3.6789 | 4.7890 | 5.8901 | 6.9012 | 7.0123 | 8.1234 | 9.2345 | 10.3456 | 11.4567 | 12.5678 | 13.6789 |
| Category Item 34               |          | 1.5678 | 2.6789 | 3.7890 | 4.8901 | 5.9012 | 6.0123 | 7.1234 | 8.2345 | 9.3456 | 10.4567 | 11.5678 | 12.6789 | 13.7890 |
| Category Item 35               |          | 1.6789 | 2.7890 | 3.8901 | 4.9012 | 5.0123 | 6.1234 | 7.2345 | 8.3456 | 9.4567 | 10.5678 | 11.6789 | 12.7890 | 13.8901 |
| Category Item 36               |          | 1.7890 | 2.8901 | 3.9012 | 4.0123 | 5.1234 | 6.2345 | 7.3456 | 8.4567 | 9.5678 | 10.6789 | 11.7890 | 12.8901 | 13.9012 |
| Category Item 37               |          | 1.8901 | 2.9012 | 3.0123 | 4.1234 | 5.2345 | 6.3456 | 7.4567 | 8.5678 | 9.6789 | 10.7890 | 11.8901 | 12.9012 | 13.0123 |
| Category Item 38               |          | 1.9012 | 2.0123 | 3.1234 | 4.2345 | 5.3456 | 6.4567 | 7.5678 | 8.6789 | 9.7890 | 10.8901 | 11.9012 | 12.0123 | 13.1234 |
| Category Item 39               |          | 1.0123 | 2.1234 | 3.2345 | 4.3456 | 5.4567 | 6.5678 | 7.6789 | 8.7890 | 9.8901 | 10.9012 | 11.0123 | 12.1234 | 13.2345 |
| Category Item 40               |          | 1.1234 | 2.2345 | 3.3456 | 4.4567 | 5.5678 | 6.6789 | 7.7890 | 8.8901 | 9.9012 | 10.0123 | 11.1234 | 12.2345 | 13.3456 |
| Category Item 41               |          | 1.2345 | 2.3456 | 3.4567 | 4.5678 | 5.6789 | 6.7890 | 7.8901 | 8.9012 | 9.0123 | 10.1234 | 11.2345 | 12.3456 | 13.4567 |
| Category Item 42               |          | 1.3456 | 2.4567 | 3.5678 | 4.6789 | 5.7890 | 6.8901 | 7.9012 | 8.0123 | 9.1234 | 10.2345 | 11.3456 | 12.4567 | 13.5678 |
| Category Item 43               |          | 1.4567 | 2.5678 | 3.6789 | 4.7890 | 5.8901 | 6.9012 | 7.0123 | 8.1234 | 9.2345 | 10.3456 | 11.4567 | 12.5678 | 13.6789 |
| Category Item 44               |          | 1.5678 | 2.6789 | 3.7890 | 4.8901 | 5.9012 | 6.0123 | 7.1234 | 8.2345 | 9.3456 | 10.4567 | 11.5678 | 12.6789 | 13.7890 |
| Category Item 45               |          | 1.6789 | 2.7890 | 3.8901 | 4.9012 | 5.0123 | 6.1234 | 7.2345 | 8.3456 | 9.4567 | 10.5678 | 11.6789 | 12.7890 | 13.8901 |
| Category Item 46               |          | 1.7890 | 2.8901 | 3.9012 | 4.0123 | 5.1234 | 6.2345 | 7.3456 | 8.4567 | 9.5678 | 10.6789 | 11.7890 | 12.8901 | 13.9012 |
| Category Item 47               |          | 1.8901 | 2.9012 | 3.0123 | 4.1234 | 5.2345 | 6.3456 | 7.4567 | 8.5678 | 9.6789 | 10.7890 | 11.8901 | 12.9012 | 13.0123 |
| Category Item 48               |          | 1.9012 | 2.0123 | 3.1234 | 4.2345 | 5.3456 | 6.4567 | 7.5678 | 8.6789 | 9.7890 | 10.8901 | 11.9012 | 12.0123 | 13.1234 |
| Category Item 49               |          | 1.0123 | 2.1234 | 3.2345 | 4.3456 | 5.4567 | 6.5678 | 7.6789 | 8.7890 | 9.8901 | 10.9012 | 11.0123 | 12.1234 | 13.2345 |
| Category Item 50               |          | 1.1234 | 2.2345 | 3.3456 | 4.4567 | 5.5678 | 6.6789 | 7.7890 | 8.8901 | 9.9012 | 10.0123 | 11.1234 | 12.2345 | 13.3456 |
| Category Item 51               |          | 1.2345 | 2.3456 | 3.4567 | 4.5678 | 5.6789 | 6.7890 | 7.8901 | 8.9012 | 9.0123 | 10.1234 | 11.2345 | 12.3456 | 13.4567 |
| Category Item 52               |          | 1.3456 | 2.4567 | 3.5678 | 4.6789 | 5.7890 | 6.8901 | 7.9012 | 8.0123 | 9.1234 | 10.2345 | 11.3456 | 12.4567 | 13.5678 |
| Category Item 53               |          | 1.4567 | 2.5678 | 3.6789 | 4.7890 | 5.8901 | 6.9012 | 7.0123 | 8.1234 | 9.2345 | 10.3456 | 11.4567 | 12.5678 | 13.6789 |
| Category Item 54               |          | 1.5678 | 2.6789 | 3.7890 | 4.8901 | 5.9012 | 6.0123 | 7.1234 | 8.2345 | 9.3456 | 10.4567 | 11.5678 | 12.6789 | 13.7890 |
| Category Item 55               |          | 1.6789 | 2.7890 | 3.8901 | 4.9012 | 5.0123 | 6.1234 | 7.2345 | 8.3456 | 9.4567 | 10.5678 | 11.6789 | 12.7890 | 13.8901 |
| Category Item 56               |          | 1.7890 | 2.8901 | 3.9012 | 4.0123 | 5.1234 | 6.2345 | 7.3456 | 8.4567 | 9.5678 | 10.6789 | 11.7890 | 12.8901 | 13.9012 |
| Category Item 57               |          | 1.8901 | 2.9012 | 3.0123 | 4.1234 | 5.2345 | 6.3456 | 7.4567 | 8.5678 | 9.6789 | 10.7890 | 11.8901 | 12.9012 | 13.0123 |
| Category Item 58               |          | 1.9012 | 2.0123 | 3.1234 | 4.2345 | 5.3456 | 6.4567 | 7.5678 | 8.6789 | 9.7890 | 10.8901 | 11.9012 | 12.0123 | 13.1234 |
| Category Item 59               |          | 1.0123 | 2.1234 | 3.2345 | 4.3456 | 5.4567 | 6.5678 | 7.6789 | 8.7890 | 9.8901 | 10.9012 | 11.0123 | 12.1234 | 13.2345 |
| Category Item 60               |          | 1.1234 | 2.2345 | 3.3456 | 4.4567 | 5.5678 | 6.6789 | 7.7890 | 8.8901 | 9.9012 | 10.0123 | 11.1234 | 12.2345 | 13.3456 |
| Category Item 61               |          | 1.2345 | 2.3456 | 3.4567 | 4.5678 | 5.6789 | 6.7890 | 7.8901 | 8.9012 | 9.0123 | 10.1234 | 11.2345 | 12.3456 | 13.4567 |
| Category Item 62               |          | 1.3456 | 2.4567 | 3.5678 | 4.6789 | 5.7890 | 6.8901 | 7.9012 | 8.0123 | 9.1234 | 10.2345 | 11.3456 | 12.4567 | 13.5678 |
| Category Item 63               |          | 1.4567 | 2.5678 | 3.6789 | 4.7890 | 5.8901 | 6.9012 | 7.0123 | 8.1234 | 9.2345 | 10.3456 | 11.4567 | 12.5678 | 13.6789 |
| Category Item 64               |          | 1.5678 | 2.6789 | 3.7890 | 4.8901 | 5.9012 | 6.0123 | 7.1234 | 8.2345 | 9.3456 | 10.4567 | 11.5678 | 12.6789 | 13.7890 |
| Category Item 65               |          | 1.6789 | 2.7890 | 3.8901 | 4.9012 | 5.0123 | 6.1234 | 7.2345 | 8.3456 | 9.4567 | 10.5678 | 11.6789 | 12.7890 | 13.8901 |
| Category Item 66               |          | 1.7890 | 2.8901 | 3.9012 | 4.0123 | 5.1234 | 6.2345 | 7.3456 | 8.4567 | 9.5678 | 10.6789 | 11.7890 | 12.8901 | 13.9012 |
| Category Item 67               |          | 1.8901 | 2.9012 | 3.0123 | 4.1234 | 5.2345 | 6.3456 | 7.4567 | 8.5678 | 9.6789 | 10.7890 | 11.8901 | 12.9012 | 13.0123 |
| Category Item 68               |          | 1.9012 | 2.0123 | 3.1234 | 4.2345 | 5.3456 | 6.4567 | 7.5678 | 8.6789 | 9.7890 | 10.8901 | 11.9012 | 12.0123 | 13.1234 |
| Category Item 69               |          | 1.0123 | 2.1234 | 3.2345 | 4.3456 | 5.4567 | 6.5678 | 7.6789 | 8.7890 | 9.8901 | 10.9012 | 11.0123 | 12.1234 | 13.2345 |
| Category Item 70               |          | 1.1234 | 2.2345 | 3.3456 | 4.4567 | 5.5678 | 6.6789 | 7.7890 | 8.8901 | 9.9012 | 10.0123 | 11.1234 | 12.2345 | 13.3456 |
| Category Item 71               |          | 1.2345 | 2.3456 | 3.4567 | 4.5678 | 5.6789 | 6.7890 | 7.8901 | 8.9012 | 9.0123 | 10.1234 | 11.2345 | 12.3456 | 13.4567 |
| Category Item 72               |          | 1.3456 | 2.4567 | 3.5678 | 4.6789 | 5.7890 | 6.8901 | 7.9012 | 8.0123 | 9.1234 | 10.2345 | 11.3456 | 12.4567 | 13.5678 |
| Category Item 73               |          | 1.4567 | 2.5678 | 3.6789 | 4.7890 | 5.8901 | 6.9012 | 7.0123 | 8.1234 | 9.2345 | 10.3456 | 11.4567 | 12.5678 | 13.6789 |
| Category Item 74               |          | 1.5678 | 2.6789 | 3.7890 | 4.8901 | 5.9012 | 6.0123 | 7.1234 | 8.2345 | 9.3456 | 10.4567 | 11.5678 | 12.6789 | 13.7890 |
| Category Item 75               |          | 1.6789 | 2.7890 | 3.8901 | 4.9012 | 5.0    |        |        |        |        |         |         |         |         |





TABLE A7.5: COMPARISON OF THE NET PRESENT VALUE AND BENEFIT COST RATIO FOR DRY BEANS PRODUCTION BETWEEN CONVENTIONAL PRODUCTION AND SBOR, IN THE STUDY AREA OVER A PERIOD OF 15 YEARS.

[illegible]

TABLE A7.6: COMPARISON OF THE NET PRESENT VALUE AND BENEFIT COST RATIO FOR DRY BEANS PRODUCTION BETWEEN CONVENTIONAL PRODUCTION AND S/BSR, IN THE STUDY AREA OVER A PERIOD OF 15 YEARS.

[illegible]

**APPENDIX A8: IRWH ECONOMIC SIMULATION MODEL**



## **GUIDELINES FOR THE USE OF THE IRWH ECONOMIC SIMULATION MODEL**

### **INTRODUCTION**

The purpose of these notes is to explain and show users how to run the IRWH economic simulation model. The model's main aim is to determine the minimum farm size required to provide a farming household, using the different IRWH techniques, with enough food/income to attain household food security.

To determine the required areas of land, two approaches of household food security are employed: the household caloric requirement and the income requirement. These approaches are used in conjunction with crop enterprise budgets for the different IRWH techniques.

### **GETTING STARTED**

The model is provided on a diskette<sup>1</sup>. It is on Microsoft Excel and thus can be operated from any computer with Microsoft office. To operate the model, insert the disk/floppy with the model into the relevant drive and open the file with the model (the model can also be saved with a different name on the user's computer). This file is named IRWH economic simulation model. The language to operate the model is English and the model can be operated by anyone with a basic knowledge of Microsoft Excel.

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<sup>1</sup> A diskette of the model is available from the Department of Agricultural Economics at the University of the Free State or the Water Research Commission.

## USING THE MODEL

The model is made up of several Excel spreadsheets that are linked to the front page of the model. The front page serves both as the input and output page. This page comprises of two parts, the **INPUT** section and the **OUTPUT** section.

In the **INPUT** section, the user must specify the required data and the model will perform the relevant calculations and the output will be displayed on the same page. The diagram below shows the front page of the simulation model, which is the first worksheet that the user will be directed to on opening the model. As stated earlier the worksheet is divided into two sections. The input section is in the top half of the worksheet and the output section is in the bottom half of the worksheet.

| Infeld Rainwater Harvesting Economic Model       |                                                                                                                                                 |         |         |                              |         |         |               |     |      |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|---------|---------|------------------------------|---------|---------|---------------|-----|------|
| INPUT                                            |                                                                                                                                                 |         |         |                              |         |         |               |     |      |
| Area of Land Available (ha)                      | 1.00                                                                                                                                            |         |         | Household (about population) |         |         |               |     |      |
|                                                  |                                                                                                                                                 |         |         | Children (below 15 years)    |         |         |               |     |      |
|                                                  |                                                                                                                                                 |         |         | Adults (above 15 years)      |         |         |               |     |      |
| Crops                                            | Maize Sunflower Beans                                                                                                                           |         |         |                              |         |         |               |     |      |
| Proportion of Land Cropped (%)                   | 0.40 0.30 0.30                                                                                                                                  |         |         |                              |         |         |               |     |      |
| 110.0                                            |                                                                                                                                                 |         |         |                              |         |         |               |     |      |
| Input Prices                                     |                                                                                                                                                 |         |         |                              |         |         |               |     |      |
| Seeds                                            | Current Prices                                                                                                                                  |         |         | 1999/2000 Prices             |         |         | Output Prices |     |      |
| Maize                                            | 11.40                                                                                                                                           | PKg     |         | 11.40                        | PKg     |         | 870.00        | PKg | None |
| Sunflower                                        | 23.37                                                                                                                                           | PKg     |         | 23.37                        | PKg     |         | 1640.00       | PKg | None |
| Dry Beans                                        | 11.70                                                                                                                                           | PKg     |         | 11.70                        | PKg     |         | 2600.00       | PKg | None |
| Chemicals                                        |                                                                                                                                                 |         |         |                              |         |         |               |     |      |
| Building                                         | 207.80                                                                                                                                          | RL      |         | 207.80                       | RL      |         |               |     |      |
| Turkey                                           | 19.00                                                                                                                                           | RL      |         | 19.00                        | RL      |         |               |     |      |
| Mineralvit                                       | 87.00                                                                                                                                           | RL      |         | 87.00                        | RL      |         |               |     |      |
| Ammonium Nitrate                                 | 1.00                                                                                                                                            | PKg     |         | 1.00                         | PKg     |         |               |     |      |
| Superphosphate                                   | 1.70                                                                                                                                            | PKg     |         | 1.70                         | PKg     |         |               |     |      |
| Labour                                           | 10.00                                                                                                                                           | PKg     |         | 10.00                        | PKg     |         |               |     |      |
| OUTPUT                                           |                                                                                                                                                 |         |         |                              |         |         |               |     |      |
| Gross Margin per crop:                           | COG                                                                                                                                             | Sub     | Out     | COG                          | Sub     | Sub     | COG           | Sub | COG  |
| Maize                                            | 196.43                                                                                                                                          |         | 178.26  | 540.34                       | 831.57  | 868.79  |               |     |      |
| Sunflower                                        | 9.39                                                                                                                                            |         | 228.72  | 264.29                       | 265.54  | 265.53  |               |     |      |
| Beans                                            | 260.74                                                                                                                                          |         | 378.37  | 486.93                       | 474.95  | 548.96  |               |     |      |
| Total Gross Margin                               | 398.52                                                                                                                                          | 1114.77 | 1185.35 | 1585.56                      | 1601.50 | 1712.38 | 1798.82       |     |      |
| Crop enterprise Budgets (per hectare)            | Maize (COG) Maize (Sub) Maize (Out) Maize (COG) Maize (Sub) Maize (Out) Maize (COG) Maize (Sub) Maize (Out)                                     |         |         |                              |         |         |               |     |      |
|                                                  | Sunflower (COG) Sunflower (Sub) Sunflower (Out) Sunflower (COG) Sunflower (Sub) Sunflower (Out) Sunflower (COG) Sunflower (Sub) Sunflower (Out) |         |         |                              |         |         |               |     |      |
|                                                  | Beans (COG) Beans (Sub) Beans (Out) Beans (COG) Beans (Sub) Beans (Out) Beans (COG) Beans (Sub) Beans (Out)                                     |         |         |                              |         |         |               |     |      |
| Minimum Farm Size based Income (ha)              | 14.49                                                                                                                                           | 5.18    | 4.87    | 3.84                         | 3.91    | 3.37    | 3.37          |     |      |
| Minimum Farm Size based Caloric Requirement (ha) | 5.46                                                                                                                                            | 3.80    | 3.84    | 3.12                         | 3.86    | 1.97    | 1.87          |     |      |

## INPUT DATA REQUIREMENTS

The input data must be specified in the INPUT section of the worksheet. To facilitate easier use of the model, different colours have been used to indicate different components of the model. The data that must be specified has to be inputted into the dark gray coloured cells. There is also a further distinction based on colour in the cells. While in this guideline all the numbers appear black, they have different colours in the actual model. For the inputs section, all numbers that are blue in colour are changeable, this means they need to be specified.

Below is a description of the input data that must be specified by the user.

### **1. Land available**

This is the amount of land (in hectares) that the farmer has available or plans to grow crops on using the IRWH techniques. There is no limit on the amount of land that can be brought under cultivation. However, it should be noted that the model coefficients are based on trials that were done on small areas of about a hectare or even less.

### **2. Proportion of land cropped**

After the land available has been specified, the crops that can be produced are given in the crop row and these are maize, sunflower and drybeans. The user needs to specify how much of the available land will be put under each crop. This is the proportion of the land area that will be used for each crop. The proportions should be given as a fraction of 1 and thus should add up to 1. If the proportions do not satisfy this criterion a statement to this effect will be given below the maize proportion. The statement will either be TRUE or FALSE, if it is FALSE it means the proportions do not add up to one. Failure to meet this condition may lead to an erroneous model output.

### **3. Household labour availability**

This is the household's labour supply, with a distinction being drawn between adults and children. In the model, children are classified as those members of the household who are below sixteen years old while ages sixteen and above make the adult members of the household.

#### **4. Seed prices**

The prices for maize, sunflower and dry beans seed must be specified in Rands per kilogram (R/kg). Prices are current market prices for these inputs and they can be obtained from the nearest input supplier. If the prices cannot be obtained, the base year prices (1999/2000) are given and can be copied into the cells for the prices of the different crops.

#### **5. Costs of chemicals**

These are prices of the chemicals that are used in the production of the specified crops using the IRWH techniques. The chemicals can be broadly divided into the herbicides/pesticides and the fertilizers. The herbicides/pesticides used are Bulldog, Turbo and Metasystox and their prices should be given in Rands per liter (R/l) while the fertilizers are Ammonium nitrate and Superphosphate and the prices should be specified in Rands per kilogram (R/kg).

#### **6. Labour cost**

This is the cost of farm labour per day and should be specified in Rands per day (R/day). It should be noted that a day refers to man-day which is taken to be eight hours. An estimate for this value can be approximated by the daily wage of unskilled labour.

### **MODEL OUTPUT**

The results from the model are shown in the OUTPUT section of the front page and are displayed in the bottom half of the worksheet/page. Apart from the minimum area of land required to meet food security needs of an average household, there are some other intermediate results that are computed by the model. The results are given for each IRWH technique and the conventional production. This allows for a comparison of the techniques.

The output section, like the input section also employs different colours to aid easy use of the model. The different output sections and results are discussed below.

### 1. The production techniques

The first row of the OUTPUT section displays results of the different production techniques. These are highlighted in yellow and the entries are in black. These cannot be changed and the results for each technique are reported in the same column under that particular technique. There are six IRWH techniques and the conventional technique, thus giving a total of seven techniques in all. The acronyms used for the seven production techniques are defined below

|             |                                                                 |
|-------------|-----------------------------------------------------------------|
| <b>CON</b>  | Conventional                                                    |
| <b>BbBr</b> | Bare basins and bare runoff strip                               |
| <b>ObBr</b> | Organic mulch in the basins and bare runoff strip               |
| <b>ObOr</b> | Organic mulch in the basins and in the runoff strip             |
| <b>SbOr</b> | Stone mulch in the basins and organic mulch in the runoff strip |
| <b>ObSr</b> | Organic mulch in the basins and stone mulch in the runoff strip |
| <b>SbSr</b> | Stone mulch in the basins and in the runoff strip               |

### 2. Gross margin per crop

This is the actual gross margin that will be achieved by a given proportion of land area allocated to each crop under each production technique. The gross margin is the difference between total revenue and the total allocatable variable costs of production. The values are calculated by the model simultaneously and cannot be changed unless changes are also made to the accompanying/associated enterprise budgets (see enterprise budgets below).

### 3. Total gross margin

This is a summation of the individual gross margins of the three crops or the farm gross margin. The value is the sum of the actual gross margins and is calculated per hectare. The row showing the total gross margin is highlighted in purple while the totals are yellow in colour. The total gross margin allows the user to compare the techniques to determine which has the highest returns.

#### **4. Crop enterprise budgets**

The model uses enterprise budgets to compute most of the model outputs. As the user specifies the inputs in the INPUT section, the relevant changes are automatically effected in the enterprise budgets. The specific enterprise budget (per hectare) can be viewed by clicking on the required budget. For example if the user needs to see the budget for maize under conventional production, one needs to click on the 'maize (CON)' link. The specific budget then will be brought onto the screen and the user can alter the budget. This means that the user can change the budget(s) and the changes will be worked through to the front page. It is important that all the major changes that might be made be saved using the normal save function. To go back to the front page one needs to click on the 'front page' link, which appears at the top of the enterprise budgets. The enterprise budgets are for each of the three crops and the specific production technique employed in producing the crop.

#### **5. Minimum farm size**

The last part of the OUTPUT section of the model reports the required minimum farm sizes that an average household will need to cultivate to produce adequate food or income to satisfy its requirements. The model also assumes that some portion of household income will come from other sources outside crop farming.

The minimum farm size is determined using both the income and caloric requirement approaches. This distinction is also made in the front page, with results of the two approaches being presented separately. The first row shows the minimum farm size based on the income approach and the second row shows the farm size based on the caloric requirement. The required minimum farm sizes are calculated for each of the seven production techniques.

## Other related WRC reports available:

**Water conservation techniques on small plots in semi-arid areas to enhance rainfall use efficiency, food security, and sustainable crop production.**

*JJ Botha; LD van Rensburg; JJ Anderson; M Hensley; MS Macheli; PP van Staden; G Kundhlande; DG Groenewald; MN Baiphethi*

The project had three main objectives: (a) to study quantitatively within the in-field rain water harvesting (IRWH) system, different combinations of mulching techniques aimed primarily at reducing evaporation from the soil surface, soil fertility aspects with the focus on nitrogen, and the sustainability of the system; (b) to develop the capacity of previously disadvantaged technical assistants; and (c) to transfer the technology to the developing farmers and to the Department of Agriculture. The first and second objectives were achieved concurrently by means of field experiments at Glen and on farmers' fields near Thaba Nchu, the technical assistants gaining invaluable skills and experience by being intensively involved in all the relevant activities. The crops grown were maize, sunflower and beans. The third objective was achieved by means of the demonstration plots on farmers' fields, and by numerous information days, lectures and demonstrations in the villages, all held in close cooperation with officials of the Department of Agriculture.

Four different IRWH systems and conventional (COM) tillage were compared in field experiments at Glen and on farmers' fields near Thaba Nchu. The four IRWH treatments were: organic mulch in the basins with a bare runoff area (*ObBr*); organic mulch in the basins with organic mulch on the runoff area (*ObOr*); organic mulch in the basins with stones on the runoff area (*ObSr*); stones in the basins with organic mulch on the runoff area (*SbOr*). An empirical stress model termed "Crop Yield Prediction for Semi-Arid Areas" (CYP-SA) was developed to enable long-term yield predictions to be made. The composition of the model for each crop is described in detail, together with validation results. Measured yields over three seasons in the field experiments, and predicted long-term yields using the model, showed the following: For all the crops on all the ecotopes the *ObSr* treatment was the best IRWH treatment, but generally only statistically significantly better than *ObBr*. These results are strongly supported and eloquently described by the long-term, yield cumulative probability functions (CPFs) obtained with CYP-SA.

Measurements on the experimental plots showed that water losses by deep drainage were negligible during the three growing seasons. Since runoff losses were also zero on all the IRWH plots, the only cause of water loss was evaporation from the soil surface (*Es*). It is clear that in order to further improve precipitation use efficiency (PUE) above the current best values of 7.4 and 4.8 kg ha<sup>-1</sup> mm<sup>-1</sup> for maize and sunflower respectively, it will be necessary to find ways of suppressing *Es* still further. Taking all the above mentioned results into consideration it can be concluded that IRWH will enhance PUE, promote food security and ensure sustainability. The *ObSr* treatment was overall the best treatment, followed by *SbSr*, *ObOr*, *SbOr*, *ObBr* and a bare basin with a bare runoff area (*BbBr*).

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