Socio-economic factors determining in-field rainwater harvesting technology adoption for cropland productivity in Lambani village: A case study of Thulamela Local Municipality of the Vhembe District in Limpopo province

by

Khumo Terezan Badisa

MINI-DISSERTATION

Submitted in (partial) fulfilment of the requirements for the Degree of

Master of Science in Agriculture (Agricultural Economics)

in

Department of Agricultural Economics and Animal Production

in the

FACULTY OF SCIENCE AND AGRICULTURE

(School of Agricultural and Environmental Sciences)

at the

UNIVERSITY OF LIMPOPO

Supervisor: Mrs. P Chaminuka

Co-supervisor: Prof. A Belete

2011

DECLARATION

I declare that the mini-dissertation hereby submitted to the University of Limpopo, for the degree of Master of Science in Agriculture (Agricultural Economics) has not previously been submitted by me for the degree at this or any other university; that it is my own work in design and in execution, and that all material contained herein has been duly acknowledged.

____________________ ____________________

Surname, Initials (title) **Date**

Student number: _______________________

ACKNOWLEDGEMENTS

I wish to express my sincere appreciation and gratitude to my supervisor Mrs. Petronella Chaminuka and co-supervisor Prof Abenet Belete, thank you for your positive guidance, support, patience, motivation and availability throughout the study period; without your useful inputs this end- product would not have seen the light of day. May God bless you.

I acknowledge, with gratitude my sponsor (Department of Agriculture, Forestry and Fisheries, Pretoria) for their financial assistance throughout my studies. Thank you, may God bless you all in the Directorate of Education, Training and Extension Services especially, Ms Miriam, Ms Dora and Mr Mathebula. I extend my appreciation to fellow colleagues and staff members in the Department of Agricultural Economics at the University of Limpopo. I would also like to express my gratitude to Lesetja Ledwaba and Rebecca Baloyi for providing assistance during my research period.

I am most grateful to my family and a special thank you goes to my mother (Mantlo Priscilla Badisa) for her support, patience, trust and belief in me all these years. Also I devote my appreciation to my sister (maDaph), my brothers (Lele, Rony and Percy) as well as Malebo's family for their support and trust. I love you all. I acknowledge my fiancé, Klaas Tjale for his unconditional love, support, trust, patience and the encouragement that he gave me throughout my study, I love you. To my son Oratile Calvin Badisa, I love you, may God continue to bless you.

I wish to devote my appreciation to Michael and Frank for providing assistance with data collection and commitment in writing this dissertation. To many survey respondents in Lambani village, for taking time to complete a comprehensive and detailed questionnaire, I express my thanks. To the mighty God, I am most thankful.

DEDICATION

To my late brother (Patrick Seabelo Badisa) I will always love you, and to my lovely mother (Mantlo Priscilla Badisa)

ABSTRACT

In-field rainwater harvesting technology is the technique that combines the advantages of water harvesting, no till, basin tillage and mulching on high drought risk clay soils. It reduces total runoff to zero, and also considerably reduce surface evaporation. The scarcity of agricultural water is increasing at a faster rate than for other sectors in Limpopo Province. Sufficient, clean drinking water is essential to life, but millions of people throughout the world including South Africa continue to have no access to this basic necessity.

This study aimed at investigating the extent and nature of adoption of in-field rainwater harvesting technology by households in Lambani village of Limpopo Province. The main objectives of this study were to identify factors determining the in-field rainwater adoption technology for cropland productivity in Lambani village and to determine the extent to which in-field rainwater harvesting adoption influences cropland productivity in Lambani village. Simple random sampling technique was used to select 70 farmers in Lambani village of Limpopo Province. Data was collected using a structured questionnaire.

Descriptive statistics, logistic regression model and linear regression model were used to analyse the data. Descriptive statistics was used to describe the characteristics of households and the nature of Lambani village, and logistic regression model was used to investigate factors that determine the adoption of in-field rainwater harvesting technology, while linear regression model was used to determine the extent to which in-field rainwater harvesting influence the cropland productivity in Lambani village.

The results from the logistic regression model indicate that 5 variables out of 10 variables are significant in explaining farmers' adoption decision. Land size, access to financial service, access to information and contact with extension officer are some of the variables that have significantly positive effects on the adoption of in-field rainwater harvesting technology, while hired labour has significantly negative correlation with adoption. Variables such as household size, level of education, age of the household, level of income and the main water source do not significantly influence adoption of in-field rainwater harvesting. This information will help prioritize

efforts by extension workers and rural practitioners and provide insight on pathways to increase the adoption of in-field rainwater harvesting techniques.

The results from linear regression model indicate that six (6) variables out of nine (9) variables are significant in explaining the influence of in-field rainwater harvesting on cropland productivity. Application of fertilizer, application of pesticides, hired labour; adopters of in-field rainwater harvesting techniques, level of income and access to information are variables that were significant whereas variables such as age, level of education and land size do not significantly influence cropland productivity in Lambani village.

The results suggest the need for greater political and institutional input into in-field rainwater harvesting technologies projects. In particular, there is a need to design and develop alternative policy instruments and institutions for extension, technical assistance, training, credit services that will facilitate adoption of the farmer-participatory practices to better fit the needs of farmers in Lambani village. This suggestion also applies to the overall in-field rainwater harvesting projects in arid and semi-arid areas of South Africa.

TABLE OF CONTENTS **PAGE**

DECLARATION	ii
ACKNOWLEDGEMENTS	iii
DEDICATION	iv
ABSTRACT	v
CONTENTS	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
ACRONYMS	xii
1 INTRODUCTION	
1.1 Background of the study	1
1.2 Problem statement	3
1.3 Motivation of the study	4
1.4 Aim and objectives	5
1.5 Hypotheses	5
1.6 Organization of the study	5
2 LITERATURE REVIEW	
2.1 Introduction	6
2.2 Description of rainwater harvesting technology	6
2.3 Water as a scarce resource	7
2.4 Implementation of RWHT in South Africa	9
2.5 Factors affecting farmer’s adoption decision	10

2.6 Adoption of rainwater harvesting 13

2.7 Benefits of rainwater harvesting 14

2.8 Requirements for rainwater harvesting 15

2.9 Review from previous studies 17

3 METHODOLOGY

3.1 Introduction 19

3.2 Study area 19

3.3 Method used in data collection and sampling 20

3.3.1 Questionnaire design 21

3.4 Method used in data analysis 21

3.4.1 Logistic regression model 22

3.4.1.1 Choices of variables 23

3.4.1.2 Definition of variables in Logit model 26

3.4.2 Linear regression model 27

3.4.2.1 Definition of variables in Linear regression 30

3.5 Ethical consideration 31

3.6 Limitation of the study 31

4 RESULTS

4.1 Introduction 32

4.2 Demographic factors 32

4.3 Agricultural Production Factors 34

4.4 Logistic regression model to determine factors influencing household adoption of in-field rainwater harvesting techniques 39

4.5 Linear regression model to analyse determinants of cropland Productivity 43

5 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Summary 47

5.2 Conclusion 48

5.3 Recommandations 49

REFERENCES 52

APPENDIX: Questionnaire 65

LIST OF TABLES

Table 3.1: Definition of variables included in the Logistic model 26

Table 3.2: Present variables with their definitions and expected relationship with AMHAR 30

Table 4.1: Descriptive statistics for Age and household size 33

Table 4.2: Descriptive statistics for land size 35

Table 4.3: Logistic regression results 40

Table 4.4: Linear regression results 44

LIST OF FIGURES

Figure 1.1: In-field rainwater harvesting technique 3

Figure 3.1: Location of the study area 19

Figure 4.1: Education level of the household head 33

Figure 4.2: Level of income per month of the household head 34

Figure 4.3: Main water source 35

Figure 4.4: Access to information on in-field rainwater harvesting 36

Figure 4.5: Financial services 36

Figure 4.6: Contact with extension officer 37

Figure 4.7: Hired labour for farming 38

Figure 4.8: Application of fertilizers 38

Figure 4.9: Application of pesticides 39

ACRONYMS

ARC-ISCW	: Agricultural Research Councils Institute of Soil, Climate and Water
CGIAR	: Consultative Group on International Agricultural Research
CIMMYT	: The International Maize and Wheat Improvement Center (Centro Internacional de Mejoramiento de Maiz y Trigo)
DWA	: Department of Water Affairs
FAO	: Food and Agricultural Organization
IRWHT	: In-field Rainwater Harvesting Technique
RWHT	: Rainwater Harvesting Technology
SPSS	: Statistical Package for Social Sciences
TWDB	: Taxes Water Development Board
UNDP	: United Nations Development Programme
WMAs	: Water Management Areas
WRC	: Water Research Commission

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Rainwater harvesting, in a broad sense, is the collection of the raindrops or runoff water which will otherwise cause soil erosion for domestic consumption and or food production purposes. It could also be described as an act of maximizing utilization of the available rainfall by making use of different techniques (Ephraim, 2001).

In-field rainwater harvesting technology (IRHWT) is the technique that combines the advantages of water harvesting, no till, basin tillage and mulching on high drought risk clay soils. It reduces total runoff to zero and also considerably reduces surface evaporation. (Hensley *et al*., 2000). In IRWHT the term ‘in- field’ refers to the transportation of water over a short distance of 2 m and delivering it to the 1 m wide basin (figure 1.1). This system is regarded as a special form of water harvesting categorized as mini-catchment runoff farming (Oweis *et al.,* 1999).

South Africa is a water-stressed country with an average annual rainfall of 500 mm (60% of the world average). Only a narrow region along the south – eastern coastline receives good rainfall, while the greater part of the interior and western part of the country is arid or semi arid, 65% of the country receives less than 500mm per year, which is usually regarded as the minimum for dry land farming, and 21% receives less than 200mm per year (DWA 1994). In addition, South Africa’s growing water demand is rapidly outstripping its natural availability. In 2004, 11 of the 19 Water Management Areas (WMAs) in the country were facing water deficits (Otieno and Ochieng, 2005). In the Northern Cape for example, many local municipalities resorted to providing water by road tanker to communities whose groundwater supplies had been reduced due to drought conditions.

Access to enough water of sufficient quality is fundamental for all human, animal, and plant life as well as for most economic activity. Water has been an indispensable input for improving agricultural productivity. Throughout history, farmers and nations have depended on irrigation to produce sufficient, stable food supplies. Water shortage for agriculture is increasingly recognized as a major constraint to improving the lives of the rural poor, and is an important component of rural livelihood programs being established in Southern Africa (Vink and Kirsten, 2003).

Limpopo river basin has a catchment area of about 413 000 km^2, with an average annual rainfall of 530 mm ranging from 200 to 1200 mm. The basin has a land use where cropping occupies 234,000 ha, pasture occupies 1,780,000 ha and forestry occupies 455,000 ha. Other main issues in the Limpopo river basin are that it experiences a short and intense rain season, with highly unreliable rainfall that leads to frequent droughts. Crop production is not secure. On many reaches of the Limpopo river basin and many of its tributaries, the flow of water in the river in dry years can occur for 40 days or less. When the rivers do flow, river water can contain up to 30% sand and silt. Large areas of land are seriously degraded (CGIAR, 2003).

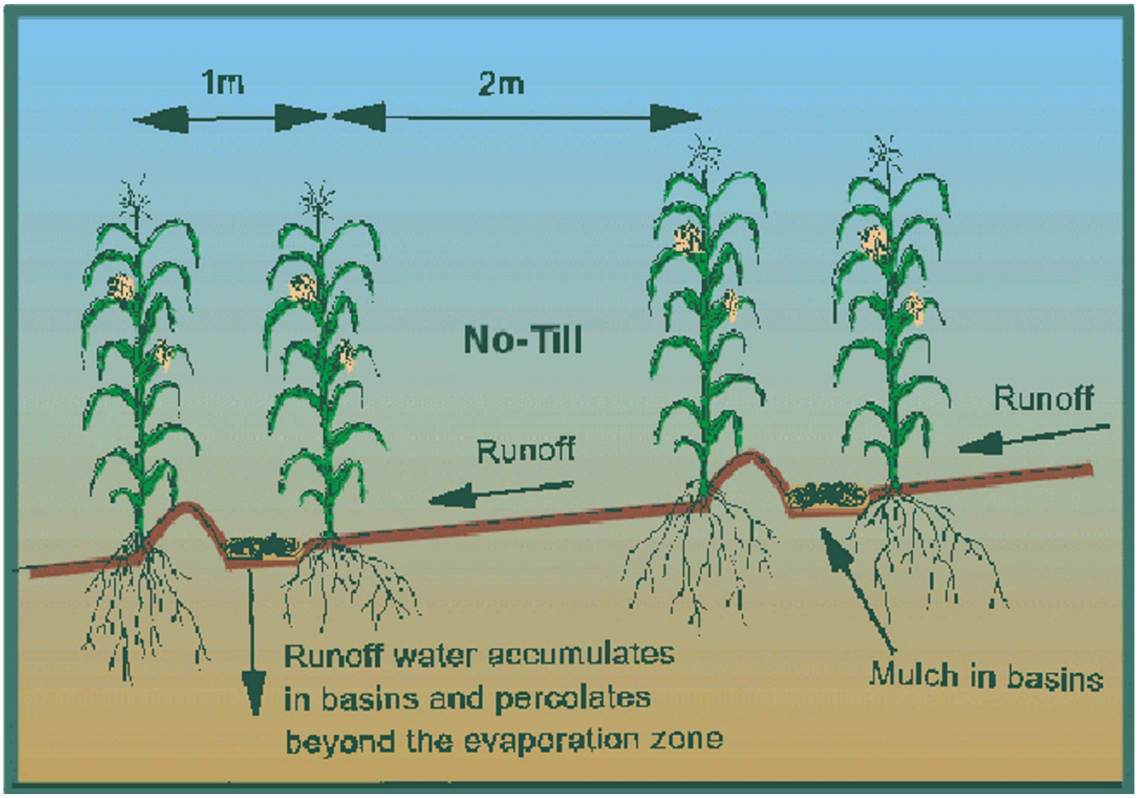

Fig.1.1: In-field rainwater harvesting technique (Botha *et al.,* 2007)

1.2 PROBLEM STATEMENT

The scarcity of agricultural water is increasing at a faster rate than for other sectors in Limpopo Province. Sufficient, clean drinking water is essential to life, but millions of people throughout the world including South Africa continue to have no access to this basic necessity. After decades of work by governments and organizations to bring potable water to the poorer people of the Limpopo Province the situation is still dire. More efficient utilisation of available water resources has the potential to contribute towards alleviation of water scarcity, especially in rural areas where the majority of people depend on rain-fed agriculture for their livelihood. Rainwater harvesting technology can contribute towards more efficient use of water resources in rural areas (Oweis, 1999; TWDB, 2006). The Agricultural Research Council and the Limpopo Department of Agriculture have for some time been implementing projects to encourage the use of in-field rainwater harvesting technology by rural households. However, there is limited knowledge on the factors that influence the adoption of in-field rainwater harvesting technology by households in the project areas such as Lambani village of Limpopo Province.

1.3 MOTIVATION OF THE STUDY

The study will provide a baseline for comprehensive implementation of in-field rainwater harvesting techniques at national level. It is necessary to understand the factors that influence the adoption of such a technology so that future intervention programmes and policy responses can be crafted to encourage farmers to adopt the technology. Any efforts to promote this technology by government or any other player, needs to be directed by the results of such studies.

Therefore, rainwater harvesting technology is convenient in the sense that it provides water at the point of consumption and family members have full control of their own systems, which greatly reduces operation and maintenance problems. Rainwater harvesting technologies are simple to install and operate. Local people can be easily trained to implement such technologies, where construction materials are readily available. Running costs are almost negligible. Rainwater harvesting can be a continuous source of water supply for both rural and poor people depending upon household capacity and needs; both the collection and storage capacity may be increased as needed within the available catchment area.

1.4 Aim and Objectives

The aim of the study is to investigate the extent and nature of adoption of in-field rainwater harvesting technology by household in Lambani village of Limpopo Province.

1.4.1 The objectives of the study will be as follows:

i. To determine the socio-economic factors influencing the adoption of in-field rainwater harvesting technology for cropland productivity in Lambani village of Limpopo Province.

ii. To determine the extent to which adoption of in-field rainwater harvesting technology influences cropland productivity.

1.5 Hypotheses

i. There are no socio-economic factors affecting the adoption of in-field rainwater harvesting technology in Lambani village of Limpopo Province.

ii. Adoption of in-field rainwater harvesting will not significantly impact on cropland productivity.

1.6 Organization of the study

The study is presented in five (5) chapters. Chapter 2 presents a literature review on factors affecting the adoption of in-field rainwater harvesting technology. Chapter 3 contains a discussion of the methods of analysis employed in the study. Chapter 4 presents the main descriptive statistics of key variables in the data, and the results of the regression analyses. Finally, Chapter 5 summarizes the study results and discusses the major conclusions. The policy implications are also discussed in this chapter.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides a brief description on rainwater harvesting technology, water as a scarce resource and requirements for IRWHT. The chapter also reviews the literature on factors affecting general technology adoption, adoption of in-field rainwater harvesting techniques, successful implementation of IRWHT in South Africa and benefits of rainwater harvesting technology.

2.2 Description of rainwater harvesting technology

Rainwater harvesting is a technology used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams. Traditionally, rainwater harvesting has been practised in arid and semi-arid areas, and has provided drinking water, domestic water, water for livestock, water for small irrigation and a way to replenish ground water levels. The techniques usually found in Asia and Africa arise from practices employed by ancient civilizations within these regions and still serve as a major source of drinking water supply in rural areas. Commonly used systems are constructed of three principal components, namely, the catchment area, the collection device, and the conveyance system (Gould, 1992). The quality of the harvested and stored rainwater depends on the characteristics of the considered area, such as the topography, the weather conditions, the proximity to pollution sources, the type of the catchments area, the type of water tank and the handling and management of the water (Sazakli *et al.,* 2007; Zhu *et al*., 2004).

2.3 Water as a scarce resource

Water scarcity affects rain-fed crop production and directly threatens the livelihood of millions of people, particularly in developing countries, and especially in Sub-Saharan Africa (Owei and Hachum, 2006). Agriculture is generally the largest user of rainwater. In South Africa, for example, about 70 % of the rainfall is used to produce food, natural fibres and forestry products, involving large numbers of people in a productive way. Where water is scarce, the need for developing rainwater management skills to improve water-use efficiency is increased. Population growth necessitates an increase in food supplies, requiring the use of marginal land for food production. Water harvesting can address this problem by increasing the water available to crops under rain fed conditions, thereby increasing yields. Many water conservation projects have failed, despite good techniques and design, because of the failure to investigate their social and economic aspects (Info, 2006).

Water plays a major role in laying the foundation for economic growth, not only by increasing the assurance of supply, but also by improving water quality and therefore human health (Phillips *et al.,* 2006). South Africa is a water scarce country and the demand for this resource is growing as the economy expands and the population increases. The irrigated agriculture sector, which currently accounts for two thirds of the water use, is increasingly required to produce more food from a limited land area using less water. Water resources are increasingly being exhausted, and competition for the available water between the municipalities and industries is increasing each year (Cornish, 1998).

South Africa is one of the signatories to the Millennium Development Goals. With its mix of both developed and developing regions, 3.7 million people have no access to any form of water supply infrastructure and an additional 5.4 million people who have some access have to be brought up to a basic level of service (Info, 2006). The South African water economy exhibits extreme competition between users, inelastic supply of water, high and increasing demand for water, and increasing social costs (Backeberg, 1994).

Demand on water supplies continues to mount owing to population and economic growth, industrialisation and urbanisation, and the need to address inequity in water allocation and environmental demands. Water scarcity in South Africa has historically been resolved with the exploitation of new sources through water management institutions concerned primarily with the construction of storage and conveyance facilities (Walmsley, 1995). However, since many water sources have been fully appropriated given current technologies, and the remaining water sources are becoming prohibitively expensive to exploit, these supply side responses to water scarcity are becoming increasingly inadequate (Conley, 1993 and Backeberg, 1994). The reassessment of the current water law to yield a new water act is a reflection of the need for new water management institutions and allocation systems better suited to future needs of the country.

Many developing countries located in arid or semi-arid regions experience significant problems in securing adequate amounts of water for rain fed crop production. Water scarcity problems in arid regions result simply from the lack of sufficient rainfall. Semi-arid regions, however, may receive enough annual rainfall to support crops but it is distributed so unevenly in time or space that rain fed agriculture is not viable (Reij *et al*., 1988).

In the dry areas, water, not land, is the most limiting resource for improved agricultural production. Maximizing water productivity, and not yield per unit of land, is therefore a better strategy for dry farming systems. Under such conditions, more efficient water management techniques must be adopted. Supplemental irrigation (SI) is a highly efficient practice with great potential for increasing agricultural production and improving livelihoods in the dry rain-fed areas. In the drier environments, most of the rainwater is lost by evaporation; therefore the rainwater productivity is extremely low. Water harvesting can improve agriculture by directing and concentrating rainwater through runoff to the plants and other beneficial uses. It was found that over 50% of lost water can be recovered at a very little cost. However, socioeconomic and environmental benefits of this practice are far more important than increasing agricultural water productivity (Oweis and Hachum, 2006).

2.4 Implementation of IRWHT in South Africa

The Agricultural Research Council's Institute of Soil, Climate and Water (ARC-ISCW), in a project funded by the WRC, developed an in-field rainwater harvesting technique which combines the advantages of water harvesting, no-till, basin tillage and mulching on high drought-risk clay soils. The practice reduces total runoff to zero and evaporation from the soil surface considerably, thus increasing crop production in the semi-arid areas with low potential clay soils.

In a decade the Institute for Soil, Climate and Water of the Agricultural Research Council (ARC-ISCW) of South Africa has been developing an in-field rainwater harvesting technique (IRWH) for communal farmers with the objective of harnessing rainwater for crop production. It has been shown that the technique resulted in a significant increase in crop yield compared to conventional practices (Hensley *et al*., 2000).

Further research conducted mainly in the Free State has shown that, on average, in-field rainwater harvesting technology increased crop yields by about a third when compared to the use of conventional tillage techniques. Long-term in-field rainwater harvesting production can be improved even more by adding various combinations of mulches on the runoff and basin areas of the field (Botha *et al* 2003).

Another WRC-funded project looking at the sustainability of rainwater harvesting to ensure food security revealed that in-field rainwater harvesting technology is, in fact, sustainable and contributes to food security. Profitability analyses using enterprise budgets show that farmers who adopt even the simplest form of in-field rainwater harvesting compared to conventional crop cultivation could increase their income by about R800 per hectare in the case of maize production (WRC, 2000).

Studies have shown that, although shortage of rainfall is an important factor, the most critical problem in semi-arid areas is often the inter- and intra-seasonal variability (Barron *et al.*, 2003). Thus, poor smallholder producers of crops and livestock in the semi-arid areas of Africa, face frequent food shortages and threats to their livelihood resulting from droughts or floods. The catastrophic consequences of inter-seasonal variation have recently (1999–2004) been experienced in Sub-Saharan Africa, where many parts of the region have gone from serious floods to serious drought and back to floods. A case study in Tanzania has shown that historically, floods have caused about 38% of all declared disasters, while droughts caused 33% (Hatibu and Mahoo, 2000). Often the floods and droughts occurred in the same semi-arid area, and in the same season. Often only a small fraction of the rainwater reaches and remains in the soil long enough to be useful. Up to 80% of the rainfall falling on rain-fed farms in semi-arid areas can be "lost" as evaporation before it is used by the plants, or as runoff that causes erosion and flooding downstream. Therefore, the detrimental consequences of both floods and droughts can be exacerbated by poor management of valuable rainwater.

The practice is currently spreading in rural South Africa, especially with the financial assistance provided by the Department of Water Affairs (DWA) to resource poor households for the capital cost of rainwater storage tanks and related works. IRWHT has been shown to increase farmers' income and reduce risk significantly. It has been proven that the technique will be suitable for application in semi-arid areas of South Africa (Baiphethi *et al.,* 2004 and Kundhlande *et al.*, 2004) and contribute to household food security and poverty alleviation.

2.5 Factors affecting farmers' technology adoption decision

Technology adoption is simply defined as act by which a person begins using a new practice to replace an old one. Adoption is taken to be the final outcome of exposure to some practice or innovation, and a variety of sources are used to communicate the message (Brien *et al*., 1965). There are several definitions and methods for evaluating adoption (Featherstone *et al.,*1997; CIMMYT, 1993). According to CIMMYT (1993), the adoption of new techniques can be defined in several ways depending on whether one applies the total application of the technological package or the number of years of application. Featherstone *et al* (1997), define adoption as the extent to which a new technology is utilized, balanced with other activities, over a long period of time and supposing that the farmer has full information on the technology and it's potential. This definition brings out the fundamental characteristics of adoption such as intensity, time spent in application and the rational choice of the farmer.

Quite often, farmers will try a technology when it is first introduced, i.e. in the project phase, only to drop out when it is time for them to stand alone without the donor or government support. Such farmers frequently make a rational economic decision after weighing the costs and benefits accruing from the continued involvement with the technology. It is important to realise that the adoption of innovations in general is not a once-off decision as many studies have assumed. Rather, it is a stepwise decision made after carefully weighing opportunity costs at each point (Goetz, 1992; Byerlee and Hesse de Polanco, 1986). Understandably, smallholder farmers always want to avoid unnecessary risks and will, therefore, abandon a technology once their perceived benefits diminish significantly or do not seem to offset the costs involved.

Many technology adoption studies have been carried out in developing countries (Feder *et al* 1985; Hassan *et al* 1998; Alene *et al* 2000). However the importance of factors affecting technology differs across countries and regions due to differences in natural resources, cultural and political ideologies and socio-economic factors.

According to Chianu and Tsujii (2004) a systematic increase in the level of education of the farmers can increase the probability of technology adoption. Mugwe *et al*. (2008) postulated that the factors that significantly influenced adoption positively were farm management, ability to hire labour and months in a year households bought food for their families, while age of household head and number of mature cattle negatively influenced adoption. Two of the most important variables that were found to influence adoption, i.e. farm management and ability to hire labour are linked to labour availability and household wealth. For instance, good farm management implies efficient resource use, increase in productivity and increase in wealth which is critical for sustainable technology adoption and retention. This is critical since in other past studies farmers mentioned that labour was one of the major problems they faced in the implementation of new technologies.

Adesina and Chianu (2002) found that farmers' characteristics that influence the adoption include the gender of the farmer, contact with extension agents, years of experience with agroforestry and tenancy status in the village. Economic factors, proxied by village level characteristics that condition resource use incentives, were also significant. These variables include the extent of village land pressure, extent of erosion intensity, village fuel wood pressure, importance of livestock as an economic activity in the village and the distance of the village locations from urban centres.

According to Feder *et al* (1985), farm size is one of the first factors on which empirical studies focus. They indicate that farm size can have different effects on the probability of adoption, depending on the characteristics of the technology and the institutional setting. Binswanger (1978) found, for example, a strong relationship between farm size and the adoption of the tractor in South Asia, while Doss *et al* (2003) did not find a clear one with the use of improved varieties.

Amsalu and de Graaff (2006) reported that adoption was influenced by farmers' age, farm size, perception on technology profitability, slope, livestock size and soil fertility, while the decision to continue using the practice is influenced by actual technology profitability, slope, soil fertility, family size etc. Research findings, for example, from Negatu and Parikh, (1999) and Batz *et al* (1999) confirm the influence of the perception of technology's characteristics on the adoption process. Shiferaw and Holden (1998) have indicated that theoretically, the perception of soil erosion and its negative impact on yield helps to increase the probability of adopting soil conservation methods.

2.6 Adoption of rainwater harvesting technology

Adoption of rainwater harvesting technology requires a bottom up approach rather than the usual top-down approach employed in most water resources development projects. This may make rainwater harvesting less attractive to some governmental agencies tasked with providing water supplies in developing countries. A number of problems associated with rainwater harvesting technologies ranged from presentation of risk of injury to people and livestock, demand for labour, time, and water logging in Zimbabwe, Ngundu in Chivi District (Mutekwa and Kusangaya, 2006).

Caswell and Zilberman (1985) investigated irrigation technology (such as drip, sprinkler, or surface) choice. Skaggs (2001) investigated drip irrigation adoption for Chile pepper producers. The diffusion of centre pivot technology was studied by Lichtenberg (1989), while the adoption of drip irrigation technology in Hawaii was also examined by Shrestha and Gopalakrishnan (1993). Unfortunately, very little attention has been given to studying adoption of rainwater harvesting technology, particularly in the Loess plateau context.

Oweis *et al*. (1999) noted that lack of widespread adoption of rainwater harvesting technology by farmers might be attributed to technical, socio-economic, and policy factors. Li *et al*. (2000) also pointed out that the spread of rainwater harvesting agriculture must consider the constraints of technological, ecological, social, economic and political factors. They do not, however, identify and analyze their hypotheses. Therefore, there is no empirical information as to why some farmers adopt rainwater harvesting technology and some do not.

The environmental effects of rainwater harvesting on agriculture should also be considered when determining whether to adopt a certain technology. Some examples of environmental damage that may occur due to water harvesting include salinization, solidification, low water tables or water logging, and soil degradation (Oweis *et al*., 1999). An additional consideration is how the use of additional rainwater from rainwater harvesting techniques will affect water users downstream that may rely on the same water supply for their crop production.

Quite a large number of studies have been carried out on rainwater harvesting technology (RHWT), Li *et al.* (2000) summarized the socioeconomic aspects of rainwater harvesting agriculture. Tian *et al.* (2003) evaluated the economic feasibility of agriculture with RWHT in a semi-arid region. Pandey (1991) conducted an economic analysis of water harvesting and supplementary irrigation in the semi-arid tropics of India. These studies focused on the economic analysis of irrigation systems and predicted the farmers' choice of irrigation technology and diffusion. However, they did not examine the factors that influence the adoption of RWHT.

2.7 Benefits of rainwater harvesting

Better utilization of rainfall through rainwater harvesting can greatly increase agricultural productivity, improve food security and alleviate poverty. Several studies have been carried out with an aim of determining the potential of rainwater harvesting to improve land productivity. Fox and Rockstrom (2000) investigated the effect of rainwater for supplementary irrigation of cereal crops to overcome intra-seasonal dry-spells in the Sahel. Their on-farm study demonstrated that supplementary irrigation during dry-spells increased sorghum harvests by 14%. Reports based on farmers opinions show that application of water and soil conservation in the central plateau, Burkina Faso, has rehabilitated degraded land and increased cereal (i.e. sorghum and millet) yields, thus improving food security and household wealth (Schweigman, 2003).

Botha *et al.* (2005) evaluated the agronomic sustainability of the in-field rainwater harvesting technique in South Africa. It was concluded that in-field rainwater harvesting techniques contributed to higher crop yields than normal conventional tillage because it stops runoff and minimizes soil evaporation losses. Pretty *et al*. (2003) examined the extent to which farmers have improved food production with low cost, locally available and environmentally sound practices. In their study, 208 projects in 52 developing countries selected from Africa, Asia and Latin America were detected owing to improvements in water productivity, improvements in soil conditions and organic pest control.

Some studies have not found significant benefits resulting from some of the rainwater harvesting practices. Hatibu *et al*. (2002) investigated the effects of modified cropping system for maize, which aims to reduce drought risk through rainwater harvesting. Macro-catchment rainwater harvesting resulted in more benefits compared to cultivation without rainwater conservation techniques. The study, however, only considered the effects of rainwater harvesting on maize and therefore, it is difficult to tell if it will give similar results if applied to other crops.

Besides improving agricultural productivity, rainwater harvesting is associated with other environmental and social benefits. Ngigi (2003) reported that construction of communal water pans to store water helped to reduce conflict over water resources among different clans in north-eastern Kenya. In addition, investment in construction of water storage facilities has greatly improved crop and livestock production leading to better standard of living in the area. Mutekwa and Kusangaya (2006) reported that successful adoption of rainwater harvesting technology lead to higher agricultural productivity and household income, soil erosion control, revival of wetlands and improvement in pasture quality.

2.8 Requirements for Rainwater Harvesting

"It is evident that there is enough freshwater available every year to fulfil the needs of the present population of this planet. However, in certain regions and countries the annual renewable supply of water is less than 500m cubed per capita" (Qadir *et al.*, 2007 pg. 1). This need for rainwater harvesting arises from many factors such as low rainfall and uneven distribution, high losses due to evaporation and runoff, and an increased demand on water due to population growth (Abu-Awwad and Shatanawi, 1997). With a large portion of the human race living in arid to semi-arid regions of the globe, it is necessary to look to rainwater harvesting to increase water access in these areas.

As rainwater harvesting becomes an important strategy to deal with water scarcity or water stress, it is important to consider the factors that go into selecting the appropriate rainwater technology methods to maximize hydrological returns. There are a number of critical factors that need to be taken into consideration when selecting the appropriate rainwater harvesting method. These include:

i) Rainfall

Rainwater harvesting depends on limited and uncertain rainfall, and the dynamics of precipitation within the environment can influence the method of rainwater harvesting that would fit best in each context (Qadir *et al.*, 2007). Various factors which should be taken into account include: The number of days in which the rain exceeds the threshold rainfall of the catchment, on a weekly or monthly basis, probability and occurrence (in years) for the mean monthly rainfall, probability and reoccurrence for the minimum and maximum monthly rainfall and frequency distribution of storms of different specific intensities (Prinz and Singh, 2000).

ii) Land Use or Vegetation Cover

Working to reduce erosion and redirect runoff into appropriate catchments can lead to high labour inputs resulting from the necessity to keep the catchment area free from vegetation, to ensure that it is as efficient as possible. The vegetation of the selected area will heavily influence runoff, infiltration and retention levels, and must be taken into account prior to implementation so as to reduce high labour costs in the future (Qadir *et al.*, 2007).

iii) Socio-Economic and Infrastructure Conditions

There are several social, cultural and economic factors that are important to consider when selecting the appropriate rainwater harvesting techniques, as depicted below:

- People’s priorities – Need to be taken into account when opting to introduce rainwater harvesting methods to a specific area. Rainwater harvesting aims to increase the availability of water resources for productive use, and it is therefore important that the rainwater harvesting infrastructure meets the needs of the individuals who are using it (Critchley and Siegert, 1991).
- Knowledge plays an important role here for individuals involved in the rainwater harvesting scheme as they need to fully understand how it operates. One potential negative effect of implementing complex rainwater harvesting technologies is that those who are left to use it are unfamiliar with the technology and thus unable to properly maintain it (Oweis and Hachum, 2006).
- Land tenure – Not having full ownership of the land on which one lives can cause an individual to be reluctant to invest in a rainwater harvesting scheme that would only benefit the user in the short term.

2.9 Further evidence from previous studies

Rainwater harvesting is a major source of drinking water in the rainy season especially in KwaZulu-Natal and the Eastern Cape (Duncker, 2000). The practice is spreading in rural South Africa, especially with the financial assistance provided by the Department of Water Affairs (DWA) to resource poor households for the capital cost of rainwater storage tanks and related works. There is a direct link between the provision of clean water, adequate sanitation and improved health (Gleick, 1996), and often inadequate water supply is pointed as a factor contributing to poor sanitation. Improving the quantity and quality of water supply improves the level of sanitation (Info, 2006).

Capturing rainwater and using it efficiently is crucial for any integrated development. Water harvesting may be developed to provide water for human and animal consumption, domestic and environmental purposes, as well as for plant production (Oweis *et al*., 1999,). According to Reijntjes *et al.* (1992) sustainable agriculture is farming that is ecologically sound, economically viable, socially just and acceptable. Sustainable agriculture aims to achieve permanence, which includes adopting technologies that ‘maintain soil fertility indefinitely whilst utilising renewable resources that minimise environmental pollution’ (Geier, 1999). In sub-Saharan Africa the potential of rainwater harvesting for improved crop production received great attention in the late 1970s and early 1980s in response to widespread droughts that left a trail of crop failures, posing serious threats to human and livestock life (Hatibu and Mahoo, 1999; Ngigi, 2003) especially in communal areas, which are characterised by a high population density and appalling household food insecurity. Since then, a number of water conservation projects have been established to combat the effects of drought by improving crop production and in some areas rehabilitating abandoned and degraded land.

According to Bekele and Drake (2003) and Asfawa and Admassie (2004), the general assumption is that there is a desire to maximize the expected utility of adopting new technologies. The utility maximizing objectives of individual farmers might be the same for farmers everywhere, however, the specific attributes influencing the utility of farmers and their technology adoption decisions are far from uniform.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter describes the research methodology used to collect data and to analyze variables that were considered. The chapter provides a brief description of the sources of information used, sampling technique, and data collection method. The way the survey data were analyzed is also presented in this chapter.

3.2 Study area

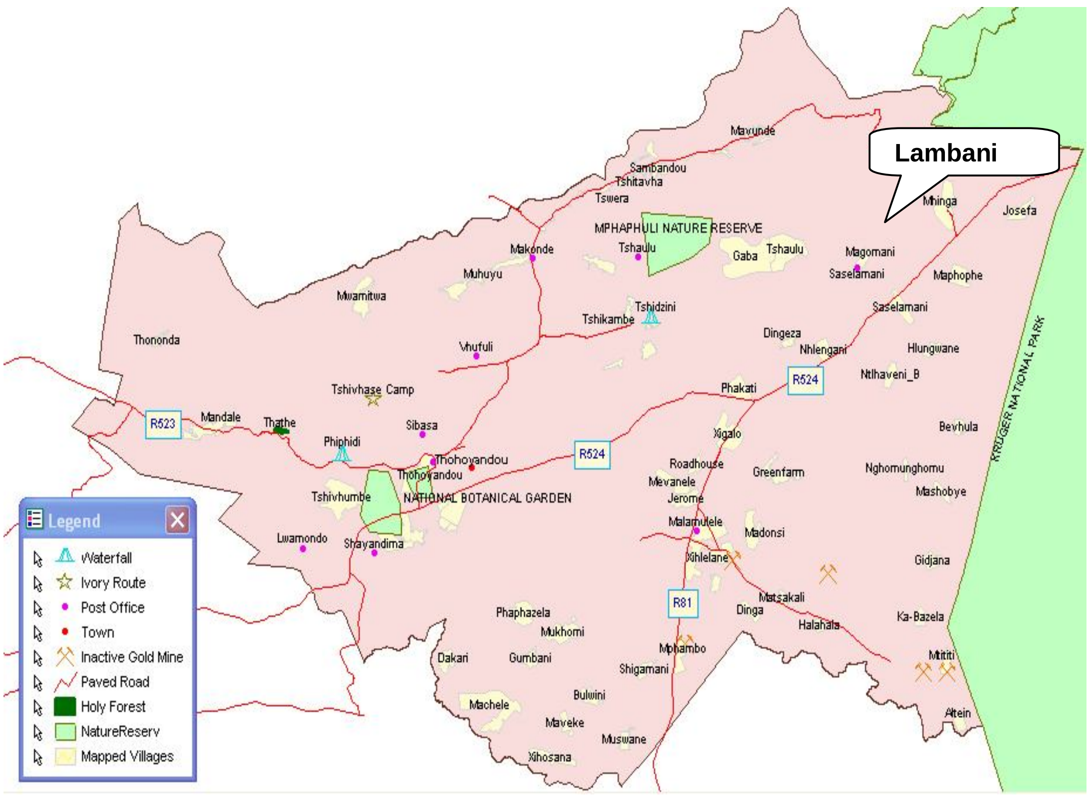

Figure 3.1: Location of the study area

Source: Thulamela Local Municipality, 2009

This study was conducted in Lambani village which falls under the Thulamela Local Municipality in the Vhembe district of Limpopo Province. Vhembe is one of the 5 districts of Limpopo Province of South Africa. It is the northern-most district of the province and shares its northern border with the Beitbridge district in Matabeleland South, Zimbabwe. The capital of Vhembe is Thohoyandou and the majority of its people speak Venda.

The western parts of Thulamela, around Lake Fundudzi and Thohoyandou, enjoy high rainfall, ranging from 1000 to 1200 mm/annum. However, the rainfall levels decreases eastward ranging from 400 to 500 mm/annum in the area that borders on the Kruger National Park. Similarly, the soil fertility also decreases from high quality agriculture soils in the west, to poorer soils in the east. The remainder of the area is mainly used for dryland and subsistence agriculture, which represents a vital component of the economic strategies of the rural households.

The western area of Thulamela Local Municipality forms part of the highly fertile Levubu valley, where a range of sub-tropical fruits such as bananas and mangoes as well as macadamia nuts are produced on a commercial scale. Compared with this, the eastern areas have much lower rainfall and mainly comprise Mopani veld, which makes it only suitable for cattle grazing. Despite the good resource base, particularly in the western areas, the agriculture sector contributes marginally (about 1 %) towards the formal economy and generates only about 4 % of all formal jobs. The population estimated for Thulamela Local Municipality in 2004 was 606 075. The population is predominantly rural, with only 5% residing in the so-called proclaimed towns, namely Thohoyandou and Malamulele (Quantec, 2006). Lambani village forms part of the eastern area of Thulamela Local Municipality.

3.3 Method used in data collection and sampling

The household was defined by Chianu and Tsujii (2004) as a group of persons who normally live and eat their meals together in the same dwelling. The data used to estimate the models were obtained from a survey of 70 households in Lambani village. The sample size of 70 households was restricted by budgetary considerations, and equalled about 5% of the estimated 1398 households in the area. There were a total of 1398 households in the area, and of these households, about 29% were involved in in-field rainwater harvesting. For the survey, the population was stratified into two groups; those households who have adopted the in-field rainwater harvesting technology and those who have not. The first stratum i.e. the adopter group had 405 households, from which 35 households were randomly selected, whilst the non-adopter stratum had 993 households, from which 35 households were selected. The sampling frame, and list of households engaged in in-field rainwater harvesting was obtained with the assistance of the local extension officer.

For the purpose of this study, the heads of the selected households (usually the household head was implicitly assumed to be the sole decision maker in adoption studies) were interviewed using a structured and semi-structured questionnaire which covered a broad range of socioeconomic aspects of household and village-level farming, the process of in-field rainwater harvesting technology adoption, etc. Households were having backyard gardens within residences and separate pieces of land outside the homestead.

3.3.1 Questionnaire design

According to Wiersma (1986), questionnaires are a list of questions or statements to which the respondents are asked to respond in writing during an interview. The questionnaire according to Cohen and Marion (1989) can either be administered under the supervision of a researcher or as a postal survey. In this study, the researcher and a trained enumerator administered the interviews. The questionnaires included both open-ended and closed questions (see appendix). The open-ended questions were included to give the individual more freedom to respond while the closed questions could easily be coded. The questionnaire was constructed in English, but subsequently administered in the local language.

3.4 Method used in data analysis

The Statistical Package for Social Sciences (SPSS) for Windows was used to analyze data. Descriptive statistics (means, frequencies, and standard deviations) were calculated. A set of analytical techniques was used with an emphasis on multivariate procedures. The logistic regression model was used to determine the socio-economic factors influencing the adoption of in-field rainwater harvesting technology for cropland productivity in Lambani village of Limpopo Province, while the linear regression model was used to determine the extent to which adoption of in-field rainwater harvesting technology influences cropland productivity.

3.4.1 Logistic regression model

In order to determine the factors that influenced farmers' decision to use in-field rainwater harvesting technology, a logistic model was specified and its parameters estimated. The model was chosen over other similar models because it was not possible to quantify adopters of in-field rainwater harvesting in this study. Logistic regression is necessary because the dependent variable is binary. Logistic regression is used to predict a categorical dependent variable on the basis of continuous and categorical independent variable (Gujarrati, 1995). The logistic regression is thus necessary to estimate the probability that households adopt in-field rainwater harvesting technology. It is also used to determine the percentage of variance in the dependent variable explained by the independents and shows the impact of independent variables on the dependent variable.

The relationship between the probability of Y = 1 and the explanatory variables are determined through the logit function, and that is the natural logarithm of odds of Y = 1. This assumes a linear relation between the log of odds and independent variables. The analysis in this study thus focuses on the probability that, households adopt in-field rainwater harvesting in Lambani village of Limpopo Province. The logistic regression model is based on the probability that Y equals to one ($P=P_1$). The value of Y is assumed to depend on the value of $X_1 \ldots\ldots X_k$. The logit model representing the relationship of Y and X is given by:

$$\text{Log}\,[p/(1-p)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_K X_K + U$$

Where: P = Predicted probability that Y equals to one (dependent variables)

B_0 …... β_K = Estimated parameters

X_1 ….. X_K = Independent variables

The specific logistic regression model is given as follows:

ADOP = b_1AGE + b_2EDUCL + b_3HHLSZ + b_4LNDSZ + b_5LVLINC + b_6CNEXT + b_7HRLBR + b_8FINCSER + b_9 WRTSOUR + b_{10} ACINFO + U

Where: ADOP = Adoption of In-field Rainwater Harvesting Technology

AGE = Age of the household head

EDUCL = Level of Education

HHLDSZ = Household Size

LNDSZ = Land Size

LVLINC = Level of Income

CNEXT = Contact with Extension

HRLBR = Hired Labour

FINCSER = Financial Service

WRTSOUR = Water Source

ACINFO = Access to Information

ADOP (referring to the dependent variable) was defined as a binary variable with a value of 1 for those farmers who have adopted IRHWT and 0 for those who have not adopted it. The explanatory variables are discussed below:

3.4.1.1 Choice of variables

The choice of most independent variables included in the empirical model was chosen based on theory, assumptions and evidence from past studies. Some variables were, however, included based on a hypothesized relationship with the dependent variable. Many past studies have demonstrated that farmer and village characteristics mostly influence adoption of improved agricultural technologies (Adesina *et al*., 2000; Ramji *et al*., 2002). Variables which have influence on cropland productivity will be used to identify factors that have negative or positive influence on the adoption of in-field rainwater harvesting technology and also will identify the adoption rate of in-field rainwater harvesting among farmers in Lambani village. Some of these variables are discussed below.

Level of formal education: the level of formal education attained was used as a proxy for farmer's ability to acquire and effectively use information. In most adoption studies (Ramji *et al.*, 2002 and Tassew, 2004), farmers with higher levels of educational attainment are more likely to adopt new technologies or practices than less educated farmers. Human capital is an important asset for adoption and an educated farmer is more likely to accept new farm technologies (Nakhumwa and Hassan, 2003). Therefore, it is expected that the level of education has a positive impact on adoption.

Age of the household head: can be positive or negative depending on the position of the household in the life cycle. Younger farmers are more likely to be attracted by new technologies and have more need for extra cash (however, limited cash resources may be a constraint). On the other hand, older farmers may easily be discouraged from adopting new technologies especially if labour demand is high (Nakhumwa and Hassan, 2003).

Household size: This variable determines the availability of household labour supply. Family labour availability may positively influence adoption and extent of adoption as it eases the labour constraint faced by most smallholder farmers (Jera and Ajayi, 2008). In this study, it is hypothesized that household size has a positive influence on the adoption.

Access to information: usefulness of farm information is likely to promote adoption of appropriate agricultural practices. For example, training workshops expose farmers to new technology and information sources outside their farms (Adesina and Baidu-forson, 1995). Contact with extension staff is expected to promote adoption of recommended farm practices because farmers who have frequent contact with extension officers and easy access to information about problems, potentials and performance can regularly upgrade their knowledge of technology (Abdulkadir, 1992).

Level of the family income: can affect the ability of the household to invest in technologies and to bear the risk associated with its adoption. A positive relationship should be expected between income level and technology adoption (Adesina, 1996).

Labour: refers to the size of the active-labour force. In sub-Sahara Africa farmers rely primarily on family labour (Ngqangweni, 2000) because family labour obtains a share of the profits, and therefore have more encouragement than hired wage workers. Labour constraints often limit farmers' use of in-field rainwater harvesting. Thus, a positive influence on the adoption of in-field rainwater harvesting is expected with the presence of a larger, active labour force (He *et al*., 2007).

Land size: most empirical studies find that larger farms are more likely to adopt new technology than small ones. The larger the land size, the more likely that a farmer can afford to set aside an extra piece of land to practice the new technology. A priori, farm size is positively related to farmers' decision to adopt the technology (Rosenzweig, 1978).

Financial support: credit is often used to promote the adoption of in-field rainwater and other yield enhancing technologies. Without credit most farmers cannot afford recommended inputs. A positive relationship is expected between access to financial support and the decision to adopt in-field rainwater harvesting (Ahmed *et al*., 2002).

Water source: although in-field rainwater harvesting will not be able to replace all other sources, it will certainly be able to ease the pressure on surface water and contaminated ground water usage as a primary source. Therefore a positive relationship is expected (Ahmed *et al.,* 2002).

3.4.1.2 Definition of variables

Table 3.1: Definition of variables included in the logistic regression model

NAME	DESCRIPTION	UNIT OF MEASUREMENT	EXPECTED SIGN
Dependent variable			
ADOP	1 if a farmer adopts rainwater harvesting technology, 0 otherwise	Dummy	
Independent variables			
AGE	Farmer's age	Years	+/-
EDUCL	1 if a farmer attained grade 1 to 4, 0 otherwise	Dummy	+
HHLDSZ	Number of people in the household	Number	+
LNDSZ	Area under crops in 2008/9	Hectare	+
LVLINC	Level of income	Rand	+
CNEXT	1 if a farmer has contact with extension officer, 0 otherwise	Dummy	+
HRLBR	1 if a farmer hire labour, 0 otherwise	Dummy	+
FINCSER	1 if a farmer receive financial service, 0 otherwise	Dummy	+
WRTSOUR	1 if a farmer use public stand pipe as a water source, 0 otherwise	Dummy	+
ACINFO	1 if a farmer receive information on rainwater harvesting technology, 0 otherwise	Dummy	+

3.4.2 Linear regression model

Linear Regression was used in this study to address objective number two , which is to find out whether or not adoption of in-field rainwater harvesting technology influences cropland productivity. Linear Regression is used to evaluate the relationship between two or more feature attributes. By identifying and measuring relationships the model will provide a better understanding of what is happening. According to Wooldridge, (2006) Linear Regression model is the best known of all regression techniques.

General model

The basic linear regression model with the independent variable r and the multiple regressors is represented as:

$$r = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_n X_n + U$$

Where: r is the quantity of harvested maize in kgs

$X_{1\ldots} X_n$ are explanatory variables

$\beta_{0\ldots} \beta_n$ are the parameters

U… is the disturbance term

Specific model

$$AMHAR = f\,(\beta_o + \beta_1 AGE + \beta_2 FERT + \beta_3 PEST + \beta_4 EDUCL + \beta_5 LVLINC + \beta_6 ADOP + \beta_7 LNDSZ + \beta_8 HRLBR + \beta_9 ACINFO + U_i$$

Where: AMHAR = Quantity of harvested maize

AGE = Age of the household head

FERT = Fertilizer application

PEST = Pesticides application

EDUCL = Level of education

LVLINC = Level of income

ADOP = Adoption of in-field rainwater harvesting technology

LNDSZ = Land size

HRLBR = Hired labour

ACINFO= Access to information

Dependent variable AMHAR (referring to quantity of harvested maize) was defined as a continuous variable, it is measured in kilograms per hectare (kg/ha).

Independent variables were, however, included based on a hypothesized relationship with the dependent. Variables which have influence on cropland productivity were used to identify factors that have negative or positive influence on the quantity of harvested maize. The basis of selecting some of the variables is outlined below.

Land size: was documented in hectares (ha). Households have different access to land in rural areas. Households with more arable land have greater potential to produce more and stand a better chance of participating in new technology. Therefore land size is expected to have positive influence on quantity of harvested maize (Emongor and Kirsten 2009).

Age of the household: this variable is taken as a proxy for the farmers experience in the production of maize. It is measured in number of years. Older household heads may have more experience in the production of maize and may have more social capital. On the other hand, older households' heads may be more risk averse, and may therefore opt not to adopt the IRHWT. Therefore the variable is expected to have either a positive or a negative impact on production of maize (Emongor and Kristen, 2009).

Level of education: is assumed to be key to increasing the level of farmers understanding and according to Monhla M.A (2009), the farm household educational attainment has a significant positive association with technical efficiency. Greater schooling could potentially enhance farm efficiency through acquisition of knowledge relevant to agriculture. It is expected to have a positive impact on quantity of harvested maize.

Application of fertilizer: is also important. Sustained fertilizer use has been an important factor in increasing crop productivity in many countries, but use of the input remains very low in sub-Saharan Africa. Average consumption of fertiliser in 1998 was 13.8 of nutrients per hectare of arable and permanently cropped land (UNDP, 2001). Application of pesticides is a variable or factor associated with changes in maize productivity. Therefore this is expected to be positively related with in-field rainwater harvesting technology.

Level of income: is expected to be positively related to intensity of in-field rainwater harvesting, since wealthier farmers are more likely to have additional resources that can be used for on-farm investments (Clay *et al* 1998).

Access to information: exposes farmers to information that may make them more receptive to acquire, interpret and use technical advice. This is expected to be positively related to in-field rainwater harvesting technology (Freeman and Omiti, 2003).

Hired labour: may influence the ability of the household to produce. Households with a higher labour supply may be able to devote more labour to the production of maize. These households may be able to produce more, making participation in the in-field rainwater harvesting technology easier. This variable is expected to have a positive impact on quantity of harvested maize (Emongor and Kirsten, 2009).

3.4.2.1 Definition of variables

Table 3.2: presents variables with their definitions and expected relationships with AMHAR.

VARIABLES	DESCRIPTION	UNIT OF MEASUREMENT	EXPECTED SIGN
Dependent Variable			
AMHAR	Quantity harvested of maize	Kg	
Independent Variables			
AGE	Age of the household head	Number	+/-
FERT	1 if a farmer applied the fertilizer, 0 otherwise	Dummy	+
PEST	1 if a farmer applied the pesticides, 0 otherwise	Dummy	+
EDUCL	1 if a farmer attained grade 1 to 4, 0 otherwise	Dummy	+
LVLINC	Level of income	Rands	+
ADOP	1 if a farmer is a adopter of in-field rainwater harvesting, 0 otherwise	Dummy	+
LNDSZ	Land size of the household	Ha	+
HRLBR	1 if a farmer hire labour, 0 otherwise	Dummy	+
ACINFO	1 if a farmer receive information on inputs, 0 otherwise	Dummy	+

3.5 Ethical considerations

The study procedure adopted was standardized and made uniform for all the households. Permission to enter to the community was obtained from the chief and the ward officer. They were informed about the research. Recruited participants were told about the research objectives. Permission was obtained from the households to indicate their willingness to participate in the survey. The households were assured that the information obtained would be treated as confidential, that the results would be used for research purpose and may be used to develop policy guidance that may be used in in-field rainwater harvesting technology.

The study also took into consideration the culture and the norms of the households because the questionnaire was structured in a way that does not offend the household, and no households were forced to participate in the questionnaire answering. There were no unnecessary personal questions asked because the questionnaire was designed in such a way that it gives much information about the respondent.

3.6 Limitations of the study

Due to budgetary constraints, the case study approach was taken and the sample size was restricted to only 70 households. This placed a limitation on the extent to which the findings of the study could be generalised. The sample size of 70 is however, above the size of 30 observations normally required for statistical estimations. As with all survey based research methods, the accuracy of the results depends on the accuracy of information given by respondents. Although measures were taken to ensure that respondents understood the confidentiality of information, some other factors such as respondent failure to recall information or answer some questions could have affected the results obtained.

CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter aims to provide some insight into the characteristics of the farmers in Lambani, Limpopo Province. The information given below is derived from the descriptive analysis of the data collected as described in Chapter 3. The results are provided in tabular forms and charts, and all of them are interpreted in terms of percentages, minimum, maximum and means. The analysis is based on data collected from a sample of 70 households.

4.2 Demographic factors

Important demographic factors identified for this study were age, household size, education level and level of income. The variable age plays an important role to enable the household to participate in farming. According to the theory of human capital, young members of a household have greater chance of absorbing and applying new knowledge (Sidibe, 2005). The results show age distribution of the farmers ranging from 20 to 87 years. The average age for a head of a household was 52 years old (see table 4.1). Out of those interviewed 67% were married, showing that the majority had complete households. The other 33% were single, divorced or widowed.

Household size plays an important role in farming; it can give an indication of the extent of pressure that could be exerted on the household resources. On the other hand it can also be an indication of the available labour; therefore a large household size might be an advantage for those who practice in-field rainwater harvesting technology (FAO, 2004; Moore and Vaughan, 1994). The results show on average the family size of 6 members. The survey results were within the range of what has been found by other studies. For example the Agriculture Support Programme (2004) found a household size of 5.5 on average.

Table 4.1: Descriptive statistics for age of household head and household size.

Variables	Minimum	Maximum	Mean	Std. deviation
AGE	20	87	52.30	15.31
HHLSZ	1	18	5.81	2.93

Education plays a very important role in a farmer's perception of technologies, how it is disseminated and its sustainability. It influences the level of understanding and assimilation of the development issue (Agricultural Support Programme, 2004). Figure 4.1 below shows the level of education of the household head in Lambani village, i.e 19% did not go to school, 36% had grade 1 to 4 , 11% had grade 5 to 7, while 16% had grade 8 to 10, 14% had grade 11 to 12 and 4% had tertiary education.

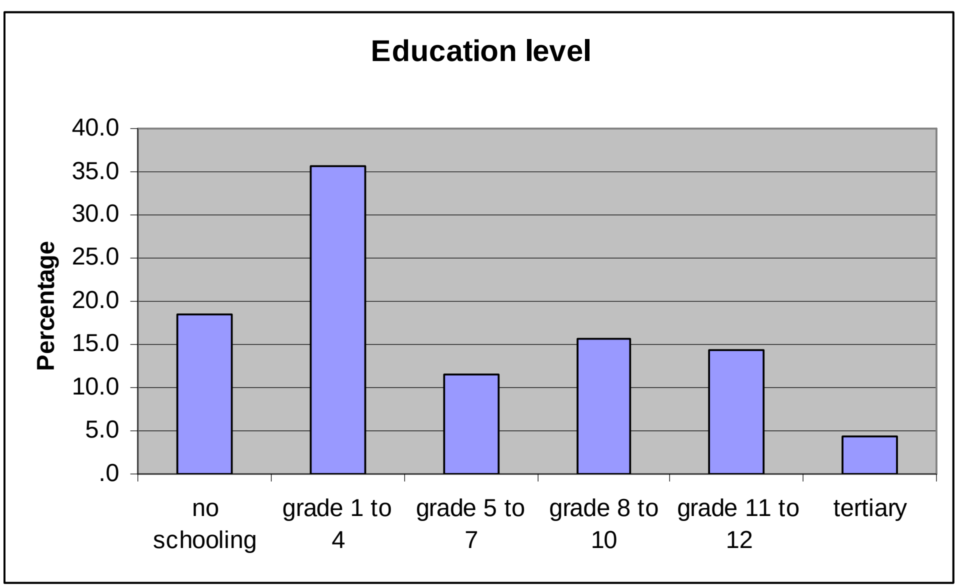

Figure 4.1: Education level of the household head

The variable level of income allows farmers to meet capital costs for technology implementation, and may also reduce risks from experimenting with new technologies. Studies have shown that the level of income positively influences adoption of new technologies (Savadogo *et al,* 1994; Adesina, 1996). Figure 4.2 below shows the level of income per month of the household head. The results indicate that 45% of the household earned less than R500 per month, 33% earned R500 to R1000, 18% earned R1100 to R1500, 2% earned R1600 to R2000 and 2% earned R2100 to R3000 per month**.** This implies that the majority of farmers in Lambani village earn less than R1000 per month.

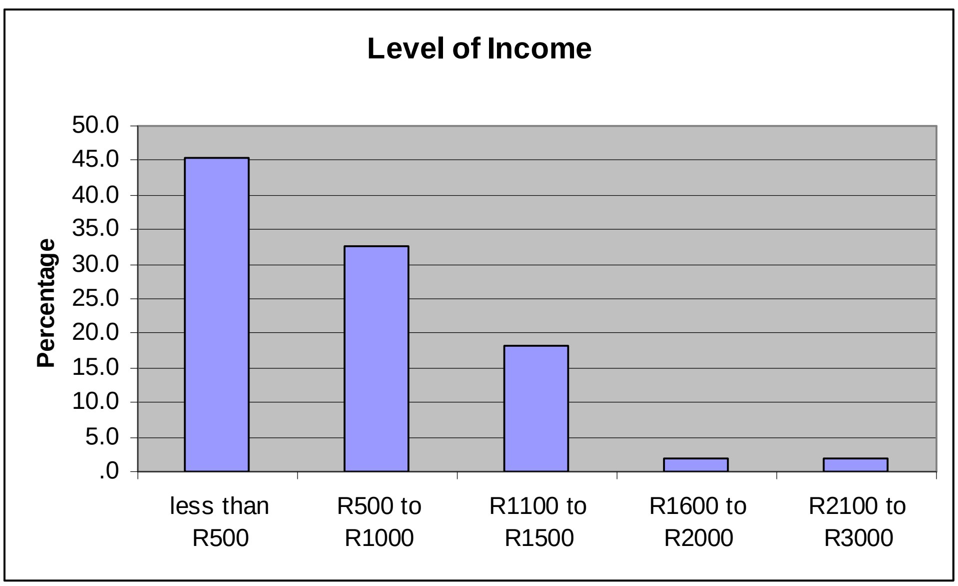

Figure 4.2: Level of income per month of the household head

4.3. Agricultural production factors

According to Makhura (2001), insufficient land constitutes one of the most constraining resources to rural households in South Africa. Land as a resource is often misallocated which then hampers agricultural development and perpetuates rural poverty. Those who have land don't know how to use it most effectively and those who know how to use it effectively don't have access to it (WB, 2006). The results show that households occupy on average1.4 ha of land. Small land size might discourage households to participate in farming. Binswanger and Elgin (1988) have shown that when rural factor markets are competitive and operate efficiently, the rural poor will have limited access to land.

Table 4.2: Descriptive statistics for land size

Variable	Minimum	Maximum	Mean	Std. deviation
LNDSZ	.003	7.00	1. 44	1.27

Figure 4.3 shows the main water source for households. Reliable water source ensures availability for water throughout the year. The results show that 57% are using public stand pipes, 19% are using rainwater, 11% are using bore holes, and 10% are using river water while 3% are using spring water. The majority of households thus depend on public stand pipes to irrigate the crops and to do household chores.

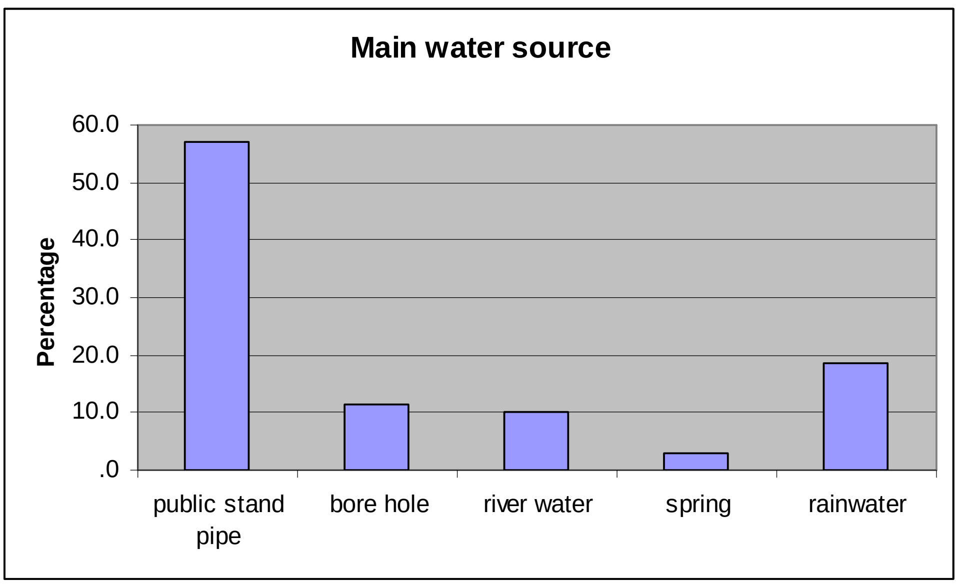

Figure 4.3: Main water source

About 64% of the household had no access to information on rainwater harvesting technology while 36% have access to information (see figure 4.4). This indicates that the majority of farmers are not informed about in-field rainwater harvesting technology and what is needed. This might be because their extension officers do not visit the farmers frequently enough.

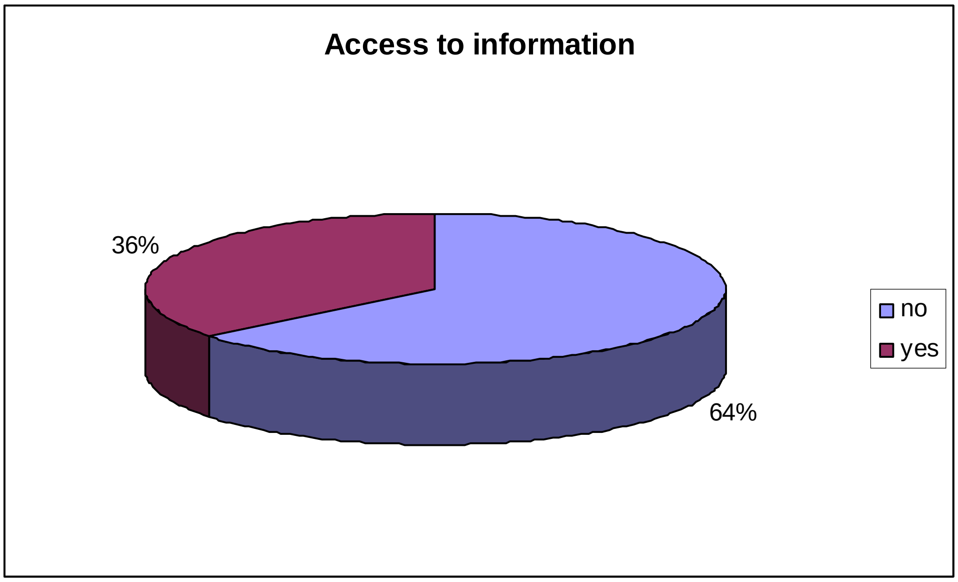

Figure 4.4: Access to information on rainwater harvesting

Figure 4.5 below shows access to financial services by households in Lambani; about 7% of households received financial support while 93% did not receive financial support for agriculture in 2008/09. This indicates that most households do not have financial support to enhance their farming.

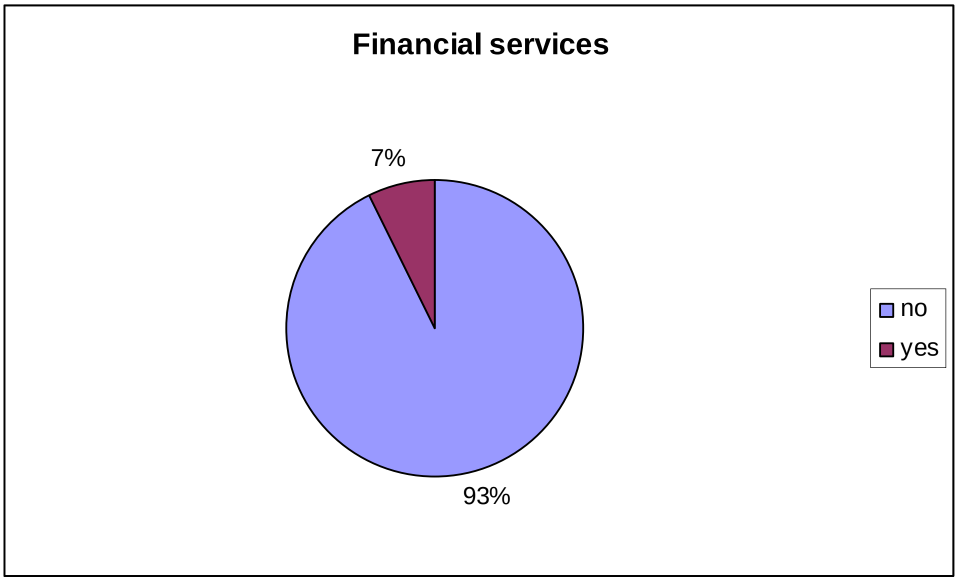

Figure 4.5: Financial services

About 56% of households indicated that they did not have contact with extension officers while 44% had contact with extension officer (see figure 4.6). This implies that a number of households in the area do not receive extension services.

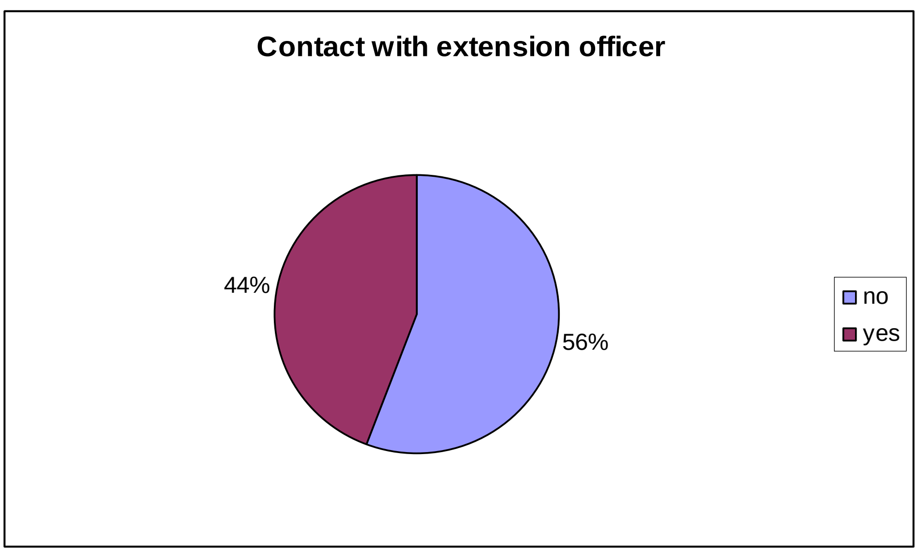

Figure 4.6: Contact with extension officer

Figure 4.7 shows that only 24% of households hired labour for farming while the rest did not hire labour to help with farming activities. It seems that the majority of households use family members for labour provision and it can be assumed that this is because they do not have money or compensation to pay for hired labour.

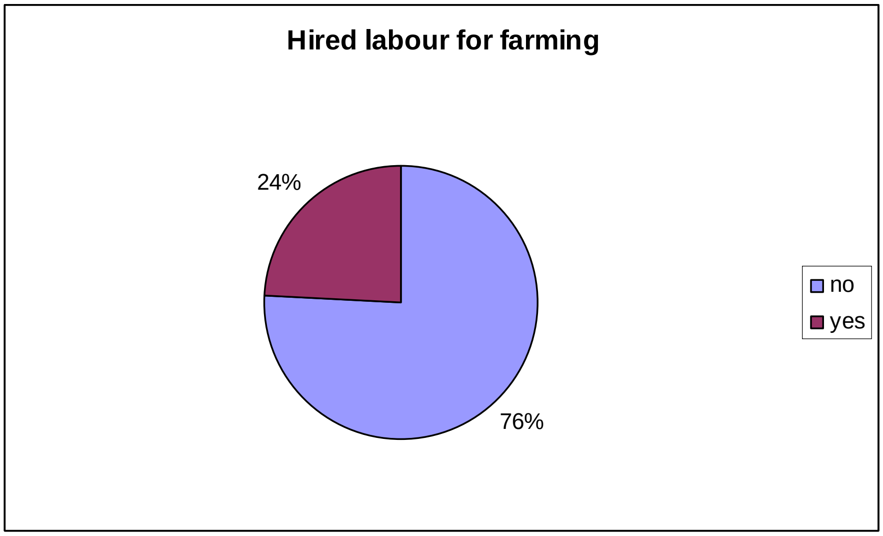

Figure 4.7: Hired labour for farming

The inputs that farmers indicated that they used were fertilisers and pesticides. Only 11% of the farmers however indicated that they had used fertiliser in the previous season, whilst 89% of the farmers in Lambani had not used fertilizers for cropping (see figure 4.8). The reason for low fertilizer use might be because farmers do not have enough money to purchase fertilizers.

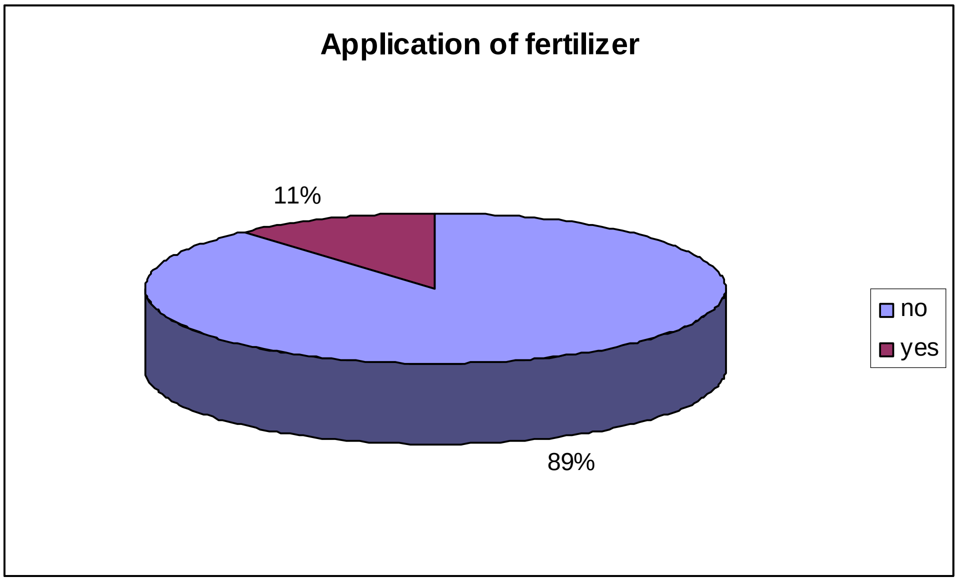

Figure 4.8 Application of fertilizer

Figure 4.9 shows that 84% of the farmers had not used pesticides the previous season, only 16% of the farmers used pesticides to protect their plant from pests.

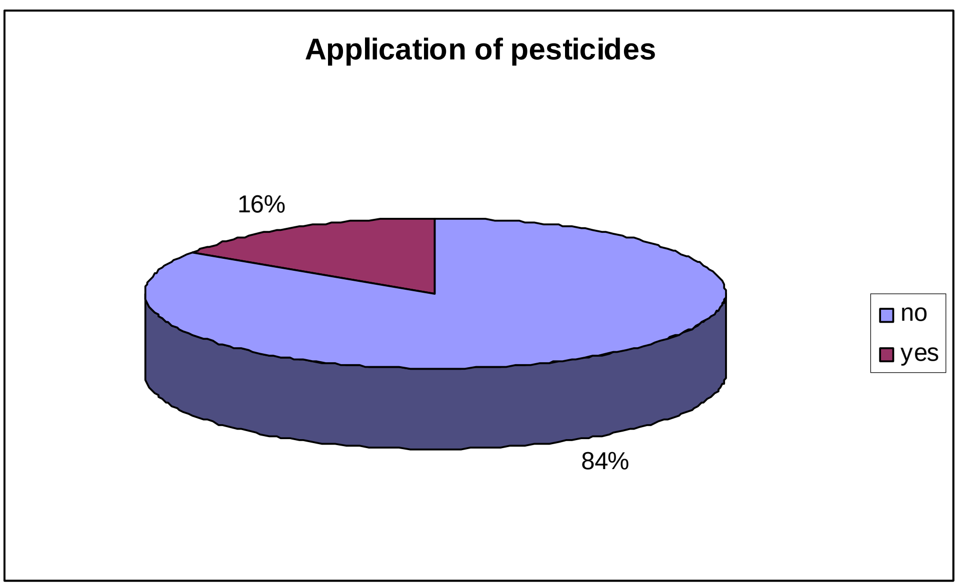

Figure 4.9 Application of pesticides

This chapter has given an overview of the demographic chararcteristics and described some variables related to agricultural production characteritics of surveyed households. The next section presents the results of the regression anlyses aimed at analysing the determinants of adoption of in-field rainwater harvesting techniques by households.

4.4 Logistic regression model to determine factors influencing household adoption of in-field rainwater harvesting techniques

A logistic regression model was run on selected variables to determine factors that are significant in influencing the decision of a household to adopt or not adopt in-field rainwater harvesting techniques.

Table 4.3: Logistic regression results

Variables	Coefficient	S.E	Wald statistics	DF	Sig
AGE	-0.007	.032	.052	1	.820
EDUCL	.637	1.155	.304	1	.582
HHLDSZ	-.034	.211	.025	1	.873
LNDSZ	1.051*	.591	3.155	1	.076
LVLINC	-.662	.979	.458	1	.499
CNEXT	3.597**	1.420	6.413	1	.011
HRLBR	-2.965*	1.545	3.684	1	.055
FINCSER	3.495*	2.008	3.029	1	.082
WRTSOUR	-1.016	1.072	.897	1	.343
ACINFO	4.028**	1.448	7.734	1	.005
Constant	-5.236*	2.582	4.114	1	.043

-2 log likelihood	33.531
Pseudo R square	73%
% correctly predicted	93%
Chi-square	50.227

**,* represent significance at 5% and 10% respectively

Table 4.3 shows that the model correctly predicted 93% of the observations which is good for explaining the relationship between the dependent and explanatory variables. A Wald test is used to test the statistical significance of each coefficient (b) in the model. A Wald test calculates a Z statistic, which is: Z=B/SE. For significance the Wald statistic is always greater than two as shown with the significant variables on the table above. Standard errors are smaller and degree of freedom is one from the above table. Pseudo R square is 73% which shows that 73% of the dependent variable is explained by the independent variable and 27% remaining is unaccountable and may be caused by factors not included in the model. The Chi-square statistic which indicates how well the independent variables affect the outcome or dependent variable had a value of 50.227 on 1 degree of freedom. The model-2 Log likelihood (33.531) is the estimation terminated at iteration number 8 because parameter estimates change less than 0.01. The "likelihood" is a probability that the values of the dependent variable may be predicted from the observed values of the independent variables.

From the model (Table 4.3) five variables out of the ten explanatory variables to influence the in-field rainwater harvesting technology were found to be statistically significant at 5% and 10% probability levels. These variables are land size (LNDSZ), financial service (FINCSER), access to information (ACINFO), hired labour (HRLBR) and contact with extension officers (CNEXT).

Land Size

The concept of land size was operationalised by the variable total land area used by the household to farm on. The variable land size appeared positive and significant at 10% level to adoption of in-field rainwater harvesting technology. This indicated that the increase in farm size by a hectare, the higher the possibility of adopting in-field rainwater harvesting technology. Amsaly and de Graaff, (2006) also reported similar findings on determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. They found that land size was positively significant to the adoption of stone terraces for soil and water conservation.

Access to financial services

The variable access to financial services appeared positive and significant at 5% level. The variable showed a positive relationship with the adoption of in-field rainwater harvesting technology. This indicated that the more farmers got financial support the more they were likely to adopt rainwater harvesting technology. This implies that financial services are required to enable households to adopt in-field rainwater harvesting for the production of agricultural produce.

Access to information on in-field rainwater harvesting

The variable access to information on in-field rainwater harvesting appeared positively significant at 10% level to adoption of in-field rainwater harvesting technology. This indicated that the more information farmers get, the higher the probability of adopting in-field rainwater harvesting technology. This might mean that the farmers' education alone might not have a great influence on the farmers' decision in deciding whether or not to establish in-field rainwater harvesting technology. Therefore farmers must rely more on the extension officer for information on such technologies. Such contacts are helpful in the early stages of technology experimentation.

Hired labour for farming

Labour constraints affect a farmer's choice of technology, [Feder *et al. (*1985); Enyong *et al*. (1999)] and can also constrain the adoption of a labour-demanding technology (Dvorak 1996). The variable hired labour was expected to have a positive influence on technology adoption, but from the analysis, the variable appears negative and significant at 10% level. This might imply that there is a negative relationship between hired labour and the adoption of in-field rainwater harvesting technology which was unexpected because in-field rainwater harvesting is labour intensive. Thus it would be expected that with an increase in hired labour farmers would be more likely to adopt the technology, but the analysis is saying otherwise. This might need further investigation in future studies.

Contact with extension officer

The variable contact with the extension officer was found to have a significant positive effect on rainwater harvesting technology adoption. It was significant at 5% level, suggesting that farmers who are in contact with extension officers had greater likelihood of adopting rainwater harvesting. Contact with extension officers allows farmers greater access to information on technology, through increased opportunities to participate in demonstration tests (Carter 1995; Dvorak, 1996), and thus increase the farmers' ability to get, process, and use in-field rainwater harvesting technology. This result corroborates findings of Adesina and Chianu (2002) on determinants of farmers' adoption and adaptation of alley farming technology in Nigeria. The study found that contact with extension agencies was positively significant at 5% level to the adoption of alley farming technology.

The variable ages of the household head and level of education did not seem to be significant as predictors of in-field rainwater harvesting technology, Jera and Ajayi (2008) also indicated similar findings on logistic modelling of small-holder livestock farmers' adoption of tree-based fodder technology in Zimbabwe. Variables such as household size, level of income and main source of water also appeared not to be significant at any level to adoption of in-field rainwater harvesting technology.

4.5 Linear regression model to analyse determinants of cropland productivity

A linear regression model was run on selected variables to determine the extent to which adoption of in-field rainwater harvesting technology and other explanatory variables influences cropland productivity in Lambani village. The explanatory variables were able to explain only 29% of the variation in the dependent variable as indicated by the adjusted R-squared (see table 4.4).

Table 4.4 Linear regression model results

Variables	B	Std. Error	T	Sig
(Constant)	25.456	13.190	1.930	.058
AGE	-.201	.198	-1.015	.314
FERT	41.969***	12.843	3.268	.002
PEST	-40.847***	12.333	-3.312	.002
EDUCL	4.600	5.947	.774	.442
LVLINC	-.9.853*	6.188	-1.592	.117
ADOP	15.524*	8.437	1.840	.071
LNDSZ	-.502	2.212	-.227	.821
HRLBR	14.885*	7.476	1.991	.051

ACINFO	5.635**	2.720	2.071	.043
Model summary				
R-squared		0.39		
Adjusted r-squared		0.29		

*, **, ***represent 10%, 5% and 1% respectively

Six variables out of the nine explanatory variables specified in the model to influence the quantity of harvested maize were found to be statistically significant at 10%, 5% and 1% probability levels. These variables are application of fertilizer (FERT), access to information (ACINFO), hired labour (HRLBR), level of income (LVLINC), adopters of in-field rainwater technology (ADOP) and application of pesticides (PEST), they are discussed below.

Adoption of in-field rainwater harvesting

The variable adoption of in-field rainwater harvesting technology was positively significant at 10% level. This shows a positive relationship between adoption and quantity harvested. This implies that the higher the probability of adopting the in-field rainwater harvesting technique the higher the yield of maize they could obtain. This could indicate the importance of adoption of in-field rainwater technology to farmers and the potential to improve food security and income generation.

Applications of fertilizers

The variable application of fertilizer was found to be positively significant at 1% level indicating a positive relationship between application of fertilizers and the quantity harvested. This implies that the more application of fertilizers by farmers in Lambani village, the more yield of maize they will obtain.

Application of pesticides

The variable application of pesticides is found to be negatively significant at 1% level. This shows a negative relationship between application of pesticides and the harvested amount. This implies that the more application of pesticides the fewer the amounts of harvested maize. This contradicts expected results as pesticides use is normally associated with higher yield.

Hired labour

The variable hired labour is found to be positively significant at 10% level. This shows the positive relationship between the quantities harvested and hired labour. This implies that the more the farmers hired labour for farming the more yields they would receive. This also shows the importance of hired labour because quantity harvested depends on the number of labourers for ploughing, weeding and irrigating the crops.

Level of income

Level of income is found to be negatively significant at 10% level. This shows the negative relationship between level of income of the household and quantity of harvested maize. This variable was expected to have been positive, however this indicates that the higher income earned the less the quantity of harvested maize. This is not true because usually the higher the income earned the higher the quantity of harvested maize because the farmer will be able to buy innovative equipment for ploughing, harvesting and weeding

Access to information

The variable is found to be positively significant at 5% level. This shows the positive relationship between access to information and quantity of harvested maize. Access to information is therefore a significant factor associated with changes in quantity of harvested maize because the more access to information, the more quantity of maize harvested increased. Access to information gives advantage in farming because farmers are able to apply innovative methods of ploughing, harvesting and weeding the maize.

The variable ages of the household, level of education and land size were not significant at any level. This implies that these variables do not have a direct relationship with the quantity of harvested maize.

The adjusted R squared for this model is lower than expected. This could be because there were some important explanatory variables that were critical in determining maize productivity which were not included in this model due to unavailability of information, especially those that are non-socio-economic, for example, soil type, farmers' management practice and pre and post-harvest losses. For instance, good farm management practice improves resource use, increases productivity and also increases income which is critical for sustainable technology adoption and retention (Mugwe *et al* 2008). The study also did not have a large sample size, which could have affected the ability of the model to fully explain factors variation in maize productivity.

An important shortcoming of the study was that we only considered socio-economic characteristics of the households, which turned out not to have a major effect on production output. It is recommended that future studies should also consider bio-physical and management practices and not only focus on socio-economic characteristics of the household.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter reviews the main findings of the study and discusses the conclusions to be derived from the empirical results. The chapter also makes practical recommendations on the best way to improve the adoption of in-fields rainwater harvesting technology. The Chapter is presented in three sections. Section 5.1 presents the summary of the study, Section 5.2 the conclusion while Section 5.3 gives recommendations.

5.1 Summary

This study was undertaken to improve our understanding of how efforts to promote in-field rainwater harvesting technology should be focused. The objectives of this study were to identify factors determining the in-field rainwater adoption technology for cropland productivity in Lambani village and to determine the extent to which in-field rainwater harvesting adoption influences cropland productivity in Lambani village. This study was aimed at investigating the extent and nature of adoption of in-field rainwater harvesting technology by households in Lambani village of Limpopo Province. A selective logistic model was used to simulate the decision-making process of farmers with respect to adoption and beyond that, and linear regression model was used to determine the extent of impact adoption has on cropland productivity. Several useful conclusions that provide the pathways to increase the adoption of rainwater harvesting technology in Lambani village emerge from this research.

The results show that land is an important variable that influences farmers' decisions to adopt in-field rainwater harvesting technology. Farmers with larger farms are more likely to set aside land for in-field rainwater harvesting technology. As a result, farmers who possess more land should be targeted for new technology implementation.

The results of the logistic regression analysis reveal factors that influence farmers' decisions to adopt in-field rainwater harvesting. Farmers' decisions to adopt rainwater harvesting was positively influenced by land size, access to financial services, access to information and contact with extension office, while hired labour has a significantly negative influence on the adoption. Variables such as household size, level of education, age of the household, level of income and the main water source do not significantly influence adoption of rainwater harvesting. The results from linear regression reveal that adoption of in-field rainwater harvesting influences the cropland productivity positively because factors such as application of fertilizers, hired labour and users/adopters of in-field rainwater harvesting technique access to information had positive co-efficient in as far as they were related to the quantity of harvested maize per hectare, while the co-efficient for application of pesticides, and level of income were found to be negative and significant.

Other variables such as age of the household, educational level and land size were not significant in relation to quantity of harvested maize.

Literature review done to understand the underlying factors that make farmers decide on how to use their land, especially as it pertains to IRHWT(in-field rainwater harvesting technology) have shown that these factors can be broken down into internal and external factors. It also showed that the primary objective of the small holder is household food security. Literature search also shows that various explanatory variables like the factors that influence the farmers' decision do not have the same impact on influencing the farmers' decisions.

5.2 Conclusion

Hypothesis 1 stated that there are no socio-economic factors determining the adoption of in-field rainwater harvesting technology in Lambani village of Limpopo Province. The study rejects this null hypothesis because the study has revealed that there are different socio-economic factors determining in-field rainwater harvesting adoption. These factors are land size, access to financial services, access to information, contact with extension office and access to market and hired labour. Factors such as hired labour showed a negative relationship to the adoption of in-field rainwater harvesting while others showed positive relationship with the adoption.

Hypothesis 2 stated that the adoption of in-field rainwater harvesting does not significantly impact on cropland productivity. The study rejects this null hypothesis in favour of the alternative hypothesis. The findings from linear regression revealed that in-field rainwater harvesting technology impact positively on cropland productivity. Other variables such as application of fertilizers, hired labour, users of in-field rainwater harvesting and access to information shows a positive relationship to amount of harvested maize while application of pesticides and level of income shows a negative relationship. The result indicates that application of all these significant variables increases the amount harvested. Other studies have shown the IRWH increasing maize and sunflower yields by 30 to 50% compared to conventional tillage, making it a feasible option for the farmers (Woyessa and Bennie, 2004). He *et al* (2007) found similar results on econometrics analysis of the determinants of adoption of rainwater harvesting and supplementary irrigation technology in the semi-arid Loess Plateau of China. In addition, it has been shown that this technique resulted in a significant increase in crop yield compared to conventional practices (Hensley *et al*., 2000).

5.3 Recommendations

This information will help prioritize the factors that affect adoption decisions and provide insight on pathways to increase the adoption of in-field rainwater harvesting technology. The study recommends a campaign to educate the farmers so that they may be able to know how to practice in-field rainwater harvesting technology to improve their productivity. There is need for the government to give subsidies to farmers to be able to purchase the right equipment required to practice in-field rainwater harvesting, and government must pursue prudent policies that will favour the small-scale farmers.

The variable access to information appear to be positively significant to the adoption of in-field rainwater harvesting technology, therefore a regular review/visits from the extension officers, researchers and specialists, to make sure those farmers implemented the right procedures of the technology and that it is favouring the condition around the village and that the yield is increasing. This can also help farmers to develop a positive economic assessment on rainwater harvesting technology and be able to boost the confidence of the farmers. This study is also providing the needed information to initiate extension programs to teach the farmers how to operate the IRWHT. However, in recent years, adoption rates are far lower than predicted because of the difficulties associated with the many combinations of ecological and socio-economic constraints that exist in the region. Water markets, either formal or informal, can be an efficient method for reallocating scarce water supplies. The new policy and legislative tools will enable the government to make some major inroads in changing access to water and water services in South Africa.

The Department of Water Affairs could establish a new policy to provide financial assistance to resource-poor irrigation farmers; this is supported by the findings that show financial services impacting on the decision for adoption of in-field rainwater harvesting technology, indicating that the more farmers have access to finance, the more likely they will adopt the technology. Increased access to finance could open a number of opportunities for resource-poor irrigation farmers in the country and assist them in improving incomes and food security.

Many technology adoption studies have been carried out in developing countries including South Africa (Hasssan *et al* 1998, Alene *et al* 2000, Dunker, 2000). However, the importance of factors affecting technology adoption differs across countries and regions due to differences in natural resources, cultural and political ideologies and socio-economic factors, therefore the study urges policy makers, researchers, specialists and others in South Africa to review socio-economic factors in each and every region before they implement new technology.

Government should implement policy support that will encourage farmers to switch from low-price subsistence crops to high-price cash crops; this would help promote in-field rainwater harvesting technology adoption. The results also suggest the need for greater political and institutional input into in-field rainwater harvesting technologies projects. In particular, there is a need to design and develop alternative policy instruments and institutions for extension, technical assistance, training, credit services that will facilitate adoption of the farmer-participatory practices to better fit the needs of farmers in Lambani village. This suggestion also applies to the overall in-field rainwater harvesting projects in arid and semi-arid areas in South Africa.

The study recommend that the Provincial Department of Agriculture liaise with the extension officer around Lambani village to enhance social capital in smallholder farming through the revival of farmers clubs or through the creation of agricultural cooperation because cooperatives assist farmers to access inputs such as fertilizer, seeds, pesticides and information. The results found no prior reason why fertilizer cannot be an important component for farmers. Land is the main source of income and consumption for farmers in Lambani village, therefore reduces poverty. There is need for policy makers to grant secure access to land for rural poor so as to increase the welfare of the poor. The policy and research implications drawn from these results can provide useful insights for formulating strategies to intensify in-field rainwater harvesting technology use on smallholder farms in Lambani village and semi-arid areas.

REFERENCES

ABDULKADIR, A.1992. Report of periodic productivity of Acacia saligna and Leucaena Leucocephala hedgerows grown in alley with maize. Faculty of Forestry, Alemaya University of Agriculture.

ABU-AWWAD, A.M. and SHATANAWI, M.R. 1997. Water harvesting and infiltration in arid areas affected by surface crust: example from Jordan. *Journal of Arid Environment* 37: 443–452.

ADESINA, A.A. and BAIDU-FORSON, J. 1995. Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa. *Agricultural Economics* 13:1-9.

ADESINA, A.A. 1996. Factors affecting the adoption of fertilizer by rise farmers in Cote d'ivoire. *Nutrients Cycling Agroecosystems* 46:29-39.

ADESINA, A.A., MBILA, D., NKAMLEU, G.D. and ENDAMANA, D. 2000. Econometric analysis of the determinants of adoption of alley farmers in the forest zone of Southwest Cameroon. *Agriculture, Ecosystems and Environment* 80:255-265.

ADESINA, A.A. and CHIANU, J. 2002. Determinants of farmers' adoption and adaptation of alley farming technology in Nigeria. *Agroforestry Systems* 55:99-112.

AGRICULTURE SUPPORT PROGRAMME. 2004. Summary Baseline Report volume I and II. Rural Net Associates, Rural Development Consultants. Zambia.

AHMED, M.A., PAUL, V.P. and EHUI, S. 2002. Credit policy and intensification in mixed, crop-livestock system: a modelling perspective. Paper presented at the regional conference on policies for sustainable land management in the highlands of Ethiopia, April 24-2006. Addis Ababa, Ethiopia.

ALENE, M., RUFFINI, R. AND SACCHI, R., 2000. Geochemistry and geotectonic setting of Neoproterozoic rocks from northern Ethiopia (Arabian–Nubian Shield). *Gondwana Res.* 3: 333–347.

AMSALU, A. and DE GRAAFF, J. 2006. Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. *Ecological Economics* 61:249-302.

ASFAWA, A. and ADMASSIE, A.2004. The role of education on the adoption of chemical fertiliser under different socioeconomic environments in Ethiopia, *Agricultural Economics* 30: 215–228.

BACKEBERG, G. R. 1994. The Political Economy of Irrigation Policy in South Africa. Unpublished PhD Thesis, University of Pretoria.

BAIPHETHI, N., VILJOEN, M.F., KUNDHLANDE, G., BOTHA, J.J., and VAN RENSBURG, L.D.2004. Quantifying the impact of in-field rainwater harvesting (IRWH) production techniques on household food security for communal farmers in Thaba Nchu, Free State Province. Paper presented at Agricultural Economic Association South Africa Annual Conference, Cape Town, South Africa

BARRON, J., ROCKSTROM, J., HATIBU, N. and GICHUKI, F. 2003. Dry spell occurrence and maize yields for two locations in semi-arid East Africa. *Agricultural Forest and Meteorology* (in press).

BATZ, F.J., PETERS, K.J., and JASSEN, W. 1999. The influence of technology characteristics on the rate and the speed of adoption. *Agricultural Economics* 21:121–130.

BEKELE, W. and L. DRAKE, L. 2003.Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area, *Ecological Economics* 46: 437–451.

BINSWANGER, H. P. 1978. The Economics of Tractors in South Asia: An Anatical Review. Agricultural Development Council and International Crops Research Institute for Semi-arid Tropics, New York.

BINSWANGER, H.P. and ELGIN, M. 1988. What are the prospects for land reform? *Dartmouth*. 739-754

BOTHA, J.J., VAN RENSBURG, L.D., ANDERSON, J.J., HENSLEY, M., MACHELI, M.S., VAN STADEN, P.P., KUNDHLANDE, G., GROENEWALD, D.G. and BAIPHETHI, M.N. 2003. Water conservation techniques on small plots in semi-arid areas to enhance rainfall use efficiency, food security, and sustainable crop production. Report no 1176/1/03. WRC, Pretoria.

BOTHA, J.J., VAN RENSBURG, L.D., ANDERSON, J.J. and HENSLEY, M. 2005. Evaluating the agronomic sustainability of the in-field rainwater harvesting technique. OECD workshop on Agriculture and Water: Sustainability, Markets and Policies, Barmera.

BOTHA, J.J., ANDERSON, J.J., GROENEWALD, D.C., VAN RENSBURG, L.D. and HENSLEY, M. 2007. Application of the In-field rainwater harvesting technique in rural communities in South Africa to fight poverty and food insecurity. Institute for Soil, Climate and Water.

BRIEN, J.P., WRIGLEY, J.F. and JARDINE, R. 1965. A study of some personal and social factors in relation to farmer's performance. *Review of Marketing and Agricultural Economics* 33: 126-146.

BYERLEE, D., and HESSE DE POLANCO, E. 1986. Farmers' stepwise adoption of technological packages: Evidence from the Mexico Altiplano. *American Journal of Agricultural Economics* 68. 519-527.

CARTER, J. 1995. Alley farming: have resource poor farmers benefited? *Natural Resource Perspectives* 3:1-4.

CASWELL, M.F. and ZILBERMAN, D. 1985. The choices of irrigation technologies in California. *American Journal of Agricultural Economics* 67:224-234.

CHIANU, J.N. and TSUJII, H. 2004. Determinants of famers' decision to adopt or not adopt inorganic fertilizer in the savannas of northern Nigeria. *Nutrients Cycling Agroecosystems* 70:293-301.

CENTRO INTERNACIONAL DE MAJORAMIENTO DE MAIZ Y TRIGO (CIMMYT). 1993. The Adoption of Agricultural Technology: A Guide for Survey Design. CIMMYT, Mexico.

CRITCHLEY, W., and SIEGERT, K. 1991. A manual for the design and construction of water harvesting schemes for plant production. Food and Agriculture Organization of the United Nations (FAO). Rome.

CLAY, D., REARDON, T and KANGASNIEMI, J. 1998.Sustainable intensification in the highland tropic:Rwandan farmers investment in land conservation and soil fertility. *Economic Development and Cultural Change* 46: 351-377.

CGIAR, 2003. Challenge Program on Water and Food: Limpopo Basin Profile, Agricultural Research Council Institute for Soil, South Africa.

COHEN, L. and MARION, L. 1989. *Research methods in education.* London, Routledge.

CONLEY, D.J. and SCHELSKE, C.L. 1993. Potential role of sponge spicules in influencing the silicon biogeochemistry of Florida lakes. *Can. Journal of Fish and Aquatic Sciences.* 50:296–302.

CORNISH, G. 1998. Modern Irrigation Technologies for Smallholder in Developing Countries. Intermediate Technology, London.

Department of local Governemnt and Housing, Limpopo Province, 2011. http:// www. Limpopo-dlgh.gov.za/index.php?%20page=maps

DUNCKER, L.C. 2000. Hygiene awareness for rural water supply and sanitation projects. Report No. 819/1/00. Water Research Commission, Pretoria, RSA.

DOSS, C., MWANGI, W., VERKUIJL, H. and DE GROOTE, H. 2003. Adoption of maize and wheat technologies in Eastern Africa: a synthesis of findings of 22 case studies. *CYMMYT Economics Working Paper* 03-01. CYMMIT, Mexico, DF

DVORAK, K.A. 1996. Adoption potential of alley cropping. Final Project Report, RCMD Research Monograph No. 23, International Institute of Tropical Agriculture, Ibadan, Nigeria

DWA (Department of Water Affairs). 1994. Water Supply and Sanitation Policy. White Paper, water-an individual national asset. Cape Town.

EMONGOR, R. A and KIRTEN, J. F. 2009. The impact of South Africa supermarkets on agricultural development in the SADC: A case study in Zambia, Namibia and Botswana. *Agrekon* 48: 60-84.

ENYONG, L.A., DEBRAH, S.K. and BATIONO, A. 1999. Farmers' perceptions and attitudes towards introduced soil-fertility enhancing technologies in western Africa. *Nutrients Cycling Agroecosystems* 53: 177–187.

EPHRAIM, A.B. 2001. Overview of rainwater harvesting for crop production in Ethiopia. In: Wanyonyi, J., S. Ngigi, P. Mwangi and D. Onyango (eds). Workshop Proceedings: GHARP Strategic Planning and Project Implementation Planning Workshops. GHARP (Greater Horn of Africa Rainwater Partnership) Publication no.1. Nairobi, Kenya.

FAO (Food and Agricultural Organisation). 2004. HIV/AIDS, Gender Inequality and Rural Livelihoods, The Impact of HIV/AIDS on Rural Livelihoods in Northern Zambia.

FEATHERSTONE, A.M., KALIBA, A.R.M. and NORMAN, D.W. 1997. A stall-feeding management for improved cattle in semi-arid central Tanzania: factors influencing adoption. *Agricultural Economics* 17:133–146.

FEDER, G., JUST, R.E. and ZILBERMAN, D. 1985. Adoption of Agriculture Innovations in Developing Countries: A survey. *Economic Development and Cultural Change* 33:255-297.

FREEMAN, H.A. and OMITI, J.M. 2003. Fertilizer use in semi-arid areas of Kenya: analysis of smallholder farmers' adoption behaviour under liberalized market. *Nutrient Cycling in Agroecosystems* 66: 23-31.

FOX, P. and ROCKSTROM, J. 2000. Water harvesting for supplementary irrigation of cereal crops to overcome intra-seasonal dry-spells in the Sahel. *Chemistry of the Earth* 25:289-296.

GEIER, B. 1999. Organic Agriculture – Sustainability Put into Practice. In: Fairclough AJ (ed.) *Sustainable Agriculture Solutions*. Novello Press Ltd, London. 59-61.

GLEICK, P.H. 1996. Basic water requirements for human activities: meeting basic needs. *Water International* 21: 83–9.

GUJARRATI, D.N. 1995. "Basics Econometrics". 3rd Edition. New York: McGraw Hill Book co.

GOETZ, S.J. 1992. A selectivity model of household food marketing behavior in Sub-Saharan Africa. *American Journal of Agricultural Economics* 74: 444–452.

GOULD, J.E. 1992. Rainwater Catchment Systems for Household Water Supply, Environmental Sanitation Reviews, No. 32, ENSIC, Asian Institute of Technology, Bangkok.

HASSAN, R.M., MURITHI, F. and KAMAU, G. 1998. Determinants of fertilizer use and gap between farmers maize yield and potential yield in Kenya. In: HASSAN, R.M.(ed.), maize technology development and transfer. A GIS application for research planning in Kenya. CAB International, Wallingford, UK.

HATIBU, N. and MAHOO, H. 1999. Rainwater Harvesting Techniques for Agricultural Production: A Case for Dodoma, Tanzania, Sokoine University of Agriculture, Morogoro. http://www.atnesa.org/contil-hatibu-waterharvesting.(accessed on 25 September 2005)

HATIBU, N., and MAHOO, H.F. 2000. *Rainwater Harvesting for Natural Resources Management: A Planning Guide for Tanzania. Technical Handbook No.* 22, Sida Regional Land Management Unit (RELMA), Nairobi, Kenya.

HATIBU, N., YOUNG, M.D.B., GOWING, J.W., MAHOO, H.F. and MZIRAI, O.B. 2002. Developing improved dryland cropping systems for maize in semi-arid Tanzania. Part 1: Experimental evidence for the benefits of rainwater harvesting. *Experimental Agriculture* 39:279-292.

HE, Z., GENTRY, T.J., SCHADT, C.W., WU,L., LIEBICH, J., CHONG, S.C.,HUANG, Z., WU, W., GU, B., JARDINE, P., CRIDDLE, C. and ZHOU, J. 2007. Goechip: a comprehensive microarray for investigating biogeochemical, ecological and environmental processes. *The International Society for Microbid Ecology* 1:67-77.

HENSLEY, M., BOTHA, J.J., ANDERSON, J.J., VAN STADEN, P.P. and DU TOIT, A. 2000. Optimising rainfall use efficiency for developing farmers with limited access to irrigation water. Water Research Commission, Report No. 878/1/00, Pretoria, SA.

INFO, 2006. Social cluster: parliamentary media briefing, presented by the Minister of Health, Dr. Manto Tshabalala-Msimang on behalf of the social cluster.
http:// www.info.gov.za/speeches/2006/06021015451002.htm

JERA, R. and AJAYI, O.C. 2008. Logistic modelling of small-holder livestock farmers' adoption of tree-based fodder technology in Zimbabwe. *Agrekon* 47:379-393.

KHUNDHLANDE, G., GROENEWALD, D.C., BAIPHETHI, M.N., VILJOEN, M.F., BOTHA, J.J., VAN RENSBURG, L.D., and ANDERSON, J.J. 2004. Socio-Economic Study on Water Conservation Techniques in Semi-Arid Areas. Report No. 1267/1/04. Water Research Commission, Pretoria.

LI, F.R., COOK, S., GEBALLE, G.T. and WILLIAM, R.B.J. 2000. Rainwater harvesting agriculture: An integrated system for water management on rain fed land in Chinas semiarid areas. *Ambio* 29: 477-483.

LICHTENBERG, E. 1989. Land quality, irrigation development, and cropping patterns in the Northern high plains. *American Journal of Agricultural Economics* 71:187-194.

MAKHURA, M.T (2001). Promoting market participation in small-scale agriculture in the Northern Province. An outline paper presented at a seminar organised by NIEP, LAPC and the University of Pretoria on market access. Agrivillage, Northern Province Department of Agriculture, Pietersburg.

MONHLA, M.A. 2009. Economic analysis of indigenous chicken keeping system in the rural areas: a case study of Ga-Mothiba village in the Limpopo Province of South Africa. Unpublished M.Agric Thesis, University of Limpopo, South Africa.

MOORE, H and VAUGH, M. 1994. Cutting down trees: gender, nutrition, and agriculture change in the Northern Province of Zambia, 1890-1990. Hienemann and London, James Currey Ltd.

MUGWE, J., MUGENDI, D., MUCHERU-MUNA., MERCKX, R., CHIANU, J. and VANLAUWE, B. 2008. Determinants of the decision to adopt integrated soil fertility management practices by small-holder farmers in the central highlands of Kenya. *Experimental Agriculture* 45:61-75.

MUTEKWA, V. and KUSANGAYA, S. 2006. Contribution of rainwater harvesting technologies to rural livelihoods in Zimbabwe: the case of Ngundu ward in Chivi District. *Water South Africa* 32:437-444.

NAKHUMWA, T.O. and HASSAN, R.M. 2003. The adoption of soil conservation technologies by smallholder farmers in Malawi: A selective TOBIT ANALYSIS*.* *Agrekon* 42:271-285.

NEGATU, W., and PARIKH, A., 1999. The impact of perception and other factors on the adoption of agricultural technology in the Moret and Jiru Woreda (district) of Ethiopia. *Agricultural Economics* 21: 205–21

NGIGI, S.N. 2003. What is the limit of up-scaling rainwater harvesting in a river basin? *Physics and Chemistry of the Earth* 28:943-956.

NGQANGWENI, S.S.2000. Promoting income and employment growth in the rural economy of the Eastern Cape through smallholder agriculture. Unpublished Phd draft manuscript. University of Pretoria. Pretoria

OTIENO, F.A.O., and OCHIENG, G.M.M. 2005. Water management tools as a means of averting a possible water scarcity in South Africa by the year 2025. Water SA. Vol.30. no.5

OWEIS, T., HACHUM, A. and KILNE, J. 1999. Water harvesting and supplemental irrigation for improved water use efficiency in dry areas. SWIM paper no.7. IWMI, Colombo, Sri Lanka.

OWEIS, T. and HACHUM, A. 2006. Water harvesting and supplemental irrigation for improved water productivity of dry farming systems in West Asia and North Africa. *Agricultural Water Management* 80:57-73.

PANDEY, S. 1991. The economics of water harvesting and supplemental irrigation in the semi-arid tropics of India, *Agricultural System* 36: 207–220.

PHILLIPS, D., DAOUDY, M., MCCAFFREY, S., O¨ JENDAL, J., and TURTON, A. 2006. Trans-boundary Water Cooperation as a Tool for Conflict Prevention and for a Broader Benefit-Sharing. Phillips Robinson and Associates, Windhoek, Namibia, pp. 249.

PRETTY, J.N., MORISON, J.I.L. and HINE, R.E. 2003. Reducing food poverty by increasing agricultural sustainability in developing countries. *Agriculture, Ecosystems and Environment*. 95:217-234.

PRINZ, D. and SINGH, A.K., 2000. Water Resources in Arid Regions and their Sustainable Management. Annals of Arid Lands. Institute of water resources, Hydraulic and Rural Engineering (IWK). University of Karlsruhe.

QADIR, M., B.R. SHARMA, A. BRUGGEMAN, R. CHOUKR-ALLAH, F. KARAJEH. 2007. “Non-Conventional Water Resources and Opportunities for Water Augmentation to Achieve Food Security in Water Scarce Countries.” *Agricultural Water Management*. 87: 2–22.

QUANTEC. 2006. Limpopo-online Media and Business Directorate. http://www.polokwanecity.co.za. Accessed 2007.

RAMJI, P.N., SHARMA, K.R. and THAPA, G.B. 2002. Adoption of agroforestry in the hills of Nepal: A logistic regression analysis. *Agricultural System* 72:177-196.

REIJ, C., MULDER, P. and BEGEMANN, L. 1988. Water harvesting for plant production. World Bank, Washington. DC. World bank technical paper 91.

REIJNTJES, C, HAVERKORT, B and WATERS-BAYER, A. 1992. *Farming for the Future: An Introduction to Low-External-Input and Sustainable Agriculture*. Macmillan, London.

ROSENZWEIG, M.R. 1978. Schooling, allocation ability and the green revolution. Paper presented at the meeting of the eastern economic association, Washington, DC, USA.

SAVADOGO, K., REARDON, T. and PETIOLA, K. 1994. Determinants of farm productivity in Burkina Faso: implications for policy action to sustain long-term productivity. Staff Paper No. 94-79, Department of Agricultural Economics, Michigan State University, East Lansing.

SAZAKLI, E., ALEXOPOULOS, A. and LEOTSINIDIS, M. 2007. Rainwater harvesting, quality assessment and utilization in Kefalonia Island, Greece. *Water Research* 41:2039–2047.

SCHWEIGMAN, C. 2003. Food security: Opportunities and responsibilities or: the illusion of the exclusive actor: valedictory lecture. University of Groningen, Centre for Development Studies. *Econpaper and Ideas*.

SHIFERAW, B. and HOLDEN, S.I. 1998. Resource degradation and adoption of land conservation technologies in the Ethiopian highlands: a case study in Andit Tid, North Shewa. *Agricultural Economics*. 18:233–247.

SHRESTHA, R.B. and GOPALAKRISHNAN, C. 1993. Adoption and diffusion of drip irrigation technology: an econometric analysis. *Economic Development and Cultural Change* 41:407-418

SIDIBE, A. 2005. Farm-level adoption of soil and water conservation techniques in Northern Burkina Faso. *Agricultural water management* 71:211-224.

SKAGGS, R.K. 2001. Predicting drip irrigation use and adoption in a desert region. A*gricultural Water Management* 51:125-142.

TASSEW, W. 2004. The role of schooling in the alleviation of rural poverty in Ethiopia. In: Proceedings of 25th International Conference of Agricultural Economists (IAAE). 761–770. ISBN 06958-46098-1.

THULAMELA LOCAL MUNICIPALITY. 2009. Spatial Development Framework of the Integrated Development Plan. Thulamela, Limpopo Province. South Africa

TIAN, Y., LI, F.M. and LIU, P.H. 2003. Economic analysis of rainwater harvesting and irrigation methods, with an example from China. *Agricultural Water Management* 60:217–226.

TWDB, 2006. Rainwater harvesting potential and guidelines for Texas. Texas Water Development Board (TWDB).

UNITED NATIONS DEVELOPMENT PROGRAM (UNDP) 2001. Human Development report. Oxford University press, inc., New York.

VINK, N. and KRISTEN, J. 2003. Agriculture in the National Economy. In: L. Niewoudt and J. Groenewald (eds.). The Challenge of Change: Agriculture, Land and the South African Economy. University of Natal Press, Pietermaritzburg, South Africa.

WATER RESEARCH COMMISSION (WRC). 2000. Improving agricultural water management. Report No TT 127/00. Water Research Commission, Pretoria.

WALMSLEY, A. 1995. Greenways and the making of urban form. *Landscape and Urban Planning* 33: 81-127

WIERSMA, D. 1986. Psychological impairments and social disabilities: On the applicability of the ICIDH to psychiatry. Department of Social Psychiatry, State University of Groningen, Netherlands. Disability & Rehabilitation. 8: 3 – 7

WOOLDRIDGE, J.M. 2006. Introductory Econometrics, A Modern Approach. 3rd Edition. Michigan State University, United State of America.

WOYESSA, Y.E. and BENNIE, A.T.P. 2004. Factors affecting runoff and soil loss under simulated rainfall on a sandy Bainsvlei Amalia soil. *Southern African Journal of Plant Soil.* 21: 203 – 207.

ZHU, K., ZHANG, L., HART, W., LIU, M. and CHEN, H. 2004. Quality issues in harvested rainwater in arid and semi-arid Loess Plateau of Northern China. *Journal of Arid Environments.* 57:487–505.

APPENDIX: Questionnaire

SOCIO-ECONOMIC FACTORS DETERMINING RAINWATER HARVESTING TECHNOLOGY ADOPTION FOR CROPLAND PRODUCTIVITY IN LAMBANI VILLAGE : A CASE STUDY OF THULAMELA LOCAL MUNICIPALITY OF VHEMBE DISTRICT IN LIMPOPO PROVINCE

The questionnaire is part of a master's dissertation on in-field rainwater harvesting technology adoption for households. All information you provide in this questionnaire are confidential. The information will be used for research purpose only.

Researcher: Khumo Terezan Badisa (200307207)

University of Limpopo (Turfloop campus)

Department of Agricultural Economics and Animal Production

Sovenga

0727

Questionnaire No: ………………………………..

Name of Enumerator: …………………………….

Village of Household: …………………………….

Date of Interview: ………………………………...

SECTION 1: **Socio- economic characteristics**

1. What is the household head's full name: ………………………………….

2. Gender of the household head?

Male	Female
1	2

3. Age of the household head? …………………………….

4. Experience as a farmers (indicate no of years) ………………..

5. What is the marital status of the household head?

Married	Widowed	Divorced	Single
1	2	3	4

6. How many years did the household head go to school?

0	1- 4	5 -7	8-10	11-12	Tertiary
1	2	3	4	5	6

7. What is the main occupation of the household head? (One answer possible)

Farmer full time	Part-time farmers	pensioner	Employed private company	Self-employed	unemployed
1	2	3	4	5	6

8. What is the level of income per month?

< 500	500-1000	1100-1500	1600-2000	2100-3000
1	2	3	4	5

9. How many people are in your household, living together?

………………………...

10. What is the household level of education?

……………………………………………………………………………

SECTION 2: **Agricultural Production**

1. How much land do you have? ....Morgen or ....Hectares

2. Do you own land which you use for ploughing?

Yes		No	

2.1 If no, how did you acquire the land that you are farming on?
…………………...

3. Did you pay any money to acquire the land?

Yes		No	

3.1 If yes, how much per ha? ……………….

4. Which crops were planted during the past year (2008/2009?)

Crop	Area planted	Amount harvested in 2008/09 (kg or ton)
1		
2		
3		
4		
5		

5. What do you use to plough?

Hire tractor	Own tractor	Hire plough and livestock	Own plough and livestock	Hoe
1	2	3	4	5

6. If you hire tractor, how much does it cost per ha?

....

6.1. If you don't pay money, how do you pay for hiring the tractor?

……………………………..……………………………………………………

………………………………………………………………………………………

7. How many people are working in your farm?

……………………………………….

8. Do you hire labour for farming?

Yes		No	

8.1 If yes, how much do you pay them per day?

……………………………

8.2 If you do not pay, how do you compensate for the labour?

...............................……………………………………………………………

9. How many people did you hire? ……………..

Complete the following table about crop inputs in 2008/09

Inputs		In Rands
10. Did you buy any seed for crops	Yes/no	How much? ....
11. Did you buy any fertilizer	Yes/no	How much? …………..
12. Did you buy any pesticides	Yes/no	How much? …………..
13. Did you pay for ploughing	Yes/no	How much? ………..

14. What problems do you face growing crops in this area?

Drought	Difficult to get inputs	pests	Soil fertility	Labour shortage	Theft	Other (specify)
1	2	3	4	5	6	7

7: other ………………………………………………

15. Do you sell some of the crops you produce?

Yes		No	

15.1. If yes where do you sell? ……………………………………………

15.2. If no why ……………………………………………………………..

SECTION 3: **Agricultural Water Access**

1. Water source:

	Which of these water sources do you use?	What is the main use of this water?	Distance from water source to household? km
1. tap water			
2. public stand pipe			
3. well/bore holes			
4. river water			
5. spring			
6. dam/stagnant water			
7. public water			
8. rainwater			
9.Rainwater harvesting			

2. What is your main water source?

....

3. Do you practice rain water harvesting?

Yes		No	

4. How do you harvest the water?

……………………………………………………………………………………………

……………………………………………………………………………………………

5. Where do you get information on rainwater harvesting?

....……………………………………………………

……………………………………………………………………………………………

6. Are you interested in rainwater harvesting?

Yes		No	

6.1. If no. why?

…………………………………………………………………………………..

7. Do you know anyone who practices rainwater harvesting?

Yes		No	

8. Why do you think rainwater harvesting could be good if practiced here?

...............................………………………………………………………………………

……………………………………………………………………………………………

9. What are some of the problems faced here in rainwater harvesting?

……………………………………………………………………………………………
…………………………………..……………………………………………………

10. Which of these types of farming do you practice?

Rainfed farming	Irrigated farming	Both
1	2	3

11. Do you have garden or irrigated field?

Yes		No	

11.1. If yes, what is your source of water for irrigation?

River/stream	Tap water	Bore hole	Spring	Rainwater
1	2	3	4	5

12. Which method do you use under irrigation?

Sprinkler	Furrow	Drip	Center pivot	Rotation
1	2	3	4	5

13. Which crops do you grow under irrigation?

Crop
1
2
3
4
5

14. What is your total land area under irrigation?

………………………………………...

15. Which method are using for rainwater harvesting?

....………………………………………………………

………………………………………

16. And which crops are for rainfed method?

Crop
1
2
3
4
5

17. What is your total land area under rainfed farming?

………………………………………………………………………………………..

18. Do you have contact with extension officer?

Yes		No	

18.1. If yes how many times per month? …………………..

19. Do you have access to prices of crop, input suppliers information?

Yes		No	

19.1. If yes, source of information on crop prices

……………………………………………………………………………

19.2. Source of information on input supplier and their prices

………………………………………………………………………………………
………………………………

10. Do you receive financial services?

Yes		No	

10.1 If yes, how often? ……………………………………………..

11. Is erosion a problem in this area?

Yes		No	

12. Do you feel that rainwater harvesting will have positive effect on crop production?

Yes		No	

13. Do you belong to any farmer's organization?

Yes		No	

13.1. If yes which organization do you belong to?

……………………………………………………………………………..

13.2. When did you join the organization in years?

…………………………………………………………………………………..

THANK YOU FOR YOUR TIME

GOD BLESS