A COMPARATIVE ANALYSIS OF MAIZE TECHNICAL EFFICIENCY BETWEEN A1 RESETTLEMENT AREAS AND COMMUNAL AREAS IN GOROMONZI DISTRICT, MASHONALAND EAST PROVINCE

by

CHARITY NYASHA DANGWA

A Thesis Submitted in Partial Fulfilment of the Requirements of the Master of Science Degree in Agricultural and Applied Economics

Department of Agricultural Economics and Extension
Faculty of Agriculture
UNIVERSITY OF ZIMBABWE

DECEMBER 2011

FACULTY OF AGRICULTURE

DECLARATION

I declare that the ideas, experimental work, results, analyses, software and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also declare that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

The undersigned certify that they have read, and recommended to the Department of Agricultural Economics and Extension for acceptance, the thesis entitled;

A COMPARATIVE ANALYSIS OF MAIZE PRODUCTION EFFICIENCY BETWEEN A1 RESETTLEMENT AREAS AND COMMUNAL AREAS IN GOROMONZI DISTRICT, MASHONALAND EAST PROVINCE

Submitted by **CHARITY NYASHA DANGWA** in Partial Fulfilment of the Requirements of the Degree of **MASTER OF SCIENCE IN AGRICULTURAL AND APPLIED ECONOMICS**

Approved by;

Principal Supervisor ……………..............
Dr A. Zvinavashe

Associate Supervisor................................
Mrs N. Muzamhindo

Chairperson …………………………………
Dr. J. Mutambara

Date……………………………….

ACKNOWLEDGEMENTS

First and foremost let me praise and honor the Almighty God for the opportunity and capacity given to me to realize my aspiration.

This thesis is a result of many experiences I have encountered during my masters programme from dozens of remarkable individuals who I wish to acknowledge.

I start where the most basic source of my life energy resides: my family-my husband, my mother and late father, my brothers and sisters. I have an amazing family whose support has been unconditional all these years. They have cherished with me every great moment and supported me whenever I needed it. I thank them.

I am heartily thankful to my supervisors, Dr. A. Zvinavashe and Mrs N. Muzamhindo, whose guidance, support and constructive criticisms from the initial to the final level enabled me to better understand the subject. They contributed substantially to the writing, organizing, and editing of this thesis. Besides my supervisors, Dr. S. Siziba played an integral part in decoding the dissertation data and getting it working. I would pester him for more information, and he still provided his support with patience.

I also gratefully acknowledge the institutional support that I have received while working on this thesis. I thank the African Agricultural Economics Education Network (AAEEN) for their initiative, Collaborative Masters Program in Agricultural and Applied Economics (CMAAE) and the funding they provided for this study. They have made my dream to pursue further studies a reality. I also thank Professor Sam Moyo together with the management of African Institute for Agrarian Studies (AIAS) for financial support during the first year of my masters program. Prof Moyo’s concern for graduate training and the future of research, his strong opinions and his willingness to share them, have been great assets to me. He has always been willing to engage ideas and to invest his time (which is scarce) and his energy (which is abundant) in improving others' work.

I also extend my gratitude to members of the Department of Agricultural Economics and Extension, University of Zimbabwe for they always extended a helping hand whenever needed. Not forgetting my friends, for they understood me when I told them I was ‘unavailable’. Lastly, I offer my regards and blessings to any other individuals who supported me in any respect during this study.

ABSTRACT

This study sought to establish the differences in technical efficiency levels between A1 and communal farmers in Goromonzi District, Mashonaland East Province. Detailed survey data was obtained from 100 farmers in Goromonzi District for the 2010/2011 agricultural season. Goromonzi was purposively selected because being located in agro-ecological region II, has historically been highly diversified and productive for both commercial and communal farmers The study aimed to answer the following questions: How socio-economically different are A1 farmers from the communal farmers? What factors influence production efficiency of both A1 and communal farmers? How different is the production efficiency of A1 farmers from communal farmers? How efficient are smaller farms relative to larger ones?

In order to achieve the broad objective of the study, a detailed literature review was carried to understand the relationship between output and farmers production. Analytical tools employed include descriptive statistics, ordinary least squares, maximum likelihood estimations, regression analysis and the stochastic frontier production. The results from the survey showed that that the mean levels of technical efficiency are 63.5 percent and 80.5 percent for A1 and communal farmers respectively suggesting existence of substantial gains in maize yield.

The efficiency differences were explained significantly by soil fertility, education level, agricultural training, and cattle ownership for A1 farmers. In the communal areas, technical efficiency levels were explained significantly by age, education, agricultural training, cropped area and cattle ownership. It was recommended that government, in providing assistance to the two groups of farmers need to be group-specific. Results emphasise agricultural extension and farmer-education programmes as key policy instruments for governments seeking to improve efficiency. Study results showed that farmers located in fertile soil areas showed higher levels of technical efficiency than those in less fertile areas. Coordinated effort to promote effective soil management was recommended to improve and maintain soil productivity. Cattle ownership was shown to have a positive impact on technical efficiency. It was therefore recommended that government designs appropriate policy for improving cattle production systems in Zimbabwe by solving the shortage of feed and health problems among other problems.

ACRONYMS

AP	Average Product
CA	Communal areas
COLS	Corrected Ordinary Least Squares
DEA	Data Envelopment Analysis
FAO	Food and Agricultural Organisation
FTLRP	Fast Track Land Reform Programme
GoZ	Government of Zimbabwe
GDP	Gross Domestic Product
LSCF	Large Scale Commercial Farms
MP	Marginal Product
MLE	Maximum Likelihoods Estimates
RTS	Returns to Scale
SFA	Stochastic Frontier Analysis/Approach
TE	Technical Efficiency

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CHAPTER 1: INTRODUCTION

1.1 Background to Study

Zimbabwe has gone under immense social and economic change over the past decade. A general principle for many Government of Zimbabwe (GoZ) policies was to bring the previously excluded black community into the mainstream economy through job creation and entrepreneurship. As part of the Zimbabwe agricultural policy, the government undertook the Fast Track Land Reform Programme (FTLRP) to de-racialise ownership of the large-scale commercial farm (LSCF) sector by encouraging participation by blacks. Compulsory acquisition was largely made from white commercial farmers, private companies, and absentee landlords.

The FTLRP redistributed about 80 percent of the former LSCF to a broad base of beneficiaries leaving most land in Zimbabwe under small-scale farming, either as communal areas (CA) or resettlement (Moyo *et al*., 2009 and Scoones *et al*. 2010). The overall pattern of land distribution and agrarian structure has changed beyond recognition. The creation of a number and array of small, medium and large scale farms resulted in the classification of land into several models, one of which is the A1 model[1]. Model A1 was targeted at land-constrained farmers in communal areas with the intention of decongesting communal areas. The bulk of the FTLRP is based on Model A1 with an estimated 146,000 households having acquired 70 percent of the transferred land (Moyo, 2011). The major thrust for the A1 resettlement scheme was to achieve the policy goal of ensuring food security at the household level for small farmers (GoZ, 2000).

[1] Other classifications include the most traditional (communal) model, white commercial, institutional (parastatals, estates etc), A2 among others

Maize is the most important cereal crop grown in Zimbabwe. It ranks first in number of producers, area grown and total cereal production (Mashingaidze, 2004). As the country's main crop, it was a major enterprise on large-scale and small-scale farms before the FTLRP, and it still continues to be valued as a major crop by new farmers even after the implementation of the program. Maize exhibits year-to-year variations according to rainfall, so the maize industry has moved through great cycles of surplus and shortfall before the land reform and after. The GoZ policy objective for the maize sub-sector is to encourage increased production so that self-sufficiency and food security can be achieved. Shortage of maize in Zimbabwe results in malnutrition among the poor urban and rural households.

During the FTLRP, some reorganization took place in the CAs. A large group of the people who relocated as a result of the program was hopeful of starting a better life, with higher agricultural production than they were experiencing in the CAs. Thus the production of maize would have been expected to increase partly because of this reason. The other reason why an increase in production was expected was because those farmers that were landless in CAs also benefitted from the program thereby increasing the total number of farmers who were producing maize. These new settlers moved to former commercial areas which had better soils for production than in the traditional CAs.

Whilst the FTLRP is slowly beginning to be accepted as a fact, debate still continues on its ability to resuscitate the economy. It questions the newly resettled farmers' capability to restore the country to its bread basket status. The argument is that the new farmers have no capacity to fully utilize land, to produce diverse crops including specialized high value export commodities such as tobacco and horticultural crops, to realize high yields and to efficiently use inputs ranging from machinery to labour (Moyo and Chambati, 2007:13). In order for informed answers to be provided to this debate there needs a thorough evaluation of the emerging agrarian structure. However, this thorough assessment of the emerging agrarian structure, the new agrarian relations, and the wider social relations of production in the countryside has so far been constrained by the narrow base of available empirical data (Moyo *et al*., 2009). A few independent social surveys of the newly resettled areas have been carried out highlighting the impact of such a huge programme as the FTLRP. These include GoZ assessments, (Buka Report, 2002; Presidential Land Review Committee, 2003), Chaumba *et al*., (2003), Wolmer *et al*. (2003, 2004), Marongwe, (2008), Murisa, (2009), Jowah, (2010) and Chambati (2010).

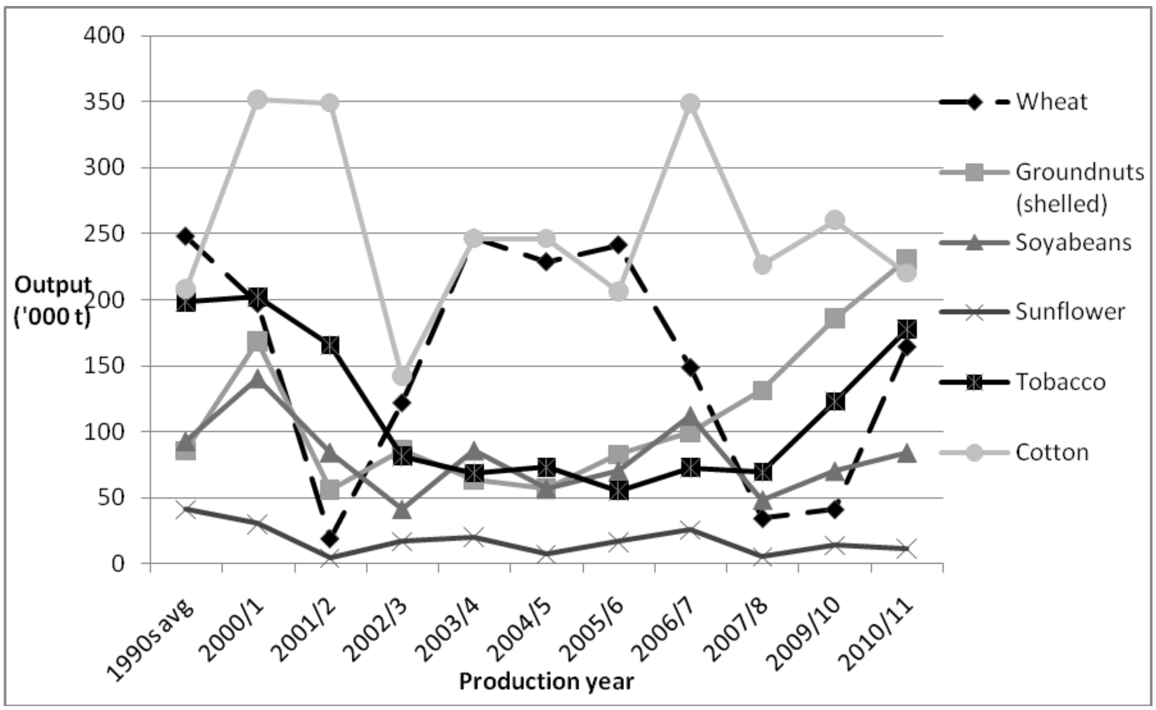
1.2 Problem Statement

Since the implementation of the FTLRP, Zimbabwe experienced reduced food and export crop production both in terms of value and volume, reduced agricultural foreign currency generation and shrinking agricultural growth (Moyo *et al*., 2003 in Utete Report, 2003; World Bank, 2006; Volume 2; Richardson, 2007a; Richardson, 2007b; Zikhali, 2008; Matshe, 2009; Moyo *et al*., 2009; Kapuya *et al*., 2010). The economy witnessed a shift from which the agricultural sector once employed more than 70 percent of the labour force; between 9 percent and 15 percent constitution of the Gross Domestic Product (GDP); and between 20 percent and 33 percent of export earnings to relatively less (Zikhali, 2009; World Bank, 2004). It is noted that by 2004, the economy contracted by 30 percent (Richardson, 2004). The reduced pattern of production led to various degrees of shortages of goods for domestic consumption markets and in exports earnings, both of which contributed significantly to the high levels of inflation (monetary and fiscal policy instability), food insecurity and unemployment (Richardson, 2004).

The levels of decline in crop production have been varied among commodities and in different regions, while the outputs of some crops such as cotton predominately grown by the smallholder sector was stable and/or increased (Moyo *et al*., 2009). During the FTLRP period, agricultural production declined less in the communal and resettled areas, despite the adverse economic condition (Moyo, 2011). Especially resilient were cotton, groundnuts and beans, with declines of less than 15 percent in non-drought years. Wheat, tobacco, soybeans and sunflower, experienced reduced area plantings and output levels due to low uptake and use of land as well as inexperience and lack of resources on the part of new farmers in the early years of the FTLRP (Zikhali, 2008). As is highlighted in Fig 1.1 and Fig 1.2, the production of the main food grains such as maize and wheat declined variably, to between 35 percent and 65 percent of past output levels (Moyo, 2011). Fig 1.1 shows that overall cereal output dropped sharply from 2001 to 2003, then stalled at low levels from 2004 to 2006, only to drop sharply again during the hyper-inflation to around 2007. On average, cereal production levels in the 2000s were between 30 percent and 65 percent of national requirements, depending on whether it was a drought year (Moyo, 2011).

Tobacco production plummeted from a peak of 230 million tonnes in 1989/9 to a low 55,000 tonnes in 2005/6, down from five times that of 2000. Its production has been recovering in recent years owing to the dominance of the newly resettled farmers. The main force driving the change has been the extension of contract farming by tobacco companies and buyers, which have provided training and inputs for black farmers as they seek to boost output of the Zimbabwean leaf (England and Hawkins, 2011). The changes observed in agricultural production patterns since 2000 reflect differentiated forms of financing and marketing of agriculture, and the priorities of the differentiated classes of farmers in the new agrarian structure within the diverse land use potentials under varied agro-ecological and market conditions (Moyo, 2011).

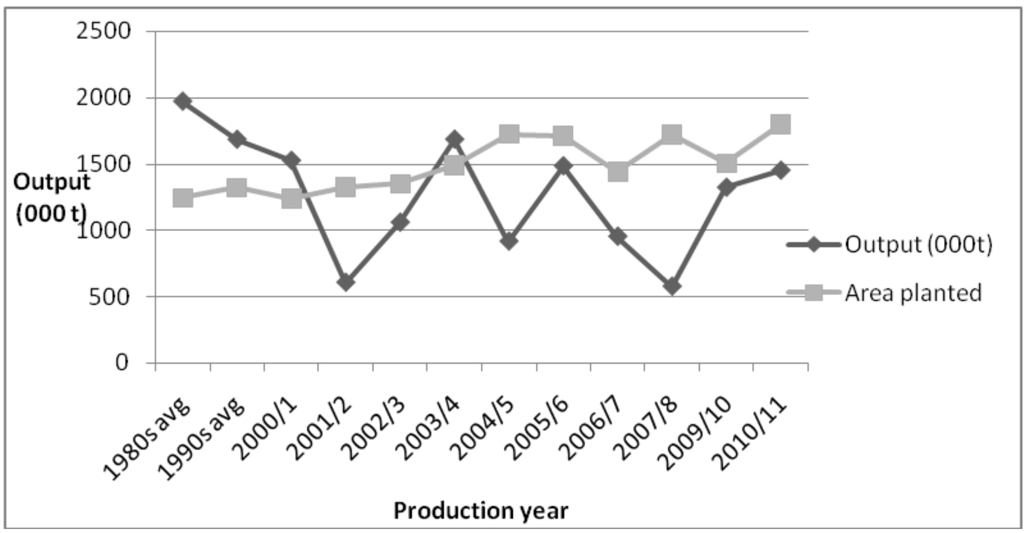
Fig 1.1: National crop production trends: 1990s average versus 2000s



Source: GoZ, 2011; Moyo, 2011

Fig 1.2 shows the cyclical trends in maize production that took place since the year 2000 against 1980s and 1990s average. In general, maize output levels during the 2000s period were lower than the 1980s and 1990's average. Post-Independence, maize production by communal farmers experienced a sharp increase as a result of increased area cropped. Communal land maize production surpassed large-scale commercial production in 1984 and this scenario was maintained in many seasons. In 1991, the total communal, resettlement and small-scale commercial contribution to the Grain Marketing Board intake was 60 percent, a sharp increase from 7.6 percent in 1979/80 level (Mashingaidze, 2004). The seasons of drought from 1981/82 to 1983/84; 1991/92 to 1992/93 and 2001/2002 to 2002/2003 reduced maize production to lower than the national requirements. Thus, the GoZ then resorted to emergency grain imports and food aid to curtail food shortages.

Fig 1.2: National maize production (1990-2007)

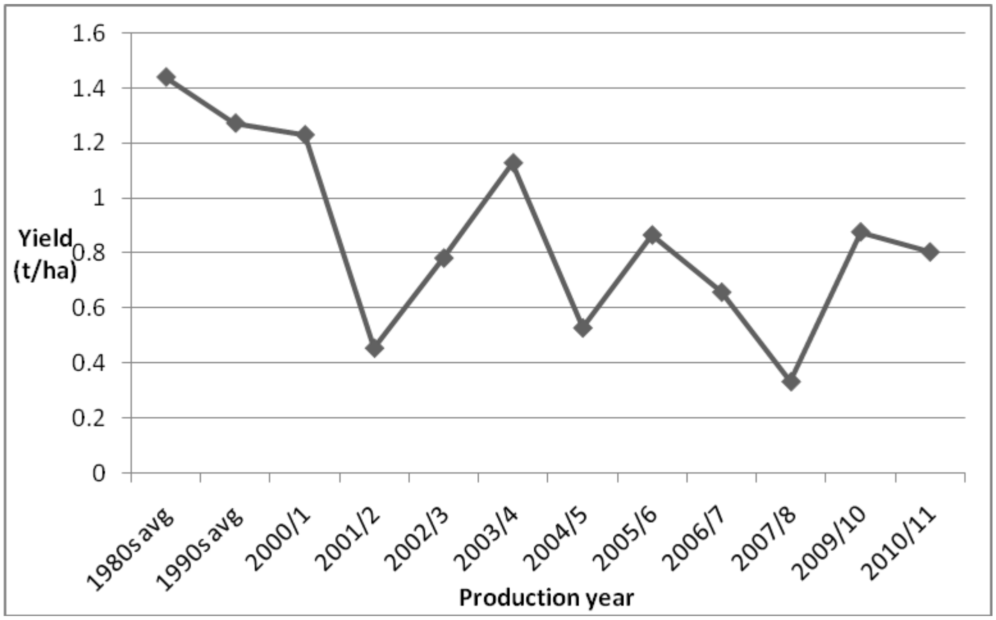


Source: GoZ, 2011; Moyo, 2011

Maize is the most cultivated crop in the small-scale farming sector, contributing about 50 percent of the arable land in most years (Mashingaidze, 2004). The 1980s period experienced a growth in area planted under maize. Most of the increase in communal maize production in the first two years of Independence resulted in the expansion in the area under maize because of the return of war refugees and war returnees to their original communal homes (Ibid). This resulted in the increase in number of cultivators and the land under cultivation. During the 2000s period there was an observed decline in maize output despite the marginal increase in area planted (SAT, 2008, Zikhali, 2008). However, in the past three years maize production has been slowly rising from the lows as shown in Fig 1.2. Some experts argue that growth levels for maize production are likely to remain depressed for some time to come unless prices for the commodity improve and payments for the commodity to farmers by GMB are made on time.

Total area harvested for maize reached a high of 1.8 million ha in the 2010/11 agricultural season, as shown in Fig 1.2. This represents a 20 percent growth over the previous season. Given the early start of the rains and with an even distribution of precipitation for the first two months of the season in the 2010/2011 agricultural season, there was an extended planted period in some provinces, particularly Mashonaland West where area planted expanded by 35 percent over last season’s level, which is cited as an additional factor attributed to the expansion (FAO, 2010). The stability of the economy also enabled farmers to prepare and plan for the 2009/10 and 2010/11 seasons, due to the lower risks that are associated with steep inflation rates (FAO, 2010). Farmers increased their acreage through utilizing previous fallow arable land (FAO, 2010).

Fig 1.3: National maize yields (1990-2008)



Source: GoZ, 2011; Moyo, 2011

Fig 1.3 shows trends in 2000s maize yields against 1980s and 1990s averages. Maize yields increased significantly in the communal lands after 1980, thus the high yield average for the 1908s period. Maize yields were about 0.7 tonnes/ha in 1980 in the communal areas (Tattersfield, 1982). The adoption of high-yielding technology, complemented by credit and input availability, and increased support services were mainly responsible for the sharp increases in communal land maize yields after independence. The national yield in 2003/04 was about 1 to 1.5 tonnes/ha in predominantly dryland farming areas (Mashingaidze, 2004). Maize yields were in their lowest in the 2000/1, 2004/5 and 2007/8 years. This may have been caused by a delay in the distribution of fertilizers during these years. Fertilizer use was not sufficient to cover all the planted areas; therefore farmers practiced extensive farming methods rather than intensive. Nationally, maize yields decreased to 0.75 tonnes/ha, from 0.82 tonnes/ha recorded in the 2009/10 season.

With indications that population growth is increasing in less developed countries such as Zimbabwe, future increase in maize production will heavily depend on yield improvement rather than expansion in area under production. It is important to note however that analysis of the maize sector after the land reform programme is complex, not only because of a combination of other policy factors that have come into play since the programme, but also because of policy and non-policy factors that affected the agricultural sector in Zimbabwe during this period.

1.4 Research Objectives, Hypotheses and Questions

Research Objectives

The broad objective of this study therefore is to analyze the production efficiency of maize by newly resettled A1 resettlement farmers and communal farmers from the district of Goromonzi, Mashonaland East province, Zimbabwe. The performance of the newly resettled farmers is compared to the production efficiency of communal farmers.

In order to achieve this broad objective, the following specific objectives are made;

i. Determine socio-economic characteristics of both A1 resettlement farmers and communal farmers;
ii. Estimate the functional relationships of socio-economic factors that influence production efficiency in both the A1 resettlement farms and communal areas;
iii. Compare production efficiency differences between the A1 resettlement farmers and communal areas; and
iv. Test the inverse relationship between cropped area and production efficiency.

Hypotheses

To achieve the above specific objectives, the following hypotheses are tested;

i. There are significant socio-economic characteristics different between both A1 resettlement farmers and communal farmers;
ii. Technical efficiency of both A1 resettlement farmers and communal farmers is positively related to levels of education, agricultural training, age, access to assets, better soil types, residency of farmer on the farm and negatively related to farm size within each category of farmers;
iii. A1 resettlement farmers produce maize more efficiently than communal farmers; and
iv. Small-land holding farmers are more efficient than the large land-holding farmers.

Research questions

To achieve the above stated minor objectives, the study will answer the following research questions;

i. What socio-economic characteristics are different between A1 resettlement farmers and communal farmers?
ii. What factors influence technical efficiency of both A1 resettlement and communal farmers?
iii. How different is the technical efficiency of A1 resettlement farmers from communal farmers?
iv. How efficient are smaller farms relative to larger ones?

1.5 Justification and Expected Contribution of the Study

Despite the fact that technical efficiency of smallholder farmers has extensively been studied in many African countries, it is still a great area of concern. Technical efficiency measurements have huge relevance for policy intervention. Zimbabwe's economy highly hinges on rain-fed traditional agriculture, with inadequate resources and limited opportunities for developing and adopting better resources. Thus technical efficiency measurements are important as they assist in reducing inefficiencies which hamper productive growth. Technical efficiency measurements help to benefit traditional economies, as policy intervention may need to have a prior information as to how farmers are operating; what factors affect their production; what inputs are important in their farming operations; and how the current technology is operating (Bamlaku *et al*., 2002)

This paper aims at contributing to the thin literature that focus on the country's land reform programme, by assessing the performance of farmers post-FTLRP. It investigates the performance of maize producing farmers in the A1 resettlement areas in comparison with the traditional communal farmers. It identifies the underlying factors influencing technical efficiency. Comparison is made between the groups because Model A1 resettlement farmers are fairly comparable to existent communal farmers.

1.6 Organization of the Rest of the Thesis

Chapter 2 reviews literature on the economics of crop production and technical efficiency. The first part of literature review looks at theories of farm production and farm production efficiency. The chapter further shows the basic theory of production. The chapter further looks at production efficiency measures and methods used to estimate these efficiency measures. It looks at the several methods, their pros and cons so as to give a platform to choose the methods for use in this study. The chapter further looks at methods used to measure production efficiency and technical relationships between the factors of production and output. The chapter concludes by discussing lessons which have been learnt from the literature. These lessons are learnt from synthesizing results from different studies on production and production efficiency.

Research methods which are going to be used to test the hypotheses which were raised in Chapter 1 are highlighted in Chapter 3. The chapter looks at methods used to measure technical efficiency, and technical relationships between the factors of production and output. These relationships are discussed within a conceptual framework surrounding production and technical efficiency. The chapter illustrates the relationship that exists between factors of production and efficiency. The chapter also lays out the analytical framework that has been selected for the study. The chapter further discusses how sources of data and how the data was collected.

The fourth chapter, Chapter 4, describes the general socio-economic characteristics of the A1 resettlement farmers and communal farmers. The chapter also analyses the characteristics of the qualities that otherwise influence agricultural production of these farmers. The general agricultural activities that are carried out by farmers that influence maize production are also discussed in this chapter. A comparative analysis is also made between A1 resettlement farmers and communal farmers in maize production, focusing on their maize yields and how they are utilizing the area of land that they possess. The chapter is described to provide a basic foundation for Chapter 5, which specifically analyses the differences in technical efficiency between the farmers from the different models.

Chapter 5 specifies the model that was used to estimate measurements of technical efficiency levels for A1 resettlement farmers and communal farmers in Goromonzi District, Mashonaland East Province, Zimbabwe. In discussing the model specification that is used for the study, the advantages of using the model to estimate the parameters are also provided. The variables that are analyzed in the study are also defined. This chapter also determines presence of inefficiency in the production input-output data for the sample households. The chapter calculates values of the parameters that were set out to be estimated at the start of the study. The technical efficiency levels for each individual farmer are also calculated in this chapter and comparisons area made between the two farming models, A1 resettlement areas and communal areas. The chapter then finally analyses the socio-economic factors that influence inefficiency in maize production Goromonzi District by the A1 resettlement farmers and communal farmers.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature on the economics of crop production and technical efficiency. This chapter compares analysis of production trends and technical efficiency of smallholder farmers in general. The first part of literature review looks at theories of farm production and farm production efficiency. The process of process of production and technical efficiency are defined in this chapter. The chapter further shows that the basic theory underlying production.

Furthermore, the chapter looks at production efficiency measures and methods used to estimate these efficiency measures. The chapter shows the several alternative approaches which can be used to measure technical efficiency. The chapter looks at the several methods, their pros and cons so as to give a platform to choose the methods for use in this study. It further looks at methods used to measure technical efficiency and technical relationships between the factors of production and output. These methods used in different studies are shown to construct a production frontier indicating maximum production attainable under current conditions and technology, and evaluate production for each unit. Several studies that have been done to measure the performance of farmers against different production variables are discussed.

The chapter concludes by discussing lessons which have been learnt from the literature. These lessons will be learnt from synthesizing results from different studies on production and production efficiency. The studies were carried out by different authors, making use of different methods, aimed at different research objectives.

2.2 Theory of Farm Production and Farm Production Efficiency

Production is the processes and methods employed to transform tangible factors/resources or inputs (raw materials; semi-finished goods; or subassemblies) and intangible inputs (ideas, information, knowledge) into goods and services or output (Oluwatayo *et al*., 2008). These resources can be organized into a farm or producing unit whose ultimate objectives may be profit maximization, output maximization, cost minimization or utility maximization or a combination of the four (Oluwatayo *et al*., 2008). In this production process the farmer may be concerned with efficiency in the use of factor inputs to achieve technological or economic efficiency. The economic efficiency occurs when the cost of producing a given output is as low as possible. The objective of efficiency provides us with some basic rules about the manner in which firms should utilize inputs to produce goods and services (Oluwatayo *et al*., 2008). Thus productive efficiency is defined as the ability to produce a good using the fewest resources possible.

The basic theory of production is thus simply an application of constrained optimization. The farm-unit attempts either to minimize the cost of producing a given level of output or maximize the output attainable with a given level of costs (Oluwatayo *et al*., 2008). Both optimization problems lead to the same rule for the allocation of inputs and choice of technology. Since there are alternative means of attaining the production goals i.e. the theory of production presents the theoretical and empirical framework that facilitates a proper selection among alternatives so that any one or a combination of the farmer's objectives can be attained (Ibid).

Certain parameters have to be known for one to understand how farmers make their decisions that enable them to attain their goals. These parameters can be shown through a production function, which shows the technical relationship between factor inputs and outputs involved in the production process. The production process is normally specified as;

$$Q = f(X_1, X_2, \ldots X_n) \tag{1}$$

where Q represents a farmer's output and $X_1 \ldots Xn$ represents the production inputs used by the farmer. These inputs may include labor, fertilizers, seeds and land.

Given the production function, production efficiency measures can be computed as;

$$AP = \frac{f(X1, X2, \ldots Xn)}{X} \quad \text{and} \quad MP = \frac{dQ}{dX} = f^1(X) \tag{2}$$

where AP is average product and MP is marginal product. Together with the returns to scale (RTS) concept the AP and MP help the farmer in determining the use of resources and the pattern of outputs which maximize farm profits. The RTS concept shows how output responds to increase in all inputs together. RTS can either be constant, increasing or decreasing. These parameters can be derived for the various forms of production function – exponential, power, semilog and applied to both long and short run productions (Oluwatayo *et al*., 2008).

Efficiency has always been on the agenda of economics literature, with all its aspects (Dudu, 2006). There is vast literature that tries to figure out the underlying reasons of efficiency. For example, Smith (1776) analyzed the relationship between land tenure and economic efficiency in the Wealth of Nations. The work of Cowles Commission on the formulation of Neo-Walrasian production theory also provides the root of efficiency analysis. However, recognition of the need to define and analyze efficiency in economics is relatively belated (Ibid). The attempts to shed light on the role of efficiency in the production theory started to develop "non-homogeneously" after the 1950 (Fare *et al*., 1985). Koopmans, Debreu, Vincze and Eichron were pioneers of the modern approach that was formally stated by M.J. Farrell (1957). Farrell's seminal paper, in one way or the other, was the basis of all approaches developed by modern productivity literature. It is possible to find the roots of all approaches and methods developed in the last 30 years in Farrell's paper (Førsund and Sorofoglou, 2000). The last three decades again are also in which the popularity of efficiency analysis developed due to the rapid development in "calculation methods" (Dudu, 2006). The tools used in efficiency measurement, namely stochastic frontier analysis (SFA) and data envelopment analysis (DEA), offer highly advanced, but easy to implement procedures for economists. The former employs econometric methods while the latter make use of linear programming as will be discussed further.

The analytical framework that lies behind the efficiency measurement model is mainly developed by Farrell (1957). Farrell (1957) organized the ideas of Koopmans (1951), Debreu (1951) and Shephard (1953) to form an efficiency measurement framework. Although Farrell (1957) did not cite Shephard, his definition of efficiency utilizes the properties of distance functions (Dudu, 2006). He combined the activity analysis of Koopmans and Debreu with the distance function idea of Shephard to obtain an analytical definition of efficiency (Dudu, 2006). He decomposed efficiency into three components: technical, allocative and economic (Kibaara, 2005). Farrell proposed an approach that distinguishes between technical and allocative efficiency. Technical efficiency refers to the ability of producing a given level of output with a minimum quantity of inputs under a given technology (Omonona, *et al*., 2010). Allocative efficiency is the farmer's ability to achieve the optimal mix that is, having the right and efficient combination of inputs that gives optimal outputs (Oluwatayo *et al*., 2008). However, both Kibaara (2005) and Omonona *et al.* (2010) factor in the issue of factor prices within the definition of allocative efficiency. According to Kibaara (2005), allocative efficiency deals with extent to which farmers make efficient decisions by using inputs up to the level at which their marginal contribution to production value is equal to the factor costs. Omonoma *et al*. (2010) define it as the choice of the optimal inputs proportions given relative prices. Economic or total efficiency refers to the product of technical and allocative efficiency.

As a component of productive efficiency, technical efficiency is derived from the production function (Chirwa, 2007). Productive efficiency consists of both technical and allocative efficiency. Productive efficiency represents the efficient resource input mix for any given output that minimizes the cost of producing that level of output or, equivalently, the combination of inputs that for a given monetary outlay maximizes the level of production (Ibid). Developments in cost and production frontiers are attempts to measure productive efficiency as proposed by Farrel (Chirwa, 2007). The frontier defines the limit to a range of possible observed production (cost) levels and identifies the extent to which the firm lies below (above) the frontier (Chirwa, 2007). The level of technical efficiency of a particular firm is characterized by the relationship between the observed and some ideal or potential production (Oluwatayo *et al*., 2008). The measurement of firm specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier (Oluwatayo *et al*., 2008). If a firm's production point lies on the frontier, it is perfectly efficient, if it lies below the frontier, then it is technical inefficient with the ratio of the actual to potential production defining the level of technical efficiency of the individual firm (Oluwatayo *et al*., 2008). Technical efficiency is just one component of overall economic efficiency. However, for a firm to be economically efficient, a firm must be technically efficient (Oluwatayo *et al*., 2008).

Farrell’s model, which is known as a deterministic non-parametric frontier, attributes any deviation from the frontier to inefficiency and imposes no functional form on the data. The work of Farrell was subsequently adjusted and extended by a number of authors – Aigner and Chu (1968), Afriat (1972), Richmond (1974), Schmidt (1980), and Greene (1980) among others (Ajibefun, 2008; Omonona *et al*., 2010) based on the fact that the empirical applications on efficiency measurement encompassed both DEA and SFA methodologies. DEA applications depended on Aigner and Chu (1968) (Dudu, 2006). They developed a deterministic model by introducing Cobb-Douglas function as a benchmark and using linear and quadratic programming to find the efficient frontier (Førsund and Sorofoglou, 2000). Chu, Seitz, Timmer, Afriat and Richmond were pioneers of SFA modeling. Afriat (1972) stated the statistical foundations that were based on the deterministic model of Aigner and Chu (1968). Richmond (1974) discussed the modified ordinary least squares (MOLS) model to estimate efficiency scores by conventional econometric method (Dudu, 2006). Gabrielsen (1975) developed the corrected ordinary least squares (COLS) while Greene (1980a) used maximum likelihood estimation (MLE) (Kumbhakar and Lovell, 2000).

The current SFA models depend on the idea of modeling efficiency scores as composed error terms developed by Aigner, Lovell and Schmidt (1977), Meusen and Broeck (1977), and Battese and Corra (1977). Dudu (2006) further notes that Aigner, Lovell and Schmidt (1977) decomposed the error term of Afriat (1972) to an independently and identically distributed “noise” which stands for the ‘deviations from efficient frontier due to the chance factors and a one-sided error term that stands for the deviation from efficient frontier because of inefficiency (Kumbhakar and Lovell, 2000). Pitt and Lee (1981) extended cross-section analysis to a panel data. Schmidt and Sickles (1984) applied panel data models by using fixed and random effects. Cornwell, Schmidt and Sickles (1990), Kumbhakar (1990) and Battese and Coelli (1992) introduced time-variable efficiency (Kumbhakar and Lovell, 2000). Lastly, technical efficiency effects models are introduced by Battese and Coelli (1996) to analyze the effect of factors that characterize the production process but are not among the arguments of production function. Battese and Broca (1997) has further developed technical inefficiency effects model to allow for non-neutrality between inputs and characteristic factors.

2.3 Production Efficiency Measures and Estimation Methods

Efficiency can be considered in terms of the optimal combination inputs to achieve a given level of input (input orientation) or the optimal output that could be produced given a set of inputs (an output orientation) (Oluwatayo *et al*., 2008). Literature suggests several alternative approaches to measuring productive efficiency, grouped into non-parametric frontiers, which employ mathematical programming and parametric frontiers, which involve econometric methods. Both methods construct a production frontier indicating maximum production attainable under current technology, and evaluate production for each unit (Oren and Alemdar, 2005). However each method uses a different approach to construct production frontiers. Non-parametric frontiers do not impose a functional form on the production frontiers and do not make assumptions about the error term. These have been used in linear programming approaches; the most popular non-parametric approach has been the DEA (Chirwa, 2007). The most common functional forms include the Cobb-Douglas, constant elasticity of substitution (CES) and translog production function (Ibid). Parametric specification of the production function is mostly performed by employment of the SFA (Bayda, 2003; Chirwa, 2007).

The other distinction is between deterministic and stochastic frontiers. Deterministic frontiers assume that all the deviations from the frontier are a result of firm's inefficiency, while the stochastic frontiers postulate the existence of technical inefficiencies of production of firms involved in producing a particular output (Batesse and Coelli, 1995). In DEA, a piecewise linear production frontier is constructed from observed data. No a-priori functional and distributional forms are assumed in the analyses. Multiple inputs and outputs can easily be handled. These are the strengths of the DEA. However DEA, as a deterministic model, all deviations from the production frontier are attributed to inefficiencies (Oren and Alemdar, 2005). Since random errors and statistical noise are not taken into consideration, DEA is very sensitive to measurement errors (Oren and Alemdar, 2005). On the contrary, stochastic frontier analysis makes a distinction between statistical noise and inefficiency. However the major weakness of the stochastic frontier analysis is the assumption of a-priori distributional forms for the inefficiency component and the imposition of an explicit function form for the underlying technology. In agricultural economics literature, the use of stochastic frontier analysis is highly recommended because of the inherent nature of uncertainty associated with agricultural production.

Contrary to econometric approaches, DEA approach does not distinguish data noise and inefficiency (Bayna, 2003). However stochastic DEA models, which eliminate such problems, have been developed in literature (e.g. Land et al, 1990; Desai and Schinnar, 1987; Petersen and Olsen, 1989). However, empirical implications of these models are extremely difficult due to rigorous data requirements (Bayna, 2003). In addition to the inputs and outputs data, it is necessary to have information on expected values of all variables, variance-covariance matrices for all variables, and probability levels at which feasibility constraints are to be satisfied (Bayna, 2003).

2.4 Comparative Analysis of Production Efficiency Studies

Empirical measurements of efficiency have used a variety of approaches in the various studies that have been carried out by scholars. These approaches were used in modeling frontier production functions: parametric vs non-parametric; deterministic vs stochastic, and programming vs statistical methods (Xu and Jeffrey, 1997; Chirwa, 2007). The approaches used for these studies were used to achieve different objectives; whether it was to determine the farm-size/efficiency relationship (which is a traditional field of research in agricultural economics) or resource-use level as influenced by certain characteristics.

Several researches have carried out studies to measure the performance of farmers against their farm size level ownership. Sen (1982) found an inverse relationship between farm size and yields per acre. This led to the development of a number of research papers to support these findings. These follow-up researches were carried out in Rwanda, Pakistan, Nigeria, Ethiopia Cote d'Ivoire among many other countries. A productivity study in Rwanda that was carried out by Byiringiro and Reardon (1996) showed that there was a strong inverse relationship between farm size and land productivity, whilst it was the opposite for labour productivity. These findings are echoed by Borass Jnr (2007) in a study in which land reforms were supported from an economic perspective. The argument underlying the research was land reforms centered on the belief that 'large farms underutilize land, whilst small farms are wasteful of labour, resulting in low levels of land and labour productivity and consequently leading to poverty'. Therefore it made sense, from an economic point of view to institute land reforms with the intention of increasing agricultural (land) productivity rather than labour productivity. Although there was general agreement amongst scholars that large farms were inefficient, the major question behind land reforms was the question of enhancing economic development (Jowah, 2009). The farm size vs efficiency argument has been used to for the advocacy of land reforms. The Zimbabwean case based on the premise that if land was redistributed from LSCF to the smallholder farmers, there would be an increase in productivity and improved distribution for the people of Zimbabwe (Utete report, 2003)

Bekele, Vilijoen and Ayele (2002), investigated the effect of farm size on the technical efficiency of wheat production in central Ethiopia. Their study covered the 2000/2001 cropping season, and a multi-stage sampling method was used to sample the respondents involved. Farm size was designated as the size of total cultivated land operated by the farm households. Farms that were greater than two hectares were classified as large while those that were equal or less than two hectares were classified as small. Yield of wheat per hectare was used as the dependent variable. Independent variables were those that influence wheat yields such as land area, input usage, farm equipment etc. The research made use of the stochastic frontier approach, and found out results that indicated that differences in technical efficiency existed between small and large farm groups owning more oxen; increased family size and more income per household reduced inefficiency in both large and small farm sizes. Although these authors came up with expected results the margin between their definition of large and small farm is too narrow. Better results could have been obtained if the difference between a larger and smaller farmer was widened (Mushunje, 2005).

Tadesse and Krishnamoorthy (1997) examined the level of technical efficiency across ecological zones and farm size groups in paddy farms of the southern Indian state of Tamil Nadu. Their study shows that 90% of the variation in output among paddy farms in the state was due to differences in technical efficiency. The level of technical efficiency among paddy farms in the state differs significantly across agro-ecological zones and size groups as well. Small sized and medium sized farms showed relatively higher technical efficiency.

Mushunje et al (2003) assessed the level of efficiency of the beneficiaries of this programme as well. The stochastic frontier function model of the Cobb-Douglas type was used to determine the technical efficiency of a group of 44 cotton farmers from Mutanda resettlement scheme of Manicaland province. Technical inefficiency effects were estimated and were assumed to be a function of other observable variables related to the farming operations. The results revealed some technical efficiency levels of the sample farmers that were varied widely, ranging from 22 percent to 99 percent, with a mean value of about 71 percent. The technical inefficiency effects were found to be significant at the 25 percent level. Technical inefficiency of cotton production decreased with increased family size and of the head of household, but increased with farm size and education level of head of household.

On the other hand, smaller farm sizes are viewed to be economically not viable for use of large machinery. Land reforms have not taken place on a very large scale in places such America and Europe, and cases of machinery use in the areas proves to be appropriately economic, given the vast tracts of land that the farmers own. Therefore when compared to the redistributed smaller pieces of land, smaller farms count as a disadvantage as they make it impossible to make use of large and complicated machinery, which in most cases increases agricultural efficiency and growth (Sender and Johnston, 2004).

An economic efficiency measurement through the use of cost function approach with a combination of the concepts of technical and allocative efficiency in the cost relationship in Pakistan agriculture argued that any errors in the production decision translated into higher costs for the producer (Parikh *et al*., 1995). The major finding was land fragmentation has a negative impact on efficiency, thus disproving the inverse relationship between farm size and efficiency. They argued that any errors in the production decision translate into higher costs for the producer.

A study done in Nigeria by Ajibetun *et al*. (1996) to investigate factors that influenced technical efficiencies of smallholder croppers in the country showed that the inefficiency of the smallholder farmers was not significantly related to the size of farming operations of the farmers involved. Their study made use of the translog stochastic frontier production function instead of the Cobb-Douglas frontier function (mainly because the latter did not adequately represent their) and found that technical efficiencies of the sampled farmers varied widely, ranging from about 19 percent to 95 percent. Their results also indicated that the technical efficiencies of production of farmers are significantly related to age and farming experience of the farmers and the ratio of hired-labour to total labour used.

Bravo-Ureta and Evenson (1994) acknowledged that most studies on efficiency do not go beyond the measurement of technical efficiency in developing countries agriculture. In their study they used a stochastic efficiency decomposition methodology to derive technical, allocative and economic efficiency measures separately for cotton and cassava for peasant farmers in eastern Paraguay. They found an average economic efficiency of 40.1 percent for cotton and of 52 percent for cassava, which shows that there is considerable room for improvement in the productivity of the farms sampled. However some studies have failed to come up with concrete evidence of differences in the relative economic efficiency or its components of technical or allocative efficiency, between small and large farms.

Studies of resource use levels and efficiency of farmers have yielded different in different countries. Studies that have been undertaken in these areas include those on resource use efficiency of maize, cocoyam, cowpea and cassava farmers in Nigeria; technical efficiency analysis of tobacco farming in south-eastern Anatolia; technical efficiency of rice farms under irrigated conditions in central Gujarati; sources of technical efficiency among small holder maize and peanut farmers in the slash and burn agriculture zone of Cameroon among others.

The efficiency of cotton farmers in Vehari District of Punjab, Pakistan was investigated using a stochastic frontier production function model, in which technical inefficiency effects are assumed to be a function of other observable variables related to the farming operations (Battese and Hassan, 1998 cited in Mushunje, 2005). A questionnaire was used to collect details about operations of the farms especially varieties grown, yields obtained, the use of inputs like fertilizer, seed and pesticides. The sample size was 45 and the predicted technical efficiencies of these cotton farmers ranged from 0,699 to 0,991, with the mean technical efficiency estimated to be 0,930. This implies that, on average they were producing cotton to about 93 percent of the potential (stochastic) frontier production levels, given the levels of their inputs and the technology being used. The empirical results also indicate that an increase in land area under cotton would result in greater productivity of cotton for the farmers.

Oren and Alemdar (2005) estimated the technical efficiencies of tobacco farms in southeastern Anatolia with parametric and non-parametric methods. They obtained data from 149 tobacco farms. Results obtained with an output oriented DEA were compared to those from stochastic frontier analysis. According to the results of the DEA model, mean efficiency of tobacco farmers was found to be 0.45 and 0.56 for constant and variable returns to scale (CRS and VRS) assumptions, respectively. Mean technical efficiency obtained with SFA model was found to be 0.54. a strong correlation was found between results obtained with output oriented VRS-DEA and SFA models. It was concluded that the sample tobacco farms would be able to increase their technical efficiency by 45 percent through better use of available resources, while applying current technology.

Zikhali (2008) used data on beneficiaries of the program and a control group of communal farmers to investigate the program's impact on the agricultural productivity of its beneficiaries. The data revealed significant differences between the two groups, not only in household and parcel characteristics, but also in input usage. The results suggest that FTLRP beneficiaries are more productive than communal farmers. The source of this productivity differential was found to lie in differences in input usage. In addition, it was found that FTLRP beneficiaries gained a productivity advantage not only from the fact that they used more fertilizer per hectare, but also from attaining a higher rate of return from its use.

2.5 Conclusion

This chapter reviewed literature on production and productive efficiency. Theories of farm production and farm production efficiency were analyzed and defined. Production was defined as processes and methods employed to transform inputs into output (Oluwatayo *et al*., 2008). From the literature review, it was learnt that the farm-unit attempts either to minimize the cost of producing a given level of output or maximize the output attainable with a given level of costs. Productive efficiency measures were found to be grouped into non-parametric frontiers and parametric frontiers, both of which construct a production frontier indicating maximum production attainable under current conditions and technology, and evaluate production for each unit. However it was emphasized that each method uses a different approach to construct production frontiers.

The chapter highlighted that there are several alternative approaches to measuring productive efficiency which involve both econometric non-econometric methods. Lessons were learnt from the several studies that have been done to measure the performance of farmers against different production variables were. For example the envisaged inverse relationship between land size and productivity has not reached a consensus. Some studies conclude that smaller farm sizes are efficient in the use of resources such as labour whilst other argue that fragmentation has a negative impact on efficiency, thus disproving the inverse relationship between farm size and efficiency. Other variables besides farm size were also shown to affect performance of farmers, and they also proved to be inconclusive as the farm size-productivity relationship. These included the age variable, education variable, years of agricultural experience of the farmer among other variables.

The differences in arguments that were produced for various studies informed the researcher to make a decision on the measurements and methods that could be used for this particular study. Chapter three discusses the conceptual framework, the analytical framework and the methods of analysis that will be used in the study based on the literature review. Chapter three will also discuss how data used in the study was collected. There are results that are anticipated to be obtained for this study. These expected results are also discussed in chapter three against the theoretical and analytical model chosen for the data.

CHAPTER 3: RESEARCH METHODS

3.1 Introduction

This chapter highlights research methods which are going to be used to test the hypotheses which were raised in Chapter 1. This will help to achieve the objectives of the study and answer questions that were raised. The chapter looks at methods used to measure technical efficiency, and technical relationships between the factors of production and output. These relationships are discussed within a conceptual framework surrounding production and technical efficiency. The chapter illustrates the relationship that exists between factors of technical and efficiency. It emphasizes that the basic relationship underlying the study of technical efficiency. The chapter clarifies that since the study's main focus is on technical efficiency measures, the yield that is obtained by the farmer is specifically considered in all measurements. The social, economic and physical factors that influence yield levels are discussed.

The chapter discusses the analytical framework that has been selected for the study. The chapter further explains the different forms in which the production function can be estimated for example Cobb-Douglas, linear etc. estimation of the production function will lead to estimation of technical efficiency and technical inefficiency. The chapter further discusses the sources of data and how the data for the study was collected. The choice of research area, selection of research sample and tools used to collect the data are also discussed. The chapter illustrates the type of data to be collected for the study and highlights the importance of collection of any particular type of data.

The exact location of the research survey is provided, as well as the reason why that particular area was selected. The chapter illustrates how the sample population interviewed in the study was selected, and what information was obtained from them. The chapter further outlines the research tools which were used to collect data such as questionnaires (Appendix C).

3.2 Conceptual Framework

This section contributes to this study through the identification of research variables and clarification of the relationships among the identified variables. The section is linked to the problem statement and therefore sets the stage for presentation of the specific inquiries that are driving this investigation. This study aims to compare the performance of A1 resettlement farmers and communal farmers in the District of Goromonzi, Mashonaland East Province through a comparison of their technical efficiency levels.

The basic relationship underlying the theory of technical efficiency measures is the production function (Ellis, 1989). The production function is a purely technical relation which connects factors inputs and outputs (Ellis, 1989; Koutsoyiannias, 1979). The production describes the laws of proportion, that is, the transformation of factor inputs into products (outputs) at any particular time period (Koutsoyiannias, 1979). A method of production (process, activity) is a combination of factor inputs required for the production of one unit of output (Ellis, 1989; Koutsoyiannias, 1979). In its general form, production function is a purely technological relationship between quantities of inputs and quantities of outputs (Koutsoyiannias, 1979). Usually a commodity may be produced by various methods of production. The basic theory of production concentrates only on efficient methods. Any rational entrepreneurs would not use any inefficient method. The production function in traditional economic theory assumes the form in equation (1) below;

$$Q = f(X_1, X_2, \ldots X_n)$$

Where; Q represents the output of the farmer;

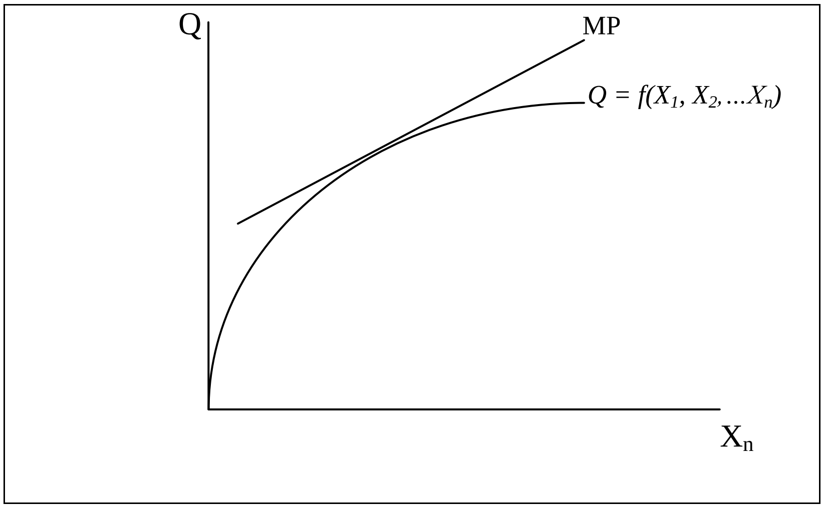
X_is are the factors of production for the ith farm such as land, labour and capital; and,

1…N represents number of farmers.

Since the study focuses on technical efficiency, therefore, Q represents an efficiency measure. Therefore Y_i will represent yield. Besides the factors of production mentioned earlier, yield obtained by a farmer is also related to a number of socio-economic factors in production. These include social factors, such as education levels, age, agricultural experience, gender, asset ownership of the farmer etc. The other factors are economic such as input usage, costs associated with use by the farmer etc. There may also be other factors that are physical such as the soil type on which the farm is located, size of the farm, size of cropped area, agro-ecological region of the farm among others. These socio-economic factors determine the level of output at any given time by the farmer.

Graphically, the production function is usually presented as a curve on two-dimensional graphs. Changes of the relevant variables are shown either by movements along the curve that depicts the production function, or by shifts of this curve (Koutsoyiannias, 1979). The most commonly used diagram for the production function of a single-input commodity is shown in Fig 3.1. The slope of the curve in Fig 3.1 is the marginal product (MP) of the factor of production. The marginal product of a factor is defined as the change in output resulting from a very small change of this factor, keeping all other factors constant (Koutsoyiannias, 1979).

Fig 3.1: Production function



Source: Koutsoyiannias (1979).

Mathematically, the MP of each factor is the partial derivative of the production function with respect to this factor. Thus $MP_X = \delta Q/\delta X$. In principle, the marginal product of a factor may assume any value, positive, zero or negative. However, basic production theory concentrates only on the part of production function, that is, on the range of output over which the marginal products of the factors are positive. Furthermore, the basic theory of production usually concentrates on the range of output over which the marginal products of factors, although positive, decrease, that is, over the range of diminishing but non-negative productivity of the factors of production (Koutsoyiannias, 1979). Alternatively, the theory of production concentrates on levels of employment of the factors over which their marginal products are positive but decrease.

3.3 Analytical Framework

This section provides the framework within which the study will be analyzed. The section relates the methods of analysis with the hypotheses that have been raised in Chapter 1. The study has four hypotheses which will make use of different methods of analysis within a certain framework of analysis.

The first hypothesis from Chapter 1 states that there are significant socio-economic characteristics between both A1 resettlement farmers and communal farmers. The hypothesis will be tested by summarizing descriptive statistics from the survey. Basic socio-economic characteristics of farmers in the study will be described and summarized from survey data. Univariate and bivariate analysis is mainly used where necessary. Descriptive statistics will analyze a number of variables that are known to influence agricultural production. These include socio-economic data such as physical characteristics of plots such as; farm size, soil types; farm inputs use such as seeds, fertilizer, labour, capital etc; age, education, access to information among others. Use is made of three characteristics of univariate analysis; the distribution, the central tendency and the dispersion. The distribution is a summary of the frequency of individual or ranges for a variable. The central tendency locates the center of a distribution of values. The three major types of estimates of central tendency are the mean, the median and the mode. Dispersion is the spread of values around the central tendency. The two common measures of dispersion are the range and the standard deviation. Common forms of bivariate analysis involve creating percentage tables, a scattergraph plot or computation of a simple correlation coefficient. T-tests and/or $\chi 2$-tests will also be carried out to determine the significance of these analyses. Analysis of these variables was done within the Sustainable Livelihoods Framework. It is predicted that A1 resettlement farmers are generally younger than the communal farmers, that the communal farmers have higher education levels than communal farmers; more communal farmers are resident on their farms than A1 farmers among others.

The second hypothesis postulates that production efficiency of both A1 resettlement farmers and communal farmers is positively related to levels of education, access to assets, better soil types, residency of farmer on the farm and negatively related to farm size within each category of farmers. In order to test this hypothesis, a comprehensive literature review is done to get general performance of both the A1 resettlement farmers and communal farmers. A review is made on how different factors have affected their performance in the past. However, the major limiting factor in literature reviews is the biasness of information as they would have been collected by other researchers for a different objective. Literature review made use of production economics theory. The theory of production economics describes the production of goods using a set of inputs. The relationship can be transformed as a production function. The traditional production function however fails to account for social economic characteristics and management as explanatory variables, and the socio-economic characteristics are thus lumped together in the error term. Therefore the stochastic frontier model was made to account for these shortcomings.

Both hypothesis 3 and hypothesis 4 will be tested using a Stochastic Frontier Approach (SFA). The approach allows estimation of both potential output and level of inefficiency. Hypothesis 3 postulates that A1 resettlement farmers produce maize more efficiently than communal farmers' and hypothesis 4 states that small-land holding farmers are more efficient than the large land-holding farmers. The stochastic frontier production functions allows both factors of production and socio-economic characteristics of the household that are assumed to be farm specific to influence actual output as well as potential output together with the error term. Q is also referred to as the total physical product (TPP). This production function can be estimated in several forms such as the: linear functional forms, polynomial forms, and Cobb-Douglas functional form. The latter can be modified into a transcendental and translog functional forms.

The stochastic frontier approach assumes that part of the deviation from the frontier is due to random effects reflecting measurement errors and statistical noise. The other part is due to a firm's specific inefficiency (Chirwa, 2007). The stochastic frontier model was first proposed by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977). Assuming a suitable production function, the stochastic production frontier can be defined as:

$$Y_i = f(x_i;\beta) + e_i \qquad where,\ i=1, 2, 3 \ldots N, \text{ and} \tag{3}$$

$$e_i = v_i - u_i \tag{4}$$

Where; Y_i represents the yield of the *i*th sample farm;

$f(x_i;\beta)$ is a suitable function such as Cobb-Douglas or translog production functions of vector, x_i,

x_is are inputs for the *i*th farm (i.e. the factors of production e.g. land, labour and capital);

βs are unknown parameters.

e_i is an error term made up of two components: v_i and u_i.

The stochastic frontier approach, unlike other parametric frontier measures makes allowance for stochastic errors arising from statistical noise or measurement errors (Chirwa, 2007). As stated earlier, the stochastic frontier model decomposes the error term into a two-sided random error. One of them, v_i, captures the random effects outside the control of the firm - the decision making unit (Chirwa, 2007). These include random factors such as measurement errors and weather (Kibaara, 2005). This is a random error having zero mean, $N(0;\delta^2_v)$ and it is assumed to be symmetric independently distributed as $N(0;\delta^2_v)$ random variables and independent of u_i. The other one is the one-sided efficiency component, u_i. U_i is a non-negative truncated half-normal $N(0, \delta^2_u)$ random variables associated with farm-specific factors, which leads to the *i*th farm not attaining maximum efficiency of production; u_i is associated with technical inefficiency of the farm and ranges between zero and one (Kibaara, 2005). However, u_i can also have other distributions such as gamma and exponential. N represents the number of firms involved in the cross-sectional survey of the farms (Ibid).

Ellis (1989) defines technical efficiency (TE) as the maximum attainable level of output for a given level of production inputs, given the range of alternative technologies available to the farmer. According to Kibaara (2007), technical efficiency of an individual farm is the ratio of the observed output to the corresponding frontier output, conditioned on the level of inputs used by the farm. Technical inefficiency is the amount by which the level of production for the farm is less than the frontier output. Equations 5 to 8 below summaries the definition.

$$T\hat{E}_i = Y_i/Y_i^* \quad \text{where } Y_i^* = f(x_i;\beta), \textit{highest predicted value for the ith farm} \tag{5}$$

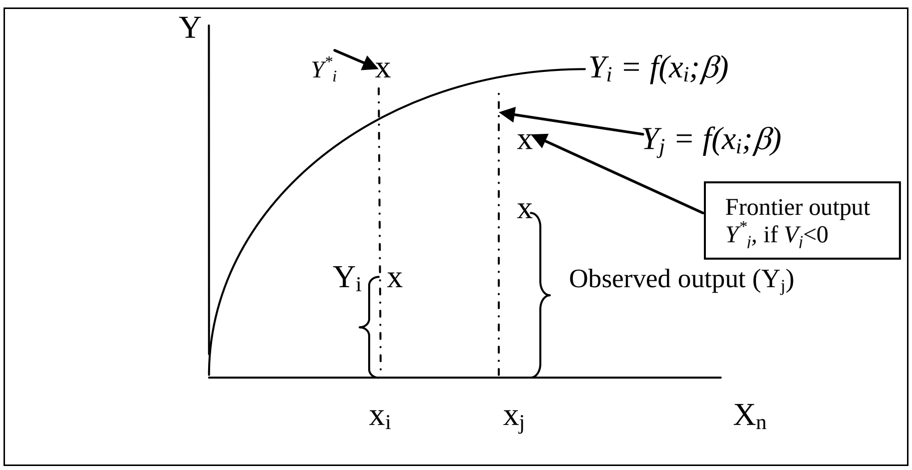
$$Y_i = \textit{ is the actual observed value for the ith farm}$$

$$T\hat{E}_i = Exp\,(-u_i) \tag{7}$$

$$\textit{Technical inefficiency} = 1 - \mathrm{T\hat{E}_i} \tag{8}$$

The basic structure of the stochastic frontier model is depicted in Fig 3.2 in which the productive activities of two firms, represented by *i* and *j*, are considered. Firm *i* uses inputs with values given by the vector x_i and produces output Y_i, but the frontier output Yi^*, exceeds the value on the deterministic production function, $f(x_i;\beta)$ because its productive activity is associated with favorable conditions for which the random error, v_i is positive. However, firm *j* uses inputs with values given by the vector x_j and produces output Y_j, which has corresponding frontier output Y_j^*, which is less than the value on the deterministic production function, $f(x_j;\beta)$, because its productive activity is associated with unfavorable conditions for which the random error v_j is negative. In both cases the observed production values are less than the corresponding frontier values, however the unobservable frontier production values lie above or below the deterministic production function depending on the existence of favorable or unfavorable conditions beyond the firm's control (Illukpitiya (2005).

Fig 3.2: Stochastic frontier production function



Source: Illukpitiya (2005)

Literature offers two approaches to analyzing technical efficiency using the stochastic frontier production function. The first one is to use two-stage OLS estimation process. In this process, if no explicit distribution for the efficiency component is made, then the production frontier is estimated using a stochastic with the version of corrected ordinary least squares (COLS) (Bravo-Ureta *et al.*, 1993). In the first stage of the OLS estimation, the production frontier is regressed and values for technical inefficiency are derived subsequently (Bamlaku *et al.*, 2002). In the second stage, the derived inefficiency values are regressed upon a vector of household and other socio-economic variables (Bamlaku *et al.*, 2002). This is done by using a probit model, with TE as the dependant variable and the socioeconomic characteristics as the independent variables (Greene, 2002). However, a caution is in order as far as this approach is concerned. This approach violates the distributional assumptions of the error terms (Bamlaku *et al*., 2002). In other words, the two stage procedure lacks consistency in assumptions about the distribution of the inefficiencies. In step one, it is assumed that inefficiencies are independently and identically distributed in order to estimate their values. In step two, estimated inefficient variables are assumed to be a function of a number of firm-specific factors, violating the assumption step one (Bamlaku *et al.*, 2002).

However, since recently the stochastic frontier and inefficiency models are jointly estimated in a one-stage process using Limdep (Green, 2002) or Frontier or Stata/IC computing packages, which apply MLE. This process supposes that an explicit distribution is assumed, such as exponential, half-normal or gamma distribution and so the frontier is estimated by MLE. Greene (2002) contends that MLE makes use of the specific distribution of the disturbance term and this is more efficient than COLS. In this study, the one-stage process is used because of its advantages. Unlike the two-stage approach, it does not violate the distributional assumption of the error terms (Bamlaku *et al*., 2002). The computer package Frontier 4.1 is used to estimate the individual farm's technical efficiency levels and the MLEs are used to assess the effects of farm location and agricultural diversification characteristics on farmer's technical efficiency. This provides the study with the efficiency level of each farmer that was interviewed.

The Cobb-Douglas production function is used for the different farmers in the sample. A number of previous studies specified a Cobb-Douglas production function to represent the frontier function. However, the Cobb-Douglas function imposes a severe *a priori* restriction on the farm's technology by restricting the production elasticities to be constant and the elasticities of input substitution to unity (Wilson *et al*., 1998). Another major criticism of the Cobb-Douglas is that it cannot represent the three stages of the neo-classical production function. It represents one stage at a time (Mushunje, 2005). Despite its well-know limitations, the Cobb-Douglas function is chosen because the methodology employed requires that the function be self-dual (Bravo-Ureta and Evenson 1994). The other reason why the specified Cobb-Douglas production function was used was because of its ease of interpretation of returns to scale (Mushunje, 2005). The function is homogeneous of degree, a+b. If a+b exceeds unity, there are increasing returns to scale; when a+b=1 there is constant returns to scale, and a+b<1 indicates diminishing returns to scale (Mushunje, 2005).

Thus the specific model estimated was given by:

$$\ln Y = \beta_0 + \sum_{i=1}^{3} \beta_1 \ln X_1 + v_i - u_i \quad \text{and} \quad u_i = \delta_0 + \sum_{n=1}^{7} \delta_m z_{mi} \qquad \text{(8) and (9)}$$

Where; Y denotes yield of the *i*th farmer in tonnes/hectare; and

X_is are the factors of production of the *i*th farm

The equation captures two sections. The first section is the stochastic frontier production function while the second part captures the inefficiency variables. The inefficiency model is estimated from the equation 9 given below;

$$u_i = \delta_0 + \sum_{n=1}^{7} \delta_m z_{mi}$$

Where;

v_is are assumed to be independently and identically distributed $N(0,\delta^2_v)$ two sided random errors, independently of the u_is; and the u_is are non-negative random variables, associated with the inefficiency in production, with are assumed to be independently distributed as truncations at zero of the normal distribution with mean, $u_i = \delta_0 + \sum_m \delta_m z_{mi}$ and variance

$$\delta^2_u(|N(\mu,\delta^2_u)|, \qquad (10)$$

ln = natural logarithm,

z_{mi}= variables representing socio-economic characteristics of the farm to explain inefficiency, m; and

β's = parameters to be estimated. A positive value of the β's implies that inefficiency is increasing by a unit increase of a particular variable, whilst a negative value indicates otherwise.

Batesse and Corra (1997) provided a way of estimating variance parameters. Their method was followed by replacing the variance parameters, σ_v^2 and σ_u^2, with $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$, and $\sigma_s^2 = (\sigma_v^2 + \sigma_u^2)$, in the estimating model, letting σ_v^2 and σ_u^2 be the variances of parameters symmetric (v) and one-sided (u) error terms, such that $\sigma_s^2 =(\sigma_v^2 + \sigma_u^2)$. This is done so that a grid search over value of γ between 0 and 1 can be used to obtain good starting values for the iterative search routine used to obtain the maiximum likelihood estimates. Coelli and Perelman (1996) further provided an estimation of farm-specific estimates of technical efficiency as follows:

$$EFF = E[exp(-u_i)|\xi_i| = \mathrm{E}[\exp(-\delta_0 - \textstyle\sum_{m=1}^{M} \delta_m z_{mi})|\xi_i|] \qquad (11)$$

where $\xi_i = v_i - u_i$, E is the expectation operator. This is achieved by obtaining the expressions for the conditional expectation u_i upon the observed value ξ_i. The method of maximum likelihood is then used to estimate the unknown parameters, with the stochastic frontier and the inefficiency effects functions estimated simultaneously (Binam *et al*., 2004).

3.4 Data Sources, Sampling Procedures and Collection Methods

The sample of smallholder farmers was drawn from Goromonzi District, Mashonaland East Province. Goromonzi District is one of the districts in one of the ten provinces of Zimbabwe. Goromonzi is located 50km east of Harare and falls within Natural Region II. Goromonzi was purposively selected because being located in region II, has historically been highly diversified and productive for both commercial and communal farmers (Muir, 1994).

The study made use of both secondary data and primary data. Secondary data was obtained from government bodies such as the Ministry of Agriculture, Mechanization and Irrigation Development; the Department of Agricultural and Rural Extension (AREX) and the Zimbabwe National Statistics Agency (ZIMSTAT) (formerly Central Statistics Office (CSO)). Information was also collected from the Food and Agricultural Organization (FAO) through FAOSTAT. Data mainly obtained was that of crop production and productivity trends to track the performance of the maize sector in different agricultural seasons. Other country-level researches that have been carried out in Zimbabwe, together with other policy documents surrounding the maize-sector augmented the secondary data used in the study. These supplied the study with the background to the maize sector which the study needed, and also provided the trends of how the sector has been developing to date.

Two administrative wards of Goromonzi District, Wards 16 and 21, were purposively selected to conduct the study. Ward 16 constituted the communal farmers of Goromonzi District, whilst Ward 21 represented the A1 resettlement farmers. A random sampling technique was adopted to select 100 respondents from the two wards. First, farmers were randomly selected from each ward through a simple household listing followed by another random selection of 50 maize farmers from each ward, making a random sample of 100 respondents for the study. The data used in this study was gathered though a smallholder farmer questionnaire administered to the 100 households with information collected at household member level. A number of variables that are known to influence agricultural production were analyzed. The data collected include plot level output of maize, the inputs used in the production process (land, capital, fertilizer and seeds) on each plot, and the socio-economic and plot-specific characteristics. As a result, models which relate production of farmers to these variables were used for better understanding of the functional relationships that exist between these variables.

In each of the selected households, the household or a person with information about farming activities was interviewed together with other individual members where necessary. The study made use of the 2010/2011 main harvest cropping year cross-sectional household data collection. Three assumptions underlined the study. The first assumption is that farmers interviewed in the study had a similar production function. The second one assumed that all the production inputs and socio-economic characteristics were included in the specification of the stochastic frontier model. Third one is that, although Goromonzi district on its own may not be representative of the whole of Zimbabwe, analysis from this study provides some indication of how farmers are performing after the FTLRP.

3.5 Expected Results of the Theoretical Model

Based on the differences that are assumed to exist between the A1 resettlement and communal farmers, it is assumed that the A1 resettlement farmers are younger, and have better access of capital and thus higher level of technical efficiency. The A1 resettlement who were resettled to former white farms under the FTLRP, are expected to be located on more fertile soils. It is also expected that the A1 farmers have generally higher maize yields than communal farmers. A1 resettlement farmers are also expected to have higher levels of inputs use compared to their communal counterparts.

Formal education has a bearing on the kind of information accessed, and on the nature of planning at household level. In certain instances, having acquired education can be a status symbol which might also have implications for processes of inclusion and exclusion within communities (Moyo, *et al.*, 2010). It thus expected that households with better educated farmers perform better than those that have reached lower levels of learning. Technical inefficiency is also expected to increase with age of the head of household, as the older household heads are perceived to have more agricultural experience that the younger farmers. Age of farmer is linked to their agricultural experience. The greater the agricultural experience, in terms of the years in which the farmer has been involved in farming, the higher the chances of producing better than those with less experience. Better experience means that a farmer has more knowledge of input use than one who is not experienced. The type of access for the range of farm machinery and equipment (hand tools, animal drawn and power driven) has a bearing on the production levels of the farmer. Better access to such assets improves the performance of a farmer than the one with limited access. Farmer with better access to farming equipment are expected to have higher technical efficiency levels than those with less access.

Based on the assumed differences in socio-economic characteristics between A1 resettlement farmers and communal farmers, it is expected that the a1 resettlement farmers will have higher levels of technical efficiency compared to communal farmers. A1 resettlement farmers are expected to also have higher technical efficiency levels because they are expected to be located on more fertile soils, have higher inputs use and to be generally younger than the communal farmers.

As has been highlighted earlier, several studies have found an inverse relationship between farm size and yields per acre. This was shown for studies carried out by Sen (1982); Byiringiro and Reardon (1996); Tadesse this research that there is an inverse relationship between farm size and technical efficiency and Krishnamoorthy (1997); and Bekele, Vilijoen and Ayele (2002) among others. Therefore from the study, it is expected that farmers with smaller pieces of land will be more technically efficient than farmers with larger pieces of land.

CHAPTER 4: PRELIMINARY ANALYSIS

4.1 Introduction

This chapter tests hypothesis 1 from chapter 1 and describes the general socio-economic characteristics of the A1 resettlement farmers and communal farmers. The chapter also analyses the characteristics of the qualities that otherwise influence agricultural production of these farmers. In the chapter, the human resources component of a farming enterprise is described to form an indispensable ingredient in agricultural production. It is discussed that through man’s ingenuity that production inputs are sequentially integrated and made compatible with one another in order to produce a desired result (Mushunje, 2005).

The general agricultural activities that are carried out by farmers that influence maize production are also discussed in this chapter. A comparative analysis is also made between A1 resettlement farmers and communal farmers in maize production, focusing on their maize yields and how they are utilizing the area of land that they possess. The chapter is described to provide a basic foundation for Chapter 5, which specifically analyses the differences in technical efficiency between the farmers from these different models.

4.3 Socio-Economic Characteristics of Farmers in Goromonzi District

The human resources component of a farming enterprise forms an indispensable ingredient in agricultural production. It is through man’s ingenuity that production inputs are sequentially integrated and made compatible with one another in order to produce a desired result (Mushunje, 2005). Man is able to manipulate the production requisites to meet his own ends. A human being may therefore rightly be considered the origin as well as the destination in the production process (Ibid). It is important to analyze the biological characteristics as well as social, economic and psychological traits of a farming community as they influence the efficiency of farming.

Farmers require human, natural, physical, financial and social capital in order for them to actively strategize for their livelihood development[2]. Human capital is required by farmers for the execution of various farm operations to achieve agricultural livelihood objectives, whilst the physical and financial capital are the durable, liquid and credit assets that a farmer uses for his/her production (Langyintuo, 2005). Social capital is the household's access to support from the social system or social networks for effectiveness. Natural capital assets are described by the total farm land available to households and the amount put under cultivation annually (Langyintuo, 2005). These can also be considered as factors that affect farmers' production.

In this study, the human capital factor is covered by variables such as the gender, marital status of the farmers, age of farmers, residency status of farmers, among others. Table 4.1 below provides the ownership of plots in Goromonzi by gender and marital status of owners. Of the 100 farmers that were interviewed in both models, 62 percent were male, while 28 percent were female. Data indicates that the majority of the farmers that have been resettled were men. Of the total A1 resettlement farmers, 78 percent are. Only 22 percent of the A1 resettlement farmers were female. About 27 percent of the sampled population was females from communal areas,

[2] Moyo *et al.* (2004) defined a farm as a living organism, and as such, has a 'right size' for good health. Its health depends on its ecological, social and economic dimensions. It has to meet the realistic expectations of those who depend on it for economic livelihood for it to be sustainable and viable.

double the population of females from A1 resettlement farms. The majority of the sampled population, about 71 percent, was married. 23 percent of the population was widowed, with a large part of this population, which is 20 percent, being women.

Table 4.1: Marital status of farmers in Goromonzi District

Gender	Marital Status	A1		Communal		Total	
		No.	**%**	**No**	**%**	**No**	**%**
Male	Married	35	89.7	22	95.7	57	91.9
	Divorced	1	2.6	1	2.6	2	3.2
	Widowed	3	7.7	-	-	3	4.8
	Total	**39**	**100.0**	**23**	**100.0**	**62**	**100.0**
Female	Single	1	9.1	1	3.7	2	5.3
	Married	5	45.5	9	33.3	14	36.8
	Divorced	1	9.1	1	3.7	2	5.3
	Widowed	4	36.4	16	59.3	20	52.6
	Total	**11**	**100.0**	**27**	**100.0**	**38**	**100.0**

Source: Field survey, 2011, N=100

The findings from the survey concerning gender of heads of household for both A1 resettlement farmers and communal farmers supports the general notion that most households in the rural areas are headed by women due to male migration to urban areas to look for better wage-jobs (Mushunje, 2005). Observations in the A1 resettlement farms highlight the opposite, with the majority of farmers being males, suggesting a perceived appreciation of the land reform programme by males.

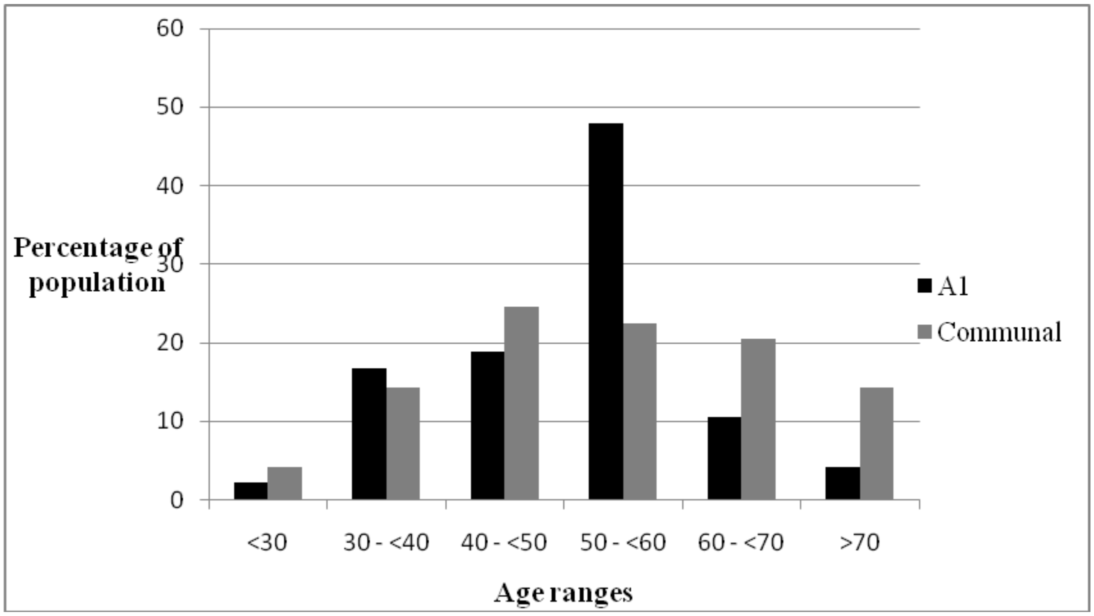
Age is an important variable in the efficiency model used in this study. An individual's age is one of the most important factors affecting personality make-up, since needs and the way in which they think, behaves and makes decisions are all closely related to the number of years one has lived (Bembridge, 1987). Although age may have an impairing effect on physical abilities, which are important on family holdings, several research studies have indicated little or no mental deterioration for at least up to 60 years of age (Bembridge, 1987). There are conflicting views concerning age and efficiency of farmers. Researchers such as Seyoum *et. al.* (1998) argue that older farmers are expected to have greater inefficiencies because they are less adaptable to new technological developments. This result was based on their research on maize producers in eastern Ethiopia which concluded that younger farmers were more efficient in maize production than older farmers. A study by Brinkman (1998) indicates that younger farmers are more successful than their older counterparts.

Coelli and Battese (1996) concluded that the expected signs for age in the inefficiency model are not always clear, and could therefore have a positive or a negative effect on the magnitude of the inefficiency. They argued that older farmers are likely to have more farming experience but also likely to be more conservative and thus to be less willing to adopt new practices, thereby perhaps having greater inefficiencies in agricultural production.

A quick glimpse at the graphical presentation of age distribution of household heads in Fig 4.1 shows a normal distribution for both model types. A visual picture of peakedness of distribution (*kurtosis*[3]) for the two sets of data shows that the distribution for A1 resettlement farmers ages is more peaked that that of communal farmers, which appears to be flatter. There is an almost equal distribution of population between the age ranges for communal farmers compared to that of A1 resettlement farmers. Close to half of the A1 resettlement farmers (47.9 percent) falls within the 50 – 60 years range, with the rest of the population spreading across the remaining age ranges.

[3] Kurtosis is that property of a distribution which expresses its relative peakedness (Clark and Schkade, 1974)

Fig 4.1: Age ranges of household heads in Goromonzi District



Source: Field survey, 2011

This data indicates that the FTLRP attracted more of the economically active age groups who felt the need to be de-congested compared to the older people who hold sentimental values to their communal homes. Only 14.6 percent of the population above 60 years of age is found in the A1 resettlement areas, against 34.7 percent of farmers in the communal areas. This data reveals something about self-selection of land beneficiaries. Data suggests that the younger group of people were more interested in applying and benefitting from the FTLRP as they believed that they had the ability to start a new life in new resettlement areas.

When discussing agricultural production, it is imperative to understand the educational levels of the farmers. Formal education has a bearing on kind of information accessed, and on the nature of planning at household level and community level (Moyo *et al.*, 2009). In some instances education can be a status symbol which might also have implications for processes of inclusion and exclusion within communities (Ibid).

Table 4.2: Education levels attained by farmer

Education level	A1		Communal		Total	
	No.	**%**	**No.**	**%**	**No.**	**%**
No formal education	5	10.4	7	14.3	12	12.4
Primary education	24	50.0	15	30.6	39	40.2
ZJC	9	18.8	7	14.3	16	16.5
Ordinary level	5	10.4	20	40.8	25	25.8
Advanced level	2	4.2	-	-	2	2.1
Tertiary	3	6.3	-	-	3	3.1
Total	**50**	**100.0**	**50**	**100.0**	**100**	**100.0**

Source: Field survey, 2011

Study results indicate that the majority of the A1 resettlement farmers have studied up to primary level. About 50 percent of the A1 farmers had attained primary level education. The majority of the farmers in communal areas were shown to have gone up to Ordinary level. About 41 percent of the communal farmers had studied up to ordinary level. The A1 resettlement farms only had farmers who attained education beyond ordinary level. A total of 10.5 percent of the A1 resettlement farmers had attained education up to advanced level and tertiary level. The levels of education of people involved in farming are critical in analyzing agricultural production.

An important variable to infer the 'seriousness' of farmer is their willingness to stay on the plot and provide hands-on management on operational activities on the farm. Results from this study showed that 76 percent of the A1 resettlement farmers are resident on the plots, whilst only 24 percent stay off-farm. The results echo those from AIAS baseline survey (2009) and Jowah's study (2010). Contrary to mainstream debates, which have seen newly resettled farmers being termed “cell phone” or “weekend” farmers, in the case of A1 resettlement farmers surveyed in Goromonzi, the majority of plot holders indicated that they resided on their plots (Jowah, 2010). Table 4.3 shows that the communal sector has fewer people staying away from their farms compared to the A1 resettlement farmers.

Table 4.3: Residency status of farmers in Goromonzi District

Residency status	A1		Communal		Total	
	No.	**%**	**No.**	**%**	**No.**	**%**
On-farm	38	76.0	48	96.0	85	85.9
Off-farm	12	24.0	2	4.0	14	14.1
Total	**50**	**100.0**	**50**	**100.0**	**100**	**100.0**

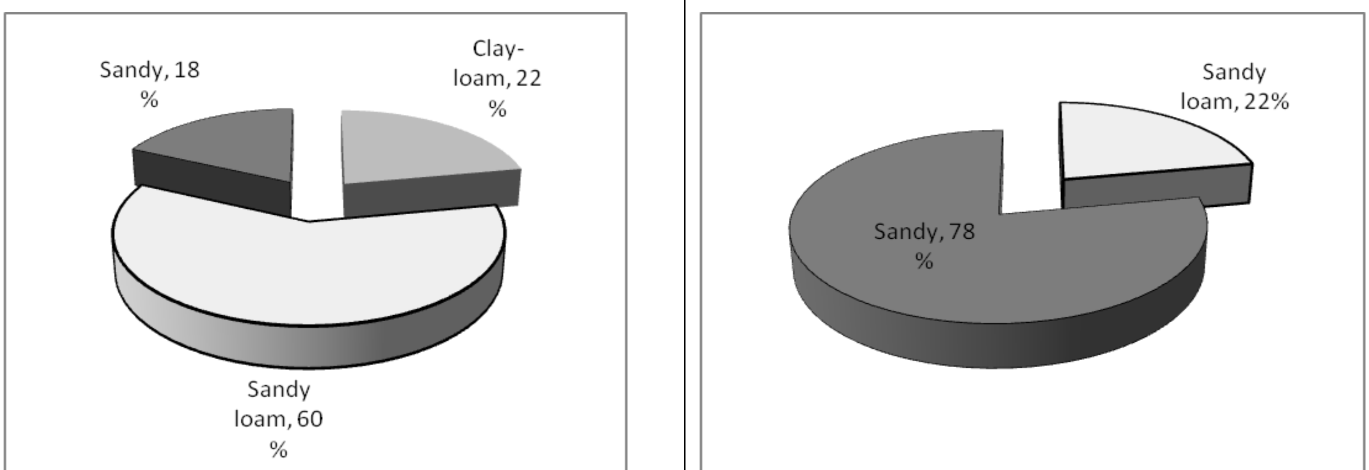
Source: Field survey, 2011

Natural capital focuses on the physical land available for cultivation and covers variables such as the predominant soil types, plot sizes, cropped areas among others. Farm and spatial heterogeneity have significant impacts on farm efficiency hence it is necessary to take account of them. In agronomy, many ecological crop growth models incorporate location-specific physical conditions such as climate conditions and soil characteristics to estimate crop growth and potential yields for particular crop types as well as for combinations of many crops (Hoang, 2011). These crop growth models are often developed using field and experimental data, thus providing reliable scientific estimates of plant growth and potential yields (Hoang, 2011).

Results from the survey show that many of the sampled plots were characterized by sandy-loam type of soils. Fig 4.2 illustrates that 88 percent of the total population was in plots that are dominated by sandy-loam soils. Only 22 percent of the communal population had their farms located on sandy-laom soils. The communal population was dominated with farms characterized by sandy soils (78 percent). None of the A1 resettlement farmers were located farms characterized with sandy soils. This is an indication that A1 farmers were generally located on more fertile soils than communal farmers.

Fig 4.2: Predominant soil types on plots

A1 sector | **Communal sector**



Source: Field survey, 2011

The average farm size for the A1 resettlement farmers was 6.0ha, whilst for the communal farmers was 0.77ha. Combined data from both Fig 4.2 and Table 4.4 informs us that the FTLRP resulted in the ownership of larger and better pieces of land in terms of soil quality.

Table 4.4: Size of land holdings and arable area in Goromonzi District

	A1			Communal		
	Avg size (ha)	Range	No. of farmers	Avg size (ha)	Range	No. of farmers
Size of plot	6.0	6.00	50	0.77	0.2 – 0.4	50

Arable area	5.53	2.0 – 6.0	50	0.77	0.2 – 0.4	50

Source: Field survey, 2011

Physical and financial capital issues are covered by the variables that concern access to credit, farming implements among others. Many agricultural finance critics point to the lack of secure land tenure as being the major disincentive to those who want to invest in agriculture financially. However, the argument does not inform the fact that the FTLRP project was undertaken without any external assistance pre- and post- settlement, due to increased economic isolation and restricted access to external credit and aid in general.

After the implementation of the FTLRP, the majority of private financial institutions withdrew from agricultural financing leaving the under-resourced state to provide the bulk of the financial resources for production to an increased number of farmers through various schemes, most of which were controlled by the Central Bank (Moyo, 2009). State-subsidised credit has been overstretched and limited to a small number of farmers in new resettlement areas. Moreso, in the wake of a serious liquidity problem in the country, agri-business divisions in most local banks have failed to fully assist farmers with loans.

Commercial farming in Zimbabwe prior to the FTLRP was heavily supported by lines of credit from the state and private sector financial institutions, while very few smallholder farmers especially those located in the high potential agro-ecological zones accessed credit (Moyo, 2009). Table 4.5 suggests that agricultural production in both A1 resettlement farms and communal farms was financed through own savings and external resources mobilised by the farmers.

Table 4.5: Access to credit in Goromonzi District

Source of credit	Did you receive money ?	A1		Communal		Total	
		No	%	No	%	No	%
Relatives and friends	Yes	3	6.1	1	2.0	4	4.0
	No	46	93.9	49	98.0	95	96.0
Government credit schemes	Yes	3	6.0	0	0.0	3	3.0
	No	47	94.0	50	100.0	97	97.0
NGOs	No	50	100.0	50	100.0	100	100.0
Banks/micro-finance institutions	No	50	100.0	50	100.0	100	100.0
Society groups	No	50	100.0	50	100.0	100	100.0

Source: Field survey, 2011

Both A1 resettlement farmers and communal farmers do not have access to any form of credit. Access to external financial resources to support agricultural production in smallholder farm areas was generally limited to a few households. Only 6 percent of the A1 resettlement farmers had access to government credit schemes. All in all, only 7 percent of the farmers either received credit from friends/relatives and/or government credit schemes.

Data collected from Goromonzi District shows that ownership levels was generally higher amongst the A1 resettlement farmers for most types of farm equipment compared to that of communal farmers. The ownership levels for common forms of hand tools i.e. hoes and axes was generally high in both A1 resettlement and communal areas. Table 4.6 highlights that level of ownership of these tools was at least 90 percent of both the A1 resettlement farmers and communal areas.

Table 4.6: Asset ownership for households in Goromonzi District

Type of asset	Asset users		Avg no. of assets used		Type of access to asset	
	A1	Communal	A1	Comm	A1	Communal

		No.	%[a]	No.	%[b]			Owned	Borrowed	Owned	Borrowed
Hand tools	Hoes	50	100.0	50	100.0	7.8	5.4	50	-	50	-
	Axes	49	98.0	45	90.0	2.9	1.9	49	-	45	-
	Muttocks	28	56.0	-	-	1.8	-	28	-	-	-
	Picks	44	88.0	4	8.0	1.7	1.5	44	-	4	-
	Spades	41	82.0	2	4.0	2.0	1.5	41	-	2	-
	Spade forks	19	38.0	-	-	1.4	-	19	-	-	-
	Wheel barrow	37	74.0	31	62.0	1.4	1.2	37	-	31	-
	Watering cans	45	90.0	6	12.0	2.3	1.5	45	-	6	-
	Knapsack Sprayer	33	66.0	12	24.0	1.4	1.0	33	-	11	**1**
Animal-drawn implements	Plough	16	32.0	13	26.0	1.3	1.0	13	3	3	**3**
	Planter	6	12.0	2	4.0	1.8	1.0				
	Ripper	-	-	1	2.0	-	1.0	-	-	1	-
	Harrow	3	6.0	3	6.0	1.0	1.3	3	-	3	-
Power driven machinery & equipment	Tractor	6	12.0	1	2.0	1.0	1.0	-	6	-	**1**
	Tractor trailer	**7**	**14.0**	**-**	**-**	**1.1**	**-**	**-**	**7**	**-**	**-**

Source: Field survey, 2011

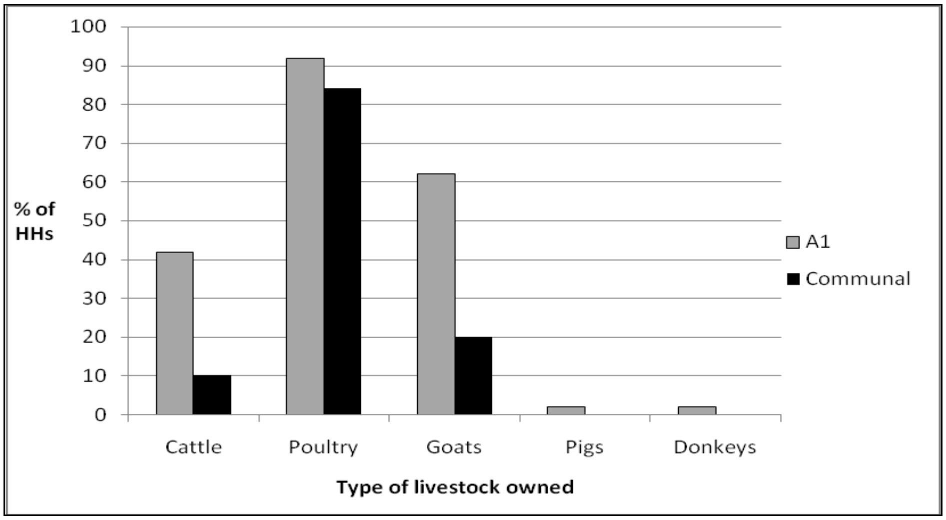
Key: [a]percentage of A1 population; [b]percentage of communal population

Other categories of hand tools such as picks, spades, mattocks, wheelbarrows and knapsack sprayers were owned by A1 resettlement farmers more than communal farmers. Apart from the hand tools, animal and power driven farm equipment was generally available to less than 20 percent of the households. However A1 resettlement farmers' access levels were higher on both the animal drawn ploughs and power-driven implements than for communal farmers. In terms of access to power-driven farm equipment, borrowing is the most common of access. Although access and ownership of farming implements by A1 resettlement farmers is higher than that of communal farmers in general, asset ownership is generally poor for animal drawn implements and power driven machinery and equipment for both A1 resettlement and communal farmers. This would be expected since most of the beneficiaries came from communal areas.

In addition to cropping, A1 resettlement and communal farmers were also involved in the rearing of livestock as part of their farming. The distribution of livestock owned by A1 resettlement and communal farmers is illustrated in Fig 4.3. In comparison to the communal sector, the A1 resettlement farms had higher percentages of households owning all the different types of livestock. Poultry was the widely held category of livestock owned by both model types. Fig 4.3 shows that 92 percent and 84 percent of A1 resettlement farmers and communal farmers owned poultry respectively. Intensive livestock enterprises, particularly poultry provide major opportunities for increased incomes of smallholder farmers and their families (Mhlanga et.al., 1999).

In addition poultry is an important source of protein in both rural and urban areas. Due to recurrent droughts and decreasing grazing land, which have resulted in the reduction of the national cattle herd, poultry has the potential to become a major source of protein and a ready source of income in the smallholder farming sectors of Zimbabwe (Mhlanga et.al., 1999). Cattle were owned by less than 50 percent of the A1 resettlement farmers and communal farmers. Only 42 percent of A1 resettlement farmers and 10 percent of communal farmers owned cattle. Given that the majority of newly resettled households, especially the small A1 resettlement farms, rely on draught animals for land preparation, other tillage operations and farm transport, the survey results suggest that A1 resettlement farmers are constrained as regards ploughing activity (Moyo et.al, 2009). Similar challenges are also experienced in the communal areas.

Fig 4.3: Types of livestock kept in Goromonzi District



Source: Field survey, 2011

Besides cattle and poultry, goats were the other type of livestock owned by farmers in Goromonzi District. Small-ruminants contribute to household welfare through cash income from sales, and through slaughter for feasts and own consumption. They are important for meeting large annual expenses such as school fees, and for intermittent cash and slaughter for births, marriages and funerals (Mhlanga et.al., 1999). In the event of drought they are also an important form of buffer capital as their numbers can be quickly restored (Mhlanga et.al., 1999). However, goats were more commonly owned by A1 resettlement farmers than communal farmers. For example 62 percent of A1 farmers owned goats, whilst only 20 percent of communal farmers owned the small ruminants. Pigs and donkeys were not commonly owned by farmers in the district.

The study results show that the numbers kept by A1 resettlement farmers and communal farmers were generally limited to five or less for the different types of livestock that were found in district. An exception was poultry. Poultry was dominant in terms of numbers kept by households. Both A1 resettlement farmers and communal farmers had similar ownership levels of poultry. For example 88 percent and 82 percent of A1 resettlement farmers and communal farmers owned at least five birds (Table 4.7).

Table 4.7: Numbers of livestock kept by farmers in Goromonzi District

No. owned	No. of households and % in parentheses									
	A1					Communal				
	Cattle	**Poultry**	**Goats**	**Pigs**	**Donkeys**	**Cattle**	**Poultry**	**Goats**	**Pigs**	**Donkeys**
0	29(58.0)	4(8.0)	19(38.0)	49(98.0)	49(98.0)	45(90.0)	8(16.0)	40(80.0)	50(100.0)	50(100.0)
1	2(4.0)	1(2.0)	7(14.0)	-	-	-	-	1(2.0)	-	-
2	4(8.0)	1(2.0)	4(8.0)	1(2.0)	-	2(4.0)	1(2.0)	2(4.0)	-	-
3-5	4(8.0)	5(10.0)	8(16.0)	-	-	2(4.0)	5(10.0)	6(12.0)	-	-
6-9	2(4.0)	8(16.0)	6(12.0)	-	1(2.0)	1(2.0)	10(20.0)	1(2.0)	-	-
10-19	6(12.0)	12(24.0)	6(12.0)	-	-	-	14(28.0)	-	-	-
20-29	3(6.0)	9(18.0)	-	-	-	-	6(12.0)	-	-	-
30-29	-	5(10.0)	-	-	-		2(4.0)	-	-	-
50-99	-	3(6.0)	-	-	-		3(6.0)	-	-	-
100+	-	2(4.0)	-	-	-		1(2.0)	-	-	-
Total	**50(100.0)**	**50(100.0)**	**50(100.0)**	**50(100.0)**	**50(100.0)**	**50(100.0)**	**50(100.0)**	**50(100.0)**	**50(100.0)**	**50(100.0)**

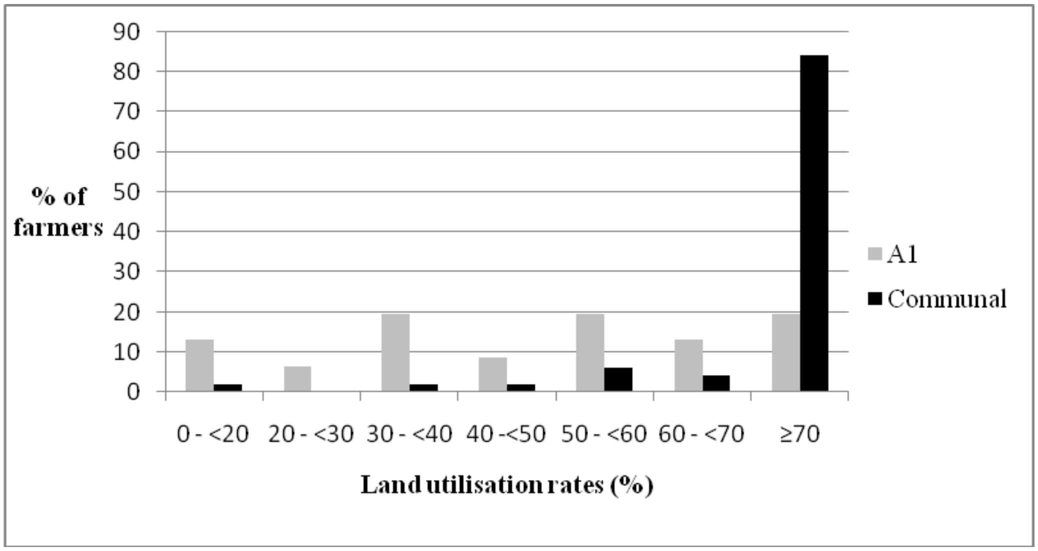
Source: Field survey, 2011

4.4 General Agricultural Activities by Farmers in Goromonzi District

In terms of the net land utilization rates[4] by A1 resettlement farmers shows some inconsistent patterns compared to that of communal farmers (Fig 4.3).Utilization rates ranges falling within 30-40 percent; 50-60 percent and >70 percent all have 19.6 percent each of A1 resettlement farmers falling within the ranges. Land use by communal farmers is higher than that of A1 farmers. 84 percent of the communal farmers exploit beyond 70 percent of their arable land for cropping.

[4] The net land utilization rate index is calculated as the percentageof the total cropped area over the total arable area for the 2010/2011 season

Fig 4.3: Land utilization rates of famers in Goromonzi District



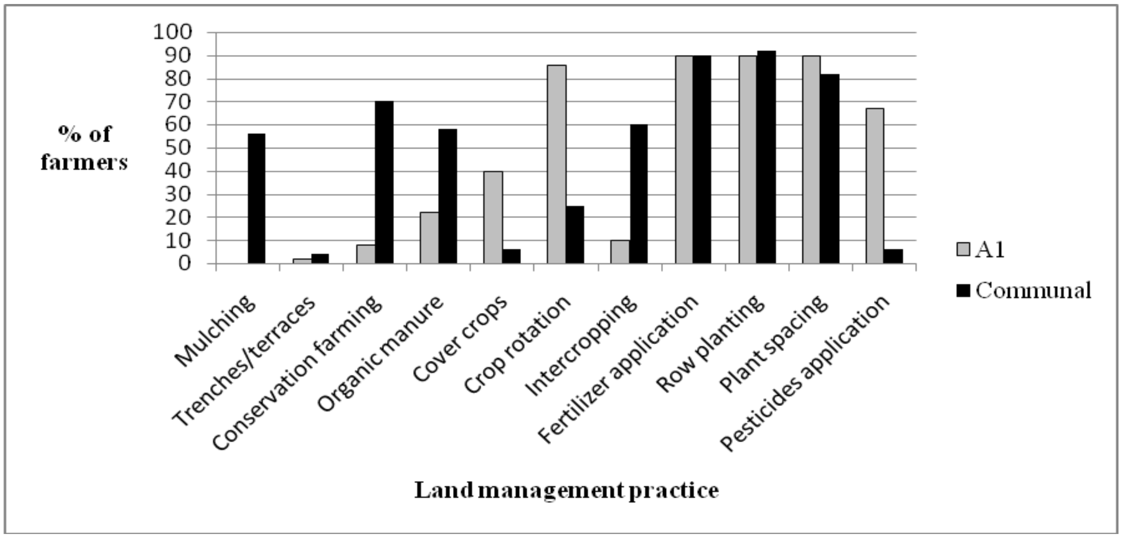
Source: Field survey, 2011

Statistics from Fig 4.3 seems to support the efficiency argument of land reforms. The large farm vs small farm efficiency debate emphasizes the more intensive utilization of land in smaller farms than in larger farms. However the A1 resettlement farmers were also expected to utilize their land in a manner similar to that of the communal farmers, because their landholdings are relatively small.

Compared to A1 resettlement farmers, communal farmers employ more water and soil conservation techniques. These include techniques such as mulching with 56 percent; conservation farming with 70 percent; application of organic manure with 58 percent and intercropping with 60 percent. Such techniques are more practical if employed on a smaller piece of land than a larger one. Therefore it makes sense for communal farmers to employ such practices compared to the A1 resettlement farmers due to their huge labour requirements. Crop rotation practice was high in A1resettlement farms compared to communal sector. For example

86 percent of the A1 farmers practiced this technique, whilst about a quarter of the communal sector population employed it.

Fig 4.4: Agricultural technologies employed by farmers in Goromonzi District



Source: Field survey, 2011

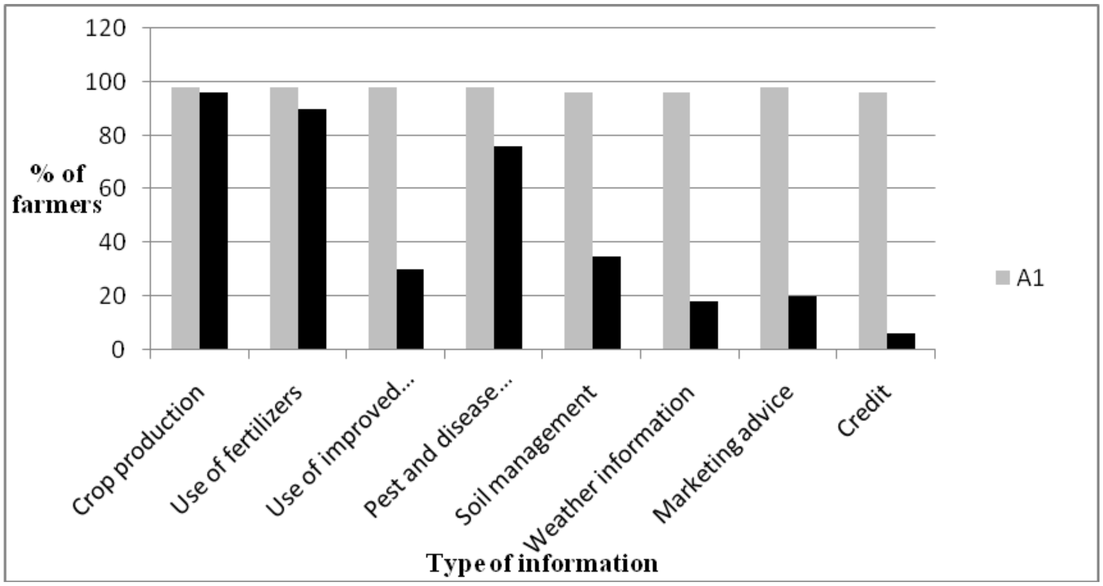
The most popular techniques for both sectors were the application of fertilizers, row planting and plant spacing practices. These were employed by a similar proportion of the population for each technique (about 90 percent for all). The least applied for both model types was trenches/terraces. Only 2 percent and 4 percent employed this technique in the A1 resettlement and CAs respectively.

In order for farmers to make use of such agricultural techniques, they have to be exposed to certain agricultural extension services. These services come in different forms ranging from crop production; use of fertilizers and improved varieties; pest, disease and soil management, weather information to marketing and credit advice. Fig 4.5 shows that there is a higher presence of agricultural extension services in the A1 resettlement farms than in the communal areas. On average 90 percent of the A1 farmers received at least one form of these types of information. This is contrary to general belief that there is not much extension work taking place in the resettlement areas. However from the study, the heavy presence of the extension services in the A1 resettlement farms was explained by the residency of two extension officers[5] within the A1 resettlement farms. These officers therefore interact with farmers on crop production issues as neighbors as well as service providers.

Farmers in the communal sector were not as privileged as the A1 ressetlement farmers as there were some areas of extension services that they received little assistance. The majority of the farmers received information on crop production and use of fertilizers compared to the other types of information available. For example 97 percent and 94 percent received information on crop production and use of fertilizers respectively. Very few farmers accessed information on credit and weather. Weather information is important for farmers both resettled and communal as the world, the country in particular is currently experiencing climate change that bear some huge influence on agricultural production.

[5] These two qualified extension officers are a married couple, who service three wards each. They were beneficiaries of the FTLRP. They couple their extension duties with farming in Goromonzi.

Fig 4.5: Information received through extension services



Source: Field survey, 2011

4.5 Comparative Analysis of Maize Production of A1 and Communal Farmers in Goromonzi District

Survey data confirms the importance of maize for the A1 resettlement and communal farmers. Production of the crop is on over 50 percent of their cropped area. On average, A1 farmers utilize 75.2 percent of their cropped area for maize production, whilst communal farmers employ 94.7 percent of their cropped land for maize production (Table 4.8). Table 4.8 shows that on average A1 farmers have a maize yield of 2.25 tonnes/ha compared to 0.86 tonnes/ha for communal farmers. For the farmers who grew maize under 0.5ha, A1 resettlement farmers had a yield of 0.714 tonnes/ha, whilst communal produced 0.797 tonnes/ha. Farmers who grew their maize on 1.0ha, shows that A1 resettlement farmers produced 1.079 tonnes/ha, and communal farmers produced 1.500 tonnes/ha. Communal farmers produced 2.0 tonnes/ha compared to 1.167 tonnes/ha on 1.5ha.

Table 4.8: Average maize yields per field in Goromonzi District

Area under maize (ha)[a]	A1				Communal				Total			
	No.	%	[b]	Avg yield (t/ha)	No.	%	[b]	Avg yield (t/ha)	No.	%	[b]	Avg yield (t/ha)
0.2	-	-		-	2	4.1	100.0	0.3	2	2.0	100.0	0.3
0.3	-	-		-	2	4.1	80.0	1.0	2	2.0	80.0	1.0
0.4	-	-		-	17	34.7	98.8	0.6	17	17.4	98.8	0.6
0.5	7	14.3	61.9	0.71	18	36.7	94.4	0.8	25	25.5	85.3	0.8
0.6	-	-		-	1	2.0	100.0	2.0	1	1.0	100.0	2.0
0.8	-	-		-	4	8.2	90.0	1.1	4	4.1	90.0	1.1
1.0	14	28.6	59.7	1.1	4	8.2	83.3	1.5	18	18.4	65.9	1.1
1.5	3	6.1	57.5	1.1	1	2.0	100.0	2.0	4	4.1	68.1	1.4
2.0	12	24.5	86.1	1.6	-	-		-	12	12.2	86.1	1.6
2.5	2	4.1	100.0	3.0	-	-		-	2	2.0	100.0	3.0
3.0	6	12.2	83.3	4.1	-	-		-	6	6.1	83.3	4.1
4.0	4	8.2	91.7	5.4	-	-		-	4	4.1	91.7	5.4
5.0	1	2.0	100.0	15.0	-	-		-	1	1.0	100.0	15.0
Total	**49**	**100.0**	**75.2**	**2.2**	**49**	**100.0**	**94.7**	**0.9**	**98**	**100.0**	**85.4**	**1.552**

Source: Field survey, 2011
[a]point estimates; [b]maize land utilization rate (area under maize as a fraction of cropped area) in percentage

Information obtained from the survey shows how many communal and A1 resettlement farmers believe they are producing as well as they should. Table 4.8 shows that about 92 percent of the communal farmers are convinced that they are performing as they should in their maize fields. This opposes the A1 resettlement farmers' belief that they should be producing much higher than they are currently producing. Only 8.2 percent of the A1 farmers feel that are performing well.

Table 4.9: Whether farmers believe that they are producing their maize as they should

Do you cultivated as you should have?	A1		Communal		Total	
	No.	%	No.	%	No.	%
Yes	8	16.0	45	91.8	53	53.5
No	42	84.0	4	8.2	46	46.5
Total	**50**	**100.0**	**49**	**100.0**	**99**	**100.0**

Source: Field survey, 2011

Table 4.10 highlights information on crops that were grown by the sample in the 2010/11 agricultural season. The one-crop category possesses the highest proportion of the crop-combination in comparison to all the other categories for the communal sector. 90 percent of the communal farmers produced a single crop (maize). Only 5 percent of the households produced two crops, maize and groundnuts.

In the A1 resettlement farms the dominating category in the crop-combination was the two-crop category with the 50 percent of the farmers producing two crops. This is despite their perception that they are performing below their potential. The two crops grown were both maize and any of the crops, groundnuts, tobacco, sugarbeans or soyabeans. 34 percent of the A1 farmers grew a single crop (maize). The cash crop tobacco was a dominant crop among the A1 resettlement farmers.

Table 4.10: Crop combination of households in Goromonzi District

Model type	Crops (n)	Count	%	Crop combination
A1	One crop	17	34.0	Maize only
	Two crops	25	50.0	Maize +any of {groundnut, (13), sugarbeans (1), soyabeans (1), tobacco (10)}
	Three crops	5	10.0	Maize+ any of the { groundnuts & tobacco (2), groundnuts & sugarbeans (3)}
	Four crops	3	6.0	Maize, groundnuts, tobacco & roundnuts (1) Maize, groundnuts, sunflower & roundnuts (2)
	Total	**50**	**100.0**	
Communal	One crop	45	90.0	Maize only
	Two crops	5	5.0	Maize + {groundnut, (5)}
	Three crops	-	-	-
	Four crops	-	-	-
	Total	**50**	**100.0**	

Source: Field survey, 2011

For maize production, hybrid seeds were utilized by a larger number of population than other inputs. Data collected from this survey reveals that more than half of the sample population utilized hybrid seeds. More households utilized hybrid seeds in the communal areas than in the A1 sector. More than 90 percent of the farmers in both sectors made use of this hybrid seeds.

Table 4.11: Utilization of agricultural inputs in Goromonzi District

Inputs	Type	A1				Communal				Total			
		No.	%	Avg qty used (kg/l)	Avg area applied to (ha)	No.	%	Avg qty used (kg)	Avg area applied to (ha)	No.	%	Avg qty used (kg)	Avg area applied to (ha)
Seed	Hybrid	47	94.0	45.3	1.8	49	98.0	13.2	0.5	96	96.0	28.9	1.2
	OPV	2	4.0	100.0	-	1	2.0	5.0	0.2	3	3.0	68.3	0.2
	Retained	3	6.0	40.0	1.7	-	-	-	-	3	3.0	40.0	1.7
Agrochemicals	Herbicides	3	6.0	10.0	2.3	-	-	-	-	3	3.0	10.0	2.3
Fertilizers	Basal	36	72.0	259.7	1.9	47	94.0	95.6	0.5	83	83.0	166.9	1.1
	Top dressing	36	72.0	222.8	1.9	46	92.0	100.0	0.5	82	83.0	153.9	1.2

Source: Field survey, 2011

Table 4.11 shows that agrochemicals use was less common as there are not much a requisite in maize production. Only 3 percent utilized agro-chemicals in A1 farms and non in the communal areas. Use of agrochemicals is limited to 6 percent in the A1 sector and no use in the communal sector.

Table 4.13: Average maize production levels in Goromonzi District

Variable	A1			Communal			Total		
	No.	%	Avg value	No.	%	Avg value	No.	%	Avg value
Maize output	49	98.0	2.2	49	98.0	0.9	98	98.0	1.6
Actual yield	46	92.0	1.1	49	98.0	1.2	95	95.0	1.2

Source: Field survey, 2011

The average maize yield was 1.1 tonnes/ha for A1 farmers whilst it was 1.2 tonnes/ha for communal farmers (Table 4.12). The communal farmers proved to be producing their maize on a higher level than that of the A1 farmers. This was an unexpected result as the A1 farmers were expected to have had higher yields than communal farmers as they are located on more fertile land than communal farmers.

4.5 Summary

This chapter described how data for the study was obtained and preliminary analysed. The chapter illustrated what type was of data was collected for the study. It was highlighted that the study made use of both secondary data and primary data. Secondary data was obtained from government bodies, and the Food and Agricultural Organization (FAO) FAOSTAT. The importance of collecting secondary data was highlighted. The chapter pointed out that the survey was carried out in Goromonzi District, which is located in Mashonaland East Province. It was explained that Goromonzi was purposively selected because, being located in Region II, it has historically been highly diversified and productive for both commercial and communal farmers (Muir, 1994). The survey was shown to have randomly selected farmers from each ward through a simple household listing followed by another random selection of 50 maize farmers from each ward, making a random sample of 100 respondents for the study.

This chapter describes the general socio-economic characteristics of the A1 farmers and communal farmers. The chapter also analysed the characteristics of the qualities that otherwise influence agricultural production of these farmers. It was therefore shown that farmers require human, natural, physical, financial and social capital in order for them to actively strategize for their livelihood development. The general agricultural activities that are being carried out by farmers in Goromonzi District that influence maize production were also discussed in this chapter. A comparative analysis was made between A1 resettlement farmers and communal farmers in maize production and it was shown that A1 resettlement farmers have higher maize yields than communal farmers. The chapter is described to provide a basic foundation for Chapter 5, which specifically analyses the differences in technical efficiency between the farmers from the different models.

CHAPTER 5: COMPARATIVE ANALYSIS OF TECHNICAL EFFICIENCY DIFFERENCES BETWEEN A1 RESETTLEMENT AND COMMUNAL FARMERS

5.1 Introduction

This chapter specifies the model that was used to estimate measurements of technical efficiency levels for A1 resettlement and communal farmers in Goromonzi District, Mashonaland East Province, Zimbabwe. The data that was used in the study was obtained from a sample of 100 farmers in Goromonzi District for the 2010/2011 agricultural season. The chapter starts by specifying a Cobb-Douglas stochastic frontier production function. The advantage of using the stochastic frontier model is its ability to estimate actual efficiency below potential efficiency. The variables that are analyzed in the study are contained in Appendix A and B. This chapter also determines presence of inefficiency in the production function data for the sampled households. This will be done by testing that influence of efficiency variables on actual output and testing inefficiency variables on potential output both influencing inefficiency levels. The model enables testing of the null hypothesis laid down in Chapter 1.

The chapter further goes on to calculate values of the parameters and impact coefficients for both the production function and the inefficiency model. These values represent the coefficients of variables for both the production function and inefficiency model. The technical efficiency levels for each individual farmer are then calculated in this chapter and comparisons are made between the two farming models, A1 resettlement and communal areas. The chapter then finally analyses the impact of factors of production on potential and actual output and the socio-economic factors that influence inefficiency in maize production in Goromonzi District by the A1 resettlement and communal farmers.

5.2 Model Specification

The model chosen to perform the efficiency analysis can be expressed in general form as

$$Y=f(X_1, X_2, X_3), \tag{12}$$

where Y is output and the X's are inputs. A more detailed definition of these variables is given below, while descriptive statistics are presented in Table 5.1. The output variable in equation

$$Y=f(X_1, X_2, X_3),$$

Where;
Y denotes maize yield of the *i*th farmer in tonnes/ha;
X_1 = 1, denotes the total land under maize cultivation in ha;
X_2 = 2, denotes the total of family labour, exchange labour and hired laour in man days; and
X_3 = 3, denotes farm capital used (total seeds, fertilizer and farm tools used).

The explanatory variables included in this model have been commonly used in estimating agricultural production frontiers for developing countries (Bravo-Ureta and Pinheiro, 1997).

The Stochastic frontier production functions of the Cobb-Douglas function were used to analyze the data for farmers from both A1 and communal farming sectors (Appendix A and B). The Cobb-Douglas functional form is used despite its well-known limitations. The Cobb-Douglas function is chosen because the methodology employed requires that the function be self-dual (Bravo-Ureta and Evenson 1994; Bravo-Ureta and Pinheiro, 1997). The other reason why the specified Cobb-Douglas production function was used was because of its ease of interpretation of returns to scale (Mushunje, 2005). The function is homogeneous of degree, a+b. If a+b exceeds unity, there are increasing returns to scale; when a+b=1 there is constant returns to scale and a+b<1 indicates diminishing returns to scale (Mushunje, 2005).

Taylor and Shonkwiler (1986) argued that if interest of study rests on efficiency measurement and not on analysis of the general production technology, the Cobb-Douglas production function provides an adequate representation of the production technology. A study that examined the impact of functional form on efficiency concluded that functional specification has a discernible but rather small impact on estimated efficiency (Kopp and Smith, 1980). The Cobb-Douglas production function was used for the different farmers in the sample. The specific model is given by;

$$\ln Y = \beta_0 + \sum_{i=1}^{3} \beta_1 \ln X_1 + \varepsilon_i \tag{13}$$

Where $\varepsilon_i = v_i - u_i$

The equation captures two sections. The first section is the stochastic frontier production function

$$\ln Y = \beta_0 + \sum_{i=1}^{3} \beta_1 \ln X_1 + v_i - u_i$$

while the second part captures the inefficiency variables. The inefficiency model is estimated from the equation 8 given below;

$$u_i = \delta_0 + \sum_{n=1}^{7} \delta_m z_{mi}$$

Thus the specific model estimated was given by:

$$\ln Y = \beta_0 + \sum_{i=1}^{3} \beta_1 \ln X_i + v_i - u_i \qquad \text{and} \qquad u_i = \delta_0 + \sum_{n=1}^{7} \delta_m z_{mi}$$

Where; Y denotes maize yield X_i represent the factors of production as stated before.

v_is are assumed to be independently and identically distributed N($0,\delta^2_v$) two sided random errors, independently of the u_is; and the u_is are non-negative random variables, associated with the inefficiency in production, which are assumed to be independently distributed as truncations at zero of the normal distribution with mean, $u_i = \delta_0 + \sum_m \delta_m z_{mi}$ and variance $\delta^2_u(|N(\mu,\delta^2_u)|$;

ln = natural logarithm;

z_{mi} = variables representing socio-economic characteristics of the farm to explain inefficiency, m.

The socio-economic and farm-level characteristics modeled in the inefficiency model include; gender of farmer, age of farmer, residency, level of education attained, agricultural training obtained, soil quality, cattle ownership, cropped area and farm size.

m = 1, gender (dummy variable to measure the sex of the farmer. Value is 1 if farmer is male, 0 otherwise);
m = 2, education (dummy variable to measure the level of education attained by farmer. Value is 0 if he/she has no received any education at all, 1 otherwise);
m = 3, agricultural training (dummy variable to measure agricultural training obtained by farmer. Value is 0 if he/she received no training at all, 1 otherwise);
m = 4, age (number of years of the farmer);
m = 5, residency (dummy variable to measure whether farmer resides on the farm or not. Value is 1 if farmer is resident on farm, 0 otherwise);
m = 6, soil quality (dummy variable to measure the soil quality of farm. Value is 1 if soil is sandy, 0 otherwise);
m = 7, cattle ownership (number of cattle owned by the farmer);
m = 8, farm size (size of farm in ha); and
m = 9, cropped area (area cropped by farmer in ha).

Traditionally, TE has been estimated using a two-stage process. The first stage was to measure the level of efficiency/inefficiency using a normal production function. The second stage was to determine socio-economic characteristics that determine levels of technical efficiency. This was done by using a probit model, with TE as the dependant variable and the socioeconomic characteristics as the independent variables. However since recently, the stochastic frontier and inefficiency models are jointly estimated in a one-stage process using Limdep (Green, 2002) or

Frontier or Stata/IC computing packages, which apply MLE. This study made use of the computer software Frontier 4.1 for its analysis. Frontier 4.1 was used to estimate the individual farm's technical efficiency levels and the maximum likelihood estimates used to assess the effects of farm location and agricultural diversification characteristics on farmer's technical efficiency. This provided the study with the efficiency levels of each farmer that was interviewed.

5.3 Model Estimation

Before proceeding to the analysis of technical efficiency and its determinants, the presence of inefficiency in the production input-output data for the sample households was determined. The test was carried out by conducting a Likelihood-ratio test assuming the null hypothesis of no technical efficiency. The test statistic was computed automatically when the frontier model was estimated using Frontier 4.1.

As is indicated in Table 5.1 in section 5.4, the inefficiency component of the disturbance term (u) was significantly different from zero. Therefore, the null hypothesis of technical inefficiency (H_0: $\delta_u = 0$) was rejected. This indicated that there was statistically significant inefficiency in the data. Results from the survey revealed that the scale coefficient was 0.132 and 0.315 for A1 resettlement and communal farmers respectively. The sum of the coefficients added up to less than one but greater than zero signifying diminishing returns to scale of maize production. Based on this, the null hypothesis of constant returns to scale for the Cobb-Douglas function could be rejected.

Another key parameter that was used is $\gamma = (\delta_u^2 / \delta^2)$ which is the ratio of the errors in the equation; $\ln Y = \beta_0 + \sum_{i=1}^{3} \beta_1 \ln X_1 + v_i - u_i$,. It is bounded between zero and one (i.e. $0<=\gamma<1$). A value equal to zero implies that technical inefficiency is not present and the ordinary least square estimation would be an adequate representation. A value close to or equal to one implies that there is no random noise, and that the model is appropriate (Piesse and Thirtle, 2000 and Battesse and Coelli, 1995).

The MLEs give appropriate results because OLS estimates fail to do so (Bamlaku *et al.*,2002). The values of $\gamma=0.98$ and $\gamma=0.95$ for A1 and communal farmers respectively establish the fact that a high level of inefficiencies exist in the A1resettlement and communal maize production systems. They illustrate that more than half of the residual variation is due to the inefficiency effects. This means that technical inefficiency is likely to have an important effect in explaining maize yield among farmers in the sample (Bamlaku *et al*., 2002).

5.4 Estimated Model Results

Based on the model discussed in the previous section, Table 5.1 presents ordinary least square (OLS) and maximum likelihood (ML) estimates of the production function parameters. The OLS function provides estimates of the "average" production function, while the ML model yields estimates of the stochastic production frontier.

The MLEs of the parameters of the Cobb-Douglas stochastic frontier function defined by the equation $\ln Y = \beta_0 + \sum_{i=1}^{3} \beta_1 \ln X_1 + v_i - u_i$, given the specifications for the inefficiency effects defined by $u_i = \delta_0 + \sum_{n=1}^{7} \delta_m z_{mi}$. are presented in Table 5.1. Estimates of the model were obtained using maximum-likelihood procedures by using Frontier 4.1 program. The results are presented in the upper part of table 5.1. Estimates of parameters of the inefficiency effects stochastic production frontier model that influence farmers' levels of technical inefficiency are listed in the lower part of Table 5.1

Table 5.1: Maximum likelihood estimates of stochastic frontier production function

Independent variables	Coefficient symbol	A1			Communal		
		Coefficient value	Std error	t-ratio	Coefficient value	Std error	t-ratio
Production function							
Intercept	β_0	1.525	0.182	8.379	1.147	0.199	5.758
Ln (land)	β_1	0.118	0.099	1.120	0.259	0.113	2.287
Ln (Labour)	β_2	0.020	0.090	0.218	0.038	0.080	0.475
Ln (capital)	β_3	-0.016	0.019	-0.816	0.018	0.198	0.930
Sum elasticities		0.122			0.315		
Variance parameters							
$\delta^2 = (\delta^2_u + \delta^2_v)$		0.486	0.267	1.822	0.497	0.191	2.605
$\gamma = (\delta_u^2 / \delta^2)$		0.983	0.019	50.846	0.949	0.035	27.371
Log likelihood		-18.480			-4.062		
LR test		0.366			0.312		
No. of farms		50			50		
Inefficiency effects							
Constant	δ_0	-0.353	2.137	-0.165	-5.061	4.361	-1.160
Gender	δ_1	0.101	0.546	0.185	-1.347	0.872	-1.544
Age	δ_2	0.004	0.016	0.266*	-82.348	0.012	-0.692
Residency	δ_3	-0.995	0.539	-1.844***	2.045	1.866	1.096*
Education	δ_4	1.893	1.964	0.964*	1.650	1.466	1.125*
Agric training	δ_5	0.701	0.565	1.241***	-0.345	0.991	-0.348
Soil quality	δ_6	-0.204	0.436	0.466*	2.221	1.526	1.456**
Cattle ownership	δ_7	-0.070	0.049	-1.448	-0.389	0.344	-1.129
Cropped area	δ_8	0.039	0.168	0.233	-0.862	0.950	-0.907
Farm size	δ_9	-0.185	0.171	-1.086	-0.553	0.559	-0.988

*, **, *** Significant at 10% level (P<0.10), 5% level (P<0.05) and at 1% level (P<0.01) respectively

Source: Author's computation

Average values of technical efficiency were obtained for both A1 resettlement and communal areas in order to generalize the results. Table 5.2 illustrates that on average communal farmers are producing their maize crop on a higher technical efficiency level than the A1 resettlement farmers. Their mean technical efficiency level was 80.5 percent, whilst that of the A1 farmers was 63.5 percent. This data implies that on average, A1 resettlement farmers were producing their maize at about 63.5 percent of the potential or stochastic frontier production levels, at the current levels of factors of production and technology. This level is 17.0 percent lower than that of the communal farmers who were producing maize crop at 80.5 percent of their potential. Although these mean efficiencies do not differ significantly, such a difference is worth, given that A1 resettlement farmers are growing their maize crop on higher levels of technology, and inputs and soils of better quality than the communal (see Table 4.2 and 4.5). Thus one would expect that A1 farmers would produce their maize at a higher level of technical efficiency than the communal farmers.

Table 5.2: Estimation results of technical efficiencies in Goromonzi District

Technical efficiency	A1		Communal		Total	
Ranges (%)	**No.**	**%**	**No.**	**%**	**No.**	**%**
<50	16	32.7	3	6.0	19	19.2
50 – 60	-	-	3	6.0	3	3.0
>60 - 70	13	26.5	1	2.0	14	14.1
>70 – 80	3	6.1	6	12.0	9	9.1
>80 – 90	12	24.5	22	44.0	34	34.3
>90 – 100	5	10.2	15	30.	20	20.2
Total	**49**	**100.0**	**50**	**100.0**	**99**	**100.0**
Mean TE	63.5		80.5		71.9	
Minimum TE	21.2		25.6		21.2	
Maximum TE	95.6		95.2		95.6	

Source: Field survey, 2011, N=100

The results also indicate that technical efficiency indices range from a minimum of 21.2 percent to a mean of 63.5 percent and a maximum of 95.6 percent for A1 resettlement farmers. This indicates that, if an average farmer in the A1 sector was to achieve the TE level of its most efficient counterpart, then the average farmer could realize 33.0 percent cost savings (i.e., 1-[63.5/95.6]) (Binam *et al*., 2004). A similar calculation for the most technically inefficient farmer reveals cost savings of 77.8 percent given by 1-[21.2/95.6]. Table 5.2 also shows that TE ranges between a minimum of 25.6 percent, a mean of 80.5 percent and a maximum of 95.2 percent for communal farmers. This also implies that, if the average farmer in the communal areas was to achieve the TE level of its most efficient counterpart, then the average farmer could realize cost savings of 15.4 percent (i.e., 1-[80.5/95.2]) (Binam *et al*., 2004). The same sector reveals cost savings of 73.1 percent for the most technically inefficient farmer. The study indicate that both the farmers in the A1 and communal sectors can gain at least an average maize output growth of 36.5 percent through full improvements in technical efficiency.

5.5 Factors Explaining Inefficiency

Parameter estimates of the inefficiency effects stochastic production frontier model employed to identify the factors influencing farmers' levels of technical inefficiency are listed in the lower part of Table 5.1. The results demonstrate that the different variables have different influence on maize yield in both A1 resettlement and communal farms. Some variables were shown to be of importance in increasing the level of technical efficiency of farmers, whilst others were not.

Results from Table 5.1 highlight that the coefficient value of the age variable was positive for A1resettlement farmers whilst it is negative for communal farmers. Age was statistically significant at 10 percent level in the A1 resettlement farms. The results obtained from the communal farmers are in line with *a priori* expectation. Therefore part of hypothesis 2 was accepted. A1 resettlement farmers are a relatively younger group, and survey results indicate that the older the farmer is, the more technically inefficient he/she is. Findings from the A1 resettlement farmers indicate that younger farmers in the A1 resettlement model have higher technical efficiency levels than their older counterparts. This may be because in the A1 farms, farmers have larger farm sizes than in communal areas. Hence they need more energy and effort to work on, which may be difficult for the older farmers than the younger and energetic group of farmers. Results for communal farmers, which comprised of generally older farmers, who are likely to have more farming experience showed age had a positive and significant impact on technical efficiency (Coelli and Battese, 1996). This means that for the communal farmers, the older ones were more technically efficient than the younger farmers. Conflicting views exist concerning the influence of age on farmer's level of technical efficiency. Seyoum *et. al.* (1998) argue that older farmers are expected to have greater inefficiencies because they are less adaptable to new technological developments, whilst Brinkman (1998) argues that younger farmers are more successful than their older counterparts. Coelli and Battese (1996) concluded that the expected signs for age in the inefficiency model are not always clear, and could therefore have a positive or a negative effect on the magnitude of the inefficiency. They argued that though older farmers are likely to have more farming experience, they are also likely to be more conservative and thus to be less willing to adopt new practices, thereby perhaps having greater inefficiencies in agricultural production.

Table 5.1 highlights that the issue of residency is important in the A1 resettlement farming sector than it is in the communal areas. There is a high correlation between residency and level of technical efficiency. Results indicated that residency is vital for the attainment of higher maize yield in the A1 resettlement farms. However, the residency variable had a negative coefficient and was significant at 1 percent level. Results showed that A1 resettlement farmers who were not resident on their farms had lower technical efficiency levels than their resident counterparts. The explanation for this is similar to that often given for the higher educated farmers which suggests that such a farmer (non-resident or more educated) will have more opportunities elsewhere, and have less attention to farm production, thus increasing inefficiencies (Phillips and Marble; 1986; Bravo-Ureta and Evenson, 1994).

These survey results re-emphasise the need for beneficiaries of the FTLRP to be resident on their farms and be ‘100 percent’ full-time farmers, if the programme is to eventually succeed. These results are consistent with part Hypothesis 2 from Chapter 1. These results further confirm findings by Kassali, Ayanwale and Williams (2009). They concluded that residing on the farm improves the farmer’s TE. In their study of farm location and determinants of agricultural productivity in the Oken-Ogun area of Oyo States, Nigeria, they concluded that farm distance and the residence of farmers during farming are important factors of agricultural productivity among food farmers in the tropics. Residency was not an issue in the communal areas because most farmers were resident on their farms anyway (see Table 4.2).

Table 5.1 shows that variable education had a negative coefficient in both A1 resettlement farms and communal farms. The results were both significant at 10.0 percent level (Table 5.1). These results indicated that farmers with higher levels of education exhibited higher levels of technical efficiency. The results agree with our expectation regarding education on TE in part of Hypothesis 2 from Chapter 1. The implication is that farmers with formal schooling tend to be more efficient in food crop production, presumably due to their enhanced ability to acquire technical knowledge, which makes them move close to the frontier output. It is very plausible that the farmers with education respond readily to the use of improved technology, such as the application of fertilizers, use of pesticides and so on, whereby producing closer to the frontier.

The results confirm findings by Batesse and Coelli (1995), Bravo-Ureta and Pinheiro (1997), Weir (1999); Weir and Knight (2000), Bamlaku et.al (2002),and Mushunje (2003). The researchers argued that education is a very important variable because it enhances the managerial and technical skills of farmers and it improves the management of farmer's resources in order to sustain the environment and produce at optimum levels. It also increases the household's ability to utilize existing technologies and attain higher efficiency levels. However, studies pointing against education argue that when a farmer gets access to better education, he/she may get better opportunities outside the farm sector to pursue other income earning activities, thus increasing the level of inefficiency in his/her farm production (Phillips and Marble; 1986; Bravo-Ureta and Evenson, 1994).

Results indicated that agricultural training had a positive coefficient for both A1 resettlement and communal farmers. This shows that agricultural training had a positive impact on technical efficiency in both A1resettlement farmers and communal farmers. The results were in line with *a priori* expectation, therefore part of Hypothesis 2 in Chapter 1 was accepted. These results emphasize agricultural extension and farmer-education programmes as key policy instruments for governments seeking to improve the productivity of agriculture, while protecting the environment (Binam, 2004). However, several researchers have documented the poor performance in the operation of extension and informal education systems, due to bureaucratic inefficiency, deficient program design, and some generic weaknesses inherent in publicly-operated, staff-intensive, information delivery systems (Binam, 2004).

The quality of soils was positively associated with technical efficiency in A1 resettlement farms only. These results indicated that A1 farmers that were located at more fertile soils performed significantly better than their counterparts in areas with less fertile soils. This supports the need for soil fertility improvement programmes by farmers, private sector and the government as a means of increasing crop productivity. The quality of soils was statistically significant at 10 percent for A1resettlement farmers. The results in A1resettlement farms were different from those in communal farms which showed that for better quality soils, there were observed higher levels of inefficiencies. The quality of soils was 5 percent for communal farmers. Results from communal farms may be due to the fact that there were limited soil type ranges i.e. only sandy and sandy-loam with the bulk of the farmers located at farms with sandy soils (Fig 4.2).

Survey results demonstrate that number of cattle owned by both A1 resettlement farmers and communal farmers had negative coefficient values for both A1 resettlement and communal farmers. Cattle ownership was shown to have a positive impact on technical efficiency. Results from Table 4.6 illustrated that cattle ownership was poor in terms of numbers owned in both A1 resettlement and communal areas. Increase in the number of cattle that can be owned by farmers will result in them improving their technical efficiency in their maize production. Cattle provide farmers with draught power for land preparation, other tillage operations and farm transport. Cattle ownership reduces the amount of effort required by farmers regarding ploughing activities. These findings were in line with the hypothesized statements in Chapter 1.

The variable cropped area's coefficients for the A1 resettlement farmers and communal farmers were positive and negative respectively. These results show that as cropped area increased in the A1 farms, technical efficiency levels for maize production was reducing for A1 resettlement farmers. Results from Fig 4.3 and Table 4.9 show that about 75 percent of the A1 resettlement farmers utilize more 50 percent of their land and that more A1 resettlement farmers grow more than one crop on their farms than communal farmers. One would expect that since the A1 resettlement farms are reasonably sized, increasing area cropped would not have that much negative influence on technical efficiency. Survey findings indicate that as cropped area increases in the communal areas, technical efficiency also increases. Communal areas are characterized by small farms, and thus any increase in cropped area on such small farms was not expected to have reduced technical efficiency level of maize production.

The stochastic production regression analysis revealed that both A1 resettlement and communal farmers had a negative coefficient of the variable farm size. Results imply that a 10 percent increase in in farm size gave the set of inputs of land, labour and capital, will respond to an input in maize yield with 1.18, 0.20 and -0.16 respectively. The results also suggest that as farm size increases, the level of technical efficiency for maize of production will also increase. These results are not in line with the *a priori* hypothesis that was made in Chapter 1The hypothesis assumed an inverse relationship between farm size and technical efficiency. However, the results are understandable for the communal areas where farmers possessed small farm sizes but not for the A1resettlement farmers who already possess large pieces of land.

5.6 Summary

This chapter specified the model that was used to estimate measurements of technical efficiency levels for A1 resettlement and communal farmers in Goromonzi District, Mashonaland East Province, Zimbabwe. Stochastic frontier production functions of the Cobb-Douglas function were used to analyze the data for farmers from both A1 resettlement and communal farming sectors. The Cobb-Douglas function was chosen because the methodology employed requires that the function be self-dual and because of its ease of interpretation of returns to scale (Bravo-Ureta and Evenson 1994; Mushunje, 2005).

The specific model estimated was given by: $\ln Y=\beta_0+\sum_{i=1}^{3}\beta_1 \ln X_1+v_i-u_i$ and $u_i=\delta_0+\sum_{n=1}^{7}\delta_m z_{mi}$
Where; Y denoted maize yield of the *i*th farmer in tonnes/ha; I = 1, 2 and 3 denoted the total land under maize cultivation (ha); total labour and farm capital used respectively. v_is and u_is were assumed to be random errors. The socio-economic and farm-level characteristics that were modeled in the inefficiency model included; gender of farmer, age of farmer, residency, level of education attained, agricultural training obtained, soil quality, cattle ownership, cropped area and farm size. The mean technical efficiency level of communal farmers was 80.5 percent, whilst that of the A1 resettlement farmers was 63.5 percent. This data implies that on average, A1 resettlement farmers were producing their maize at about 63.5 percent whilst communal farmers were producing at 80.5 percent of the potential (stochastic) frontier production levels, at the current levels of inputs and technology. The results were not in line with the *a priori* expectation, i.e. Hypothesis 3 in Chapter 1. Therefore Hypothesis number 3 was rejected.

A summary of the relationship between the factors that influenced technical efficiency in Goromonzi District and the hypotheses that were laid in Chapter 1 is shown in Table 5.3. Survey results revealed that the age variable was increased inefficiency levels as age increased for A1 farmers whilst it reduced inefficiencies for communal farmers. Results showing the relationship between residency and level of technical efficiency indicated that residency of the famer on the plot were vital for the attainment of higher maize yield in the A1 farms. The variable education had a positive coefficient in both A1 resettlement and communal farms. The results were both significant at 10 percent level. These results indicated that farmers with higher levels of education exhibited lower levels of technical efficiency. Agricultural training had a negative impact on technical efficiency in A1 resettlement farmers and a positive impact on communal farmers.

Table 5.3: Relationship between hypotheses and results of factors influencing technical efficiency

Hypothesis	Variable	A1				Communal			
		A priori expectation	Observed output	Signif[a]	Acceptance/ rejection	*A priori* expectation	Observed output	Signif[a]	Acceptance/ rejection
3	Age	+	-	10% level	Rejected	+	+	10% level	Accepted
	Residency	+	+	10% level	Accepted	+	-		Rejected
	Education	+	+	10% level	Accepted	+	+	10% level	Accepted
	Agric training	+	+	10% level	Accepted	+	+	10% level	Accepted
	Soil quality	+	+	10% level	Accepted	+	-	5% level	Rejected
	Cattle ownership	+	+	5% level	Accepted	+	+	5% level	Accepted
	Cropped area	-	-	10% level	Accepted	+	+	10% level	Accepted
4	Farm size	-	+	10% level	Rejected	-	-	10% level	Accepted

Source: Field survey, 2011
[a]Significance testing using *t-tests*

The quality of soils was positively associated with technical efficiency in A1 resettlement farms only. Survey results demonstrate that number of cattle owned by both A1 resettlement farmers and communal farmers had negative coefficient values for both A1 and communal farmers. Cattle ownership was shown to have a positive impact on technical efficiency. Results showed that as cropped area increased in the A1 resettlement farms, technical efficiency levels for maize production was reducing for A1 resettlement farmers. Survey findings indicate that as cropped area increases in the communal areas, technical efficiency also increases. The stochastic production regression analysis revealed that both A1 resettlement farmers and communal farmers had a negative coefficient of the variable farm size.

CHAPTER 6: CONCLUSIONS, POLICY RECOMMENDATIONS AND AREAS OF FURTHER STUDY

6.1 Conclusions

The major objective of the study was to compare estimates of technical efficiency of maize production between A1 resettlement farmers and communal farmers in Goromonzi District, Mashonaland East Province. It also explained variations in technical efficiency among farms due to managerial and socio-economic characteristics. Farm specific technical efficiencies were computed using 2010/2011 maize production season cross sectional data from the area. A stochastic frontier approach was used to generate technical efficiency estimated using Frontier 4.1 Software. A Cobb-Douglas production functional form was used.

From the analysis of socio-economic conditions and the factors of production, it seems there is a significant difference between A1 resettlement farmers and communal farmers. These differences are in terms of the factors of production, land, labour, capital. The study showed that A1 resettlement farmers were generally a younger group than the communal framers. The A1 resettlement farmers were also located on more fertile soils than communal farmers. A1 resettlement farmers showed that they had better access and ownership of farming equipment than communal farmers. For example, they had better levels of ownership of hand-tools such as mattocks, picks, spade forks and equipment such as watering cans and knapsack sprayers. In terms of access to animal and power driven implements, A1 resettlement farmers had better access to these implements than the communal farmers.

The estimated results of the stochastic production function showed that A1 resettlement farmers had mean technical efficiency levels lower than that of communal farmers. The mean technical efficiency levels of A1 and communal farmers in Goromonzi District were 63.5 and 80.5 respectively. The mean technical efficiency of 63.5 and 80.5 percent for A1 and communal farmers implies that, in the short-run, there was scope for increasing technical efficiency in maize production in the study area by 36.5 and 19.5 percent respectively with same level of technology. The distribution of the technical efficiency suggests that potential gain in technical efficiency among the sample farmers is large. This can be achieved through improved farmer-specific efficiency factors, which include residency of farmer on the plot, agricultural training, soil improvement and cattle ownership. The farm-specific variables that were used to explain inefficiencies indicate that those farmers who were more educated, live on more fertile soils, who are resident on their farms, who have received agricultural training and who own more cattle tend to be more efficient in A1 farms. For communal farms the more efficient farmers proved to be the older farmers, farmers with higher levels of education, who have received agricultural training, who own more cattle and have larger pieces of their farms cropped.

6.2 Policy Recommendations

The study found that there are some differences in socio-economic characteristics between A1 resettlement farmers and communal farmers. Therefore the government in providing assistance to these two groups of farmers needs be group-specific. Policies to assist A1 resettlement farmers and communal farmers need to target farmers depending on their needs.

The country has an education policy that encourages its citizens to be literate. Such a policy is vital, but can also continue to encourage farmers to continue going to school so that they can be literate. This would increase the efficiency level of farmers. Results from this study showed that agricultural training had a positive impact on technical efficiency in both A1 farmers and communal farmers. These results emphasize agricultural extension and farmer-education programmes as key policy instruments for governments seeking to improve the productivity of agriculture, while protecting the environment.

Study results showed that farmers located in fertile soil areas showed higher levels of technical efficiency, than those in less fertile areas for both A1 and communal farmers. Improving soil conditions in both sectors is of importance to improving and maintaining soil productivity. This calls for coordinated effort to promote effective soil management, for example soil erosion control, liming and fertilizer application. Most of the farmers in both the A1 and communal areas may not be able to afford to purchase lime and other mineral fertilizers, the utilization of green manure and compost is a promising option.

Cattle ownership was shown to have a positive impact on technical efficiency. Results from the survey showed that cattle ownership was poor in terms of numbers owned in both A1 and communal areas. This implies that improving the cattle ownership of the A1 and communal farmers can ultimately bring about improvement in agricultural productivity by improving technical efficiency. This could be attained by improving the production and productivity of cattle. Therefore, there is a need to design appropriate policy for improving cattle production systems in Zimbabwe by solving the shortage of feed and health problem, solving the problem of cattle rustling (in some parts of the country) and providing various technical and advisory support services.

Survey results showed that as cropped area increased in the A1 farms, technical efficiency levels for maize production was reducing for A1 farmers. One would expect that since the A1 farms are reasonably sized, increasing area cropped would not have that much negative influence on technical efficiency. Thus there is need for support to the farmers in terms of training for them to improve their efficiency even if they have to increase their cropped area. The issue of residency also proved to be important in the A1 farms. Therefore to ensure that for the land reform program to be a success, the government needs discourage farmers from 'cell-phone' farming and be available during farm production activities on their farms. This will assist in increasing technical efficiency.

The stochastic production regression analysis revealed that both A1 and communal farmers had a negative coefficient of the variable farm size. The results suggest that as farm size increases, the level of technical efficiency for maize of production will also increase. These results are not in line with the *a priori* hypothesis that was made in chapter 1, which stated that there is an inverse relationship between farm size and technical efficiency. Such findings are not in support of the efficiency argument of land reforms. The large farm vs small farm efficiency debate emphasizes the more intensive utilization of land in smaller farms than in larger farms. Therefore there is need for coordinated effort by the government to encourage intensive farming by both A1 and communal farmers and for them, especially the A1 farmers to appreciate the program of land reform.

6.3 Areas of Further Study

The empirical results obtained from this research provide meaningful information for both farmers and policy makers. Individual farmers can not only learn more about their performance in relation to other farmers but also how to improve their productive performance. Policy makers can know more about the performance of farmers located in Goromonzi district in relation to other districts and regions. They can also decide on what policies to put in place to improve the overall performance of the maize sector. The reliability of these empirical studies, however, crucially depends on the accuracy of efficiency estimates.

There are a number of directions in which this study can be extended. This study only focused on the technical efficiency of the maize in a few households in Goromonzi distirct. An extension could be to analyze the efficiency of production of more crops such as tobacco, wheat, soyabeans, cotton and livestock from more households in the district and/or in as many districts representing the nation as possible. In addition, the study focused on technical efficiency, but a study on allocative efficiency might give more insight to the efficiency studies. It would also be interesting to look at technical efficiency and allocative efficiency using panel data from Goromonzi or more districts in Zimbabwe to evaluate how technical efficiency is changing over time. In redesigning the above possible studies, variables such as health, agricultural experience, of farmer could be considered.

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APPENDICES

Appendix A: Analyzed Variables for A1 Resettlement Farmers

Qn no.	Gender	Age	Marital status	Education	Residency status	Soil	Maize yield	Maize area	Cattle	Cropped area	Basal fert used	Top fert used
1	male	55	widowed	primary education	urban area	clay-loam	1	>1 - 2	0	2	600	400
2	male	43	married	primary education	on-farm	sandy-loam	1	>2 - 3	0	2.5	150	125
3	female	.	divorced	.	.	sandy-loam	1	>0.5 - 1	0	1	250	100
4	male	57	married	ZJC	on-farm	clay-loam	0.5	>1 - 2	0	2	100	100
5	female	52	widowed	primary education	on-farm	sandy-loam	0.33	>2 - 3	0	3	100	150
6	male	55	married	primary education	on-farm	sandy-loam	0.5	>1 - 2	0	3	150	250
7	male	47	married	primary education	on-farm	sandy-loam	2	>0.5 - 1	0	2	50	75
8	female	51	married	primary education	on-farm	sandy-loam	1.25	+>3	2	3	750	300
9	male	32	married	primary education	on-farm	sandy-loam	1	+>3	0	4	100	150
10	male	68	married	primary education	on-farm	sandy-loam	1	>2 - 3	0	2.5	150	125
11	male	59	married	primary education	on-farm	clay-loam	.	>2 - 3	2	6	.	150
12	male	49	married	primary education	on-farm	clay-loam	.	+>3	2	5	.	600
13	male	50	married	ZJC	on-farm	clay-loam	0.5	>1 - 2	0	2.5	150	150
14	male	50	married	primary education	on-farm	clay-loam	3	>0.5 - 1	5	2	.	100
15	female	55	single	ZJC	on-farm	sandy-loam	1.33	>2 - 3	6	3	500	300
16	male	60	married	ordinary level	urban area	sandy	0.5	>1 - 2	0	2	100	100
17	male	85	married	.	on-farm	sandy	0.5	>1 - 2	0	2	.	.
18	male	38	married	ZJC	on-farm	sandy	1	<0.5 - 0.5	0	0.5	.	.
19	male	45	married	primary education	on-farm	clay-loam	2	>0.5 - 1	0	3	50	100
20	male	59	married	primary education	urban area	sandy	1	>0.5 - 1	1	1	150	.
21	male	53	married	no formal education	on-farm	sandy-loam	.	.	5	.	100	100
22	female	49	widowed	ordinary level	on-farm	sandy-loam	1	+>3	2	4	400	300
23	male	55	married	ZJC	on-farm	sandy	2	>1 - 2	2	4	400	250
24	male	58	married	primary education	urban area	clay-loam	1.67	>2 - 3	1	3	150	150
25	female	60	married	primary education	on-farm	sandy	2	>0.5 - 1	5	3	150	100
26	male	59	married	primary education	on-farm	sandy-loam	1	<0.5 - 0.5	0	0.5	100	50
27	male	50	married	tertiary	on-farm	sandy-loam	.	+>3	2	6	1250	1250
28	female	.	married	no formal education	on-farm	clay-loam	1	<0.5 - 0.5	0	1.5	75	50
29	female	36	married	advanced level	urban area	clay-loam	0.5	>1 - 2	0	2	300	200
30	male	31	married	no formal education	on-farm	sandy-loam	1	>0.5 - 1	1	.	100	100
31	male	34	married	ordinary level	on-farm	sandy-loam	1	>0.5 - 1	1	.	100	100
32	male	57	married	no formal education	on-farm	sandy-loam	1.5	>1 - 2	1	2	250	500
33	male	50	married	primary education	on-farm	sandy-loam	0.67	>2 - 3	0	3	100	150
34	male	49	married	tertiary	urban area	sandy-loam	1	>0.5 - 1	0	1	200	100

35	male	22	divorced	primary education	on-farm	sandy-loam	1	>0.5 - 1	0	3	50	100
36	female	37	married	ZJC	on-farm	sandy-loam	1	>1 - 2	0	3	200	500
37	male	45	married	ZJC	on-farm	sandy	1	>0.5 - 1	0	4.5	150	50
38	male	67	married	primary education	urban area	sandy-loam	1.67	>2 - 3		6	500	300
39	male	49	widowed	no formal education	on-farm	sandy-loam	1	<0.5 - 0.5	0	2	200	150
40	male	52	married	primary education	on-farm	sandy	2	>0.5 - 1	2	3	.	200
41	male	39	widowed	ordinary level	on-farm	sandy-loam	1	<0.5 - 0.5		2	100	150
42	female	54	widowed	ZJC	urban area	sandy-loam	1	<0.5 - 0.5	0	1	100	150
43	male	51	married	ZJC	urban area	sandy	0.5	>1 - 2		2	100	100
44	female	61	widowed	primary education	urban area	sandy-loam	1	>0.5 - 1		1	.	.
45	male	51	married	advanced level	urban area	sandy-loam	1	>1 - 2		4	150	100
46	male	34	married	ordinary level	on-farm	sandy-loam	0.5	>1 - 2	0	2	250	400
47	male	81	married	primary education	on-farm	sandy-loam	0.5	>1 - 2	0	4	100	150
48	male	52	married	primary education	urban area	clay-loam	2	>0.5 - 1	0	.	100	150
49	male	41	married	tertiary	on-farm	sandy-loam	2	>1 - 2	0	2	150	150
50	male	56	married	primary education	on-farm	sandy-loam	1	<0.5 - 0.5	0	0.5	100	50

Appendix B: Analyzed Variables for Communal Farmers

Qn no.	Gender	Age	Marital status	Education	Residency status	Soil	Maize yield	Maize area	Cattle	Cropped area	Basal fert used	Top fert used
1	female	52	widowed	no formal education	communal area	sandy	2	<0.5 - 0.5	0	<1	150	100
2	male	73	married	primary education	communal area	sandy	1	<0.5 - 0.5	2	<1	50	50
3	male	32	married	ordinary level	communal area	sandy	2	<0.5 - 0.5	0	1 - <2	150	200
4	male	42	married	ordinary level	communal area	sandy	1	<0.5 - 0.5	1	<1	150	200
5	male	69	married	primary education	communal area	sandy-loam	1	<0.5 - 0.5	0	<1	100	50
6	male	39	married	ordinary level	urban area	sandy	1	<0.5 - 0.5	0	<1	50	50
7	male	39	married	ordinary level	communal area	sandy	1	<0.5 - 0.5	0	<1	100	100
8	male	72	married	ZJC	communal area	sandy	1	>0.5 - 1	0	1 - <2	250	200
9	male	35	married	ordinary level	communal area	sandy	1	<0.5 - 0.5	0	<1	100	200
10	female	52	widowed	no formal education	communal area	sandy	1	<0.5 - 0.5	0	<1	50	50
11	female	64	widowed	primary education	communal area	sandy	1	<0.5 - 0.5	0	<1	.	50
12	male	72	married	primary education	communal area	sandy	1	<0.5 - 0.5	0	<1	100	100
13	female	49	married	primary education	communal area	sandy	2	>0.5 - 1	0	1 - <2	150	200
14	male	47	married	primary education	communal area	sandy	1	>0.5 - 1	0	<1	50	100
15	female	49	married	no formal education	communal area	sandy	1	<0.5 - 0.5	0	1 - <2	150	100
16	male	61	married	no formal education	communal area	sandy	1	<0.5 - 0.5	0	<1	100	100
17	male	52	married	no formal education	communal area	sandy	1	<0.5 - 0.5	0	<1	50	50
18	female	58	widowed	primary education	communal area	sandy	1	<0.5 - 0.5	0	<1	50	50
19	male	18	married	primary education	communal area	sandy	1	<0.5 - 0.5	1	<1	50	50
20	female	46	married	no formal education	communal area	sandy	2	<0.5 - 0.5	0	<1	200	200
21	male	68	married	.	communal area	sandy	1	<0.5 - 0.5	0	<1	100	100
22	male	50	married	ordinary level	communal area	sandy	2	>0.5 - 1	0	1 - <2	200	200
23	female	17	married	ZJC	communal area	sandy	1	<0.5 - 0.5	0	<1	100	100
24	female	57	widowed	ZJC	communal area	sandy	1	>1 - 2	3	1 - <2	200	200
25	female	39	widowed	ordinary level	communal area	sandy	1	<0.5 - 0.5	0	<1	50	50
26	female	37	single	ordinary level	communal area	sandy	1	<0.5 - 0.5	0	<1	50	100
27	male	68	divorced	no formal education	communal area	sandy	.	<0.5 - 0.5	0	<1	.	.
28	female	54	divorced	ZJC	communal area	sandy	2	>0.5 - 1	0	1 - <2	250	150
29	female	66	widowed	primary education	communal area	sandy	1	<0.5 - 0.5	0	<1	.	75
30	male	45	married	ordinary level	communal area	sandy	1	<0.5 - 0.5	0	<1	.	100
31	female	46	widowed	ordinary level	communal area	sandy	1	<0.5 - 0.5	0	<1	50	50
32	female	31	married	ZJC	communal area	sandy	1	<0.5 - 0.5	0	<1	50	50
33	male	81	married	primary education	communal area	sandy	1	>0.5 - 1	0	<1	50	50
34	female	64	widowed	ordinary level	communal area	sandy	1	<0.5 - 0.5	0	<1	50	50
35	female	50	widowed	ordinary level	communal area	sandy	2	>0.5 - 1	0	1 - <2	250	150
36	female	42	married	ordinary level	communal area	sandy	1	<0.5 - 0.5	0	<1	20	50
37	female	49	widowed	primary education	communal area	sandy	1	<0.5 - 0.5	0	<1	100	100

38	female	59	widowed	primary education	communal area	sandy	1	<0.5 - 0.5	0	1 - <2	50	100
39	female	42	married	ordinary level	communal area	sandy-loam	2	<0.5 - 0.5	0	<1	100	150
40	male	70	married	ordinary level	communal area	sandy	2	<0.5 - 0.5	0	<1	100	100
41	female	52	widowed	ZJC	communal area	sandy-loam	1	<0.5 - 0.5	0	<1	50	50
42	female	72	widowed	primary education	communal area	sandy-loam	2	>0.5 - 1	0	<1	50	50
43	male	48	married	ordinary level	communal area	sandy-loam	1	<0.5 - 0.5	0	<1	75	75
44	female	41	married	ordinary level	communal area	sandy-loam	1	<0.5 - 0.5	2	<1	100	100
45	male	61	married	primary education	urban area	sandy-loam	2	>0.5 - 1	0	<1	200	200
46	female	.	married	ordinary level	communal area	sandy-loam	1	<0.5 - 0.5	0	<1	50	50
47	male	64	married	ordinary level	communal area	sandy-loam	1	<0.5 - 0.5	0	<1	50	50
48	female	58	widowed	ordinary level	communal area	sandy	1	<0.5 - 0.5	0	<1	50	50
49	male	73	married	primary education	communal area	sandy-loam	2	<0.5 - 0.5	0	<1	50	100
50	female	67	widowed	ZJC	communal area	sandy-loam	1	<0.5 - 0.5		<1	100	100

Appendix C: Final MLE Estimates for A1 Farmers from Frontier 4.1

	Coefficient	Standard-error	t-ratio
beta 0	0.15249132E+01	0.18199395E+00	0.83789227E+01
beta 1	0.11843637E+00	0.99062239E-01	0.11955753E+01
beta 2	-0.15566468E-01	0.19055992E-01	-0.81688050E+00
beta 3	0.19570930E-01	0.89585086E-01	0.21846192E+00
delta 0	-0.35285550E+00	0.21367865E+01	-0.16513371E+00
delta 1	0.10106539E+00	0.54592979E+00	0.18512524E+00
delta 2	0.43932532E-02	0.16491887E-01	0.26638874E+00
delta 3	-0.99463404E+00	0.53926675E+00	-0.18444194E+01
delta 4	0.20355826E+00	0.43623395E+00	0.46662637E+00
delta 5	-0.18533560E+00	0.17066244E+00	-0.10859777E+01
delta 6	0.39139904E-01	0.16823504E+00	0.23265013E+00
delta 7	0.70145339E+00	0.56533574E+00	0.12407731E+01
delta 8	0.18934488E+01	0.19637723E+01	0.96418958E+00
delta 9	-0.70250098E-01	0.48515289E-01	-0.14479992E+01
sigma-squared	0.48643076E+00	0.26703323E+00	0.18216113E+01
gamma	0.98348501E+00	0.19342070E-01	0.50846937E+02

log likelihood function = -0.18479553E+02

LR test of the one-sided error = 0.36605263E+02

with number of restrictions = *

[note that this statistic has a mixed chi-square distribution]

number of iterations = 29

(maximum number of iterations set at : 100)

number of cross-sections = 50

number of time periods = 1

total number of observations = 50

thus there are: 0 obsns not in the panel

Appendix D: Final MLE Estimates for Communal Farmers from Frontier 4.1

	Coefficient	Standard-error	t-ratio
beta 0	0.11470235E+01	0.19919012E+00	0.57584357E+01
beta 1	0.25858670E+00	0.11304826E+00	0.22874009E+01
beta 2	0.18434578E-01	0.19812374E-01	0.93045781E+00
beta 3	0.37909525E-01	0.79818842E-01	0.47494456E+00
delta 0	-0.50609714E+01	0.43618409E+01	-0.11602834E+01
delta 1	-0.13466823E+01	0.87227543E+00	-0.15438728E+01
delta 2	-0.82347898E-02	0.11892214E-01	-0.69245218E+00
delta 3	0.20452283E+01	0.18664021E+01	0.10958133E+01
delta 4	0.22212751E+01	0.15256202E+01	0.14559817E+01
delta 5	-0.55273466E+00	0.55930433E+00	-0.98825385E+00
delta 6	-0.86187042E+00	0.95046024E+00	-0.90679271E+00
delta 7	-0.34462048E+00	0.99134591E+00	-0.34762889E+00
delta 8	0.16500508E+01	0.14663562E+01	0.11252729E+01
delta 9	-0.38869876E+00	0.34425187E+00	-0.11291115E+01
sigma-squared	0.49740401E+00	0.19096452E+00	0.26046933E+01
gamma	0.94932812E+00	0.34683638E-01	0.27371066E+02

log likelihood function = -0.40623386E+01
LR test of the one-sided error = 0.31264593E+02
with number of restrictions = *
[note that this statistic has a mixed chi-square distribution]
number of iterations = 21
(maximum number of iterations set at : 100)
number of cross-sections = 50
number of time periods = 1
total number of observations = 50
thus there are: 0 obsns not in the panel

Appendix E: Survey Questionnaire

A COMPARATIVE ANALYSIS OF MAIZE PRODUCTION EFFICIENCY BETWEEN A1 RESETTLEMENT AREAS AND COMMUNAL AREAS IN GOROMONZI DISTRICT, MASHONALAND EAST PROVINCE

Household Questionnaire

Department of Agricultural Economics, University of Zimbabwe

2011

*Hello. My name is **CHARITY NYASHA DANGWA,** a student with the University of Zimbabwe, currently pursuing an MSc degree in Agricultural & Applied Economics. I am currently carrying a research study titled **A COMPARATIVE ANALYSIS OF MAIZE PRODUCTION EFFICIENCY BETWEEN A1 RESETTLEMENT AREAS AND COMMUNAL AREAS IN GOROMONZI DISTRICT, MASHONALAND EAST PROVINCE** for my thesis in fulfilment of the MSc requirements. The study is aimed at investigating the performance of maize producers in Zimbabwe, thereby contributing to increased maize productivity. Results obtained from the research will inform policy makers on the level of farmers 'performance and the factors affecting their performance. Technical efficiency is the ability of a farmer to produce a given level of output with a minimum quantity of inputs under a given set of technology. I would please like to interview you, for me to get information on your operations on the farm especially focusing on the resources that you use during production and your output. Information obtained from this study will strictly be considered private and confidential. Names of my interviewees will not be mentioned in any part of the research write-up. Thank you for your anticipated cooperation.*

QUESTIONNAIRE NO. ……………………

A. ADMINISTRATIVE INFORMATION

A1. Enumerator's name ____
A2. Date of interview ____
A3. Place of interview ____
A4. Name of informant ____
A5. Start time ____

B. LOCATION DETAILS

B1. District ____
B2. Natural Region ____
B3. Village ____
B4. Chieftainship ____
B5. Headman ____
B6. Original Farm Name ____

C. RESPONDENT PROFILE DATA

C1. What is your name? ____
C2. Gender of respondent *1=male 2=female*
C3. How old are you (in years)? ______________________________
C4. How are you related to the farmer/household head? *1=self 2=husband 3=wife4=child 5=relative 6=worker 7=other* ______________________________ (If the answer is 'self' move to D3)

D. FARMER PROFILE DATA

D1. Gender of the farmer *1=male 2=female*
D2. How old is the farmer? _________________________
D3. What is the occupation of the farmer? *1=permanent paid employee 2=casual employee 3=employer 4=pensioner 5=paid family worker 6=undapid family worker 7=self employed 8=student 9=housewife 10-preschool 11=other*____
D4. Type of job ____
D5. Marital status *1=married 2=single 3=divorced 4=widowed*
D6. Education level attained *1=no formal education 2=primary education 3=ZJC 4=ordinary level 4=ordinary level 5=advanced level 6=tertiary 7=standard six 8=other* _________________________________
D7. What formal agricultural training has the farmer acquired? *1=no formal training 2=certificate 3=master farmer certificate 4=advanced master farmer certificate 5=diploma 6=other* ______________________
D8. Where does the farmer reside? ____
D9. If off-farm residency, specify *1=communal area 2=urban area 3=Diaspora 4=other (specify)*___________________

E. LAND BASE

E1. Type of farmer *1=A1 farmer 2=communal farmer*
E2. Size of plot ______________________
E3. Arable area ______________________
E4. Cropped area ______________________
E5. Grazing area ______________________
E6. In whose name is the plot registered _______________ Sex *1=male 2=female*
E7. Predominant soil type in arable plots *1=clay 2=clay-loam 3=sandy-loam 4=sandy soils*

F. PRODUCTIVE AND NON-RODUCTIVE ASSET OWNERSHIP AND ACCESS

F1. Provide the following information on hand tools.

Type	Total Numbers	Type of access/source		Estimated value
		Owned	*Borrowed*	
Hoes				
Axes				
Mattocks				
Picks				
Spades				
Spade forks				
Wheel barrows				
Watering cans				
Knapsack sprayers				
Other (*specify*)				

F2. Provide the following information on animal-drawn implements.

Type	**Total numbers**	**Type of access/source**		**No. in working order**	**Hiring arrangements** ***1-cash 2=reciprocal***	**How much do you spend on hiring this per year?**
		Owned	*Borrowed*			
Plough						
Planter						
Ripper						
Harrow						
Other (*specify*)						

F3. Provide the following information on machinery, power-driven implements and equipment.

Type	**Total numbers**	**Type of access/source**		**No. in working condition**	**Hiring arrangements**	**How much do you spend on hiring this per year?**
		Owned	***Borrowed***			
Motor vehicle						
Tractor						
Tractor trailer						
Plough						
Cultivator						
Other (*specify*)						

F4. Provide information on the following fixed and non-fixed productive and non-productive assets.

Type	**Total numbers**	**Type of access/source**		**No. in working order**
		Owned	***Borrowed***	
Boreholes				
Deep wells				
Irrigation infrastructure				
Other (*specify*)				

G. LIVESTOCK PRODUCTION

G1. Do you own any livestock? *1=yes 2=no*

G2. How many of each of these livestock do you own?.

Type of livestock	**Numbers**
Cattle	
Donkeys	
Goats	
Pigs	
Poultry	
Other *(specify)*	

G3. How many animals do you use for draught power?

Animal	No. owned	No. borrowed	Source[1]	Nature of payment[2]	Cost per ha (US$)

[1]1=A1 farmer 2=A2 farmer 3=LSCF 4=CAs 5=other (specify) ________________
[2]1=cash 2=free 3=labour exchange 4=harvested crop (specify)__________________5=other (specify)__________________

H. LAND USE, AGRICULTURAL PRODUCTION

H1. For the piece of land on which you are growing maize, which crops did you grow in the 2009/2010?

Crop	Area planted (ha)	Fertiliser (kg)		Seed			Manure	Qty of crops harvested (kgs)	Qty sold (t)	Total sales value ($US)
		Basal	Top	Hybrid	OPV	Retained				

H2. What ype of land are you currently using for crop production purposes? *1=land previously cleared and ued by former owner 2=virgin (recently cleared) land 3=re-growth*
H3. How much arable land did you cultivate last year? ________________________ha
H4. How many crops did you grow in the 2010/2011 season? _________
H5. Specify crops grown in 2010/2011 season ___________________________________
H6. Did you grow maize in 2010/2011 season? *1=yes 2=no*
H7. If yes, provide the following details; Area planted _____(ha); No. of fields _____; Output____(tonnes)
H8. What were your reasons for growing maize in the 2010/2011 cropping season? *1-statutory requirement 2=provides inputs 3=offer higher prices 4=proximity to market 5=accessibility to market 6=no alternative 7=other (specify)*__________________________________
H9. Do you think you cultivated as much maize as you should have cultivated on your piece of land? *1=yes 2=no*
H10. If no, why do you think you did not? *1=Lack of labour 2=Old age 3=Inadequacy of chemical inputs 4=Lack of draft power 5=Sickness 6=Poor soils 7=Poor management/agricultural practices 8=Other (specify*____________________________________
H11. How did you prepare your maize fields prior to cultivation? *1=Use of tractor for tilling 2=Use of animal (cattle/donkeys) 3=Use of own hoes (hand tilling) 4=Other (specify)*________________

H12. May you please provide information on your fertiliser application to your maize field(s) during 2010/2011

Maize	**Area (ha)**	**Month planted**	**Amt of basal planted**	**Month applied**	**Amt of top dressing applied (kg)**	**Month applied**
Plot 1						
Plot 2						
Plot 3						
Total						

H13. Please provide the following information for maize retention and marketing for the 2009/2010 and 2008/2009 seasons

Amt retained (MT/kgs/bags) *(Specify units)*	**Qty sold (MT/kgs/bags)** *(Specify units)*	**Unit price**	**Marketing channel**[1]	**Reason for choosing marketing channel**[2]

H14. Besides farming, are you involved in any other activities on your piece of land? *1=yes 2=no*

H15. If yes, what activities are you involved in?____
____

J. AGRICULTURAL LABOUR

Agricultural labour

J1. Do you hire any outside labour for agricultural activities? *1=yes 2=no*

J2. How many? ___________________

J3. Are they permanent or casual? ________________________________

J4. For which farming activities is casual labour hired?

Farming activity	**Acknowledgement** ***1=yes 2=no***	**During which months are they hired?**	**Cost (USD)**
Land clearing			
Planting			
Weeding			
Harvesting			
Pest and disease control			
Farm repairs			
Farm Security			
Other (*specify*)			

J5. How do you pay your casual workers? *1=daily 2=based on task 3=monthly wage 4=other (specify)*____

J6. If not based on task, what is the rate of payment for casual workers? Daily wage rate US$____
Weekly wage rate US$________________Monthly wage reate US$_______________

J7. How do you pay your permanent workers? *1=daily 2=based on task 3=monthly wage 4=other (specify)*____

J8. J6. If not based on task, what is the rate of payment for permanent workers? Daily wage rate US$____
Weekly wage rate US$________________Monthly wage reate US$_______________

J9. Do you use family labour? *1=yes 2=no*
J10. How many people of the family are in involved in maize production? Men _________ Women______ Children______
J11. How many days per year do your work in the maize fields? ___________________

Crop inputs
J9. For each of maize production during the 2010/2011 season, what levels, where did you access the inputs?

Inputs used	**Description**	**Qty purchased (kg/lt)**	**Cost per unit ($US)** *(specify units)*	**Area to which input was applied (ha)**	**Source[a]**	**Payment method[b]**	**Distance to regular source (km)**
Seed	Hybrid						
	OPV						
Agrochemicals	Herbicides						
	Pesticides						
Fertilizer	Basal						
	Top						
Animal manure							

[a]1=local agro-dealer/retailer 2=Govt inputs scheme 3=NGO input scheme 4=Harare agro-dealer 5=given by relative/friend 6=other (specify)__________________________
[b]1=cash 2=credit 3=free 4=in exchange for harvest 5=labour exchange 6=other (specify)_______________________

J10. Didi you face any constraints in accessing crop inputs? *1=yes 2=no*

J11. If yes, please specify? ____

Financial inputs

J12. Did you have access to any of the following sources of credit specifically for maize production in 2010/2011?

Source of credit	**Have you borrowed money?** *1=yes 2=no*	**Amount borrowed (USD)**	**Purpose of Borrowing[a]**
Relative and friends			
Society groups			
Government credit schemes			
NGO			
Bank or micro-finance institution			

[a]1=land clearance 2=Purchase of inputs 3=Application on inputs 4=Other (specify)___________________

K. ACCESS TO INFORMATION, EXTENSION AND TRAINING

K1. Did your household receive any agricultural extension service in the last 12 months? *1=yes 2=no*

K2. What kind of information was received?

Type of information	Did you receive?	Source[a]
Crop production		
Use of fertilizer		
Use of improved varieties		
Pest and disease management		
Soil management		
Weather information		
Marketing advice		
Credit		
Other (specify)		

[a]*1=Fellow farmer 2=Community/group leader 3=Govt Extension agent 4=NGO staff 99=Other (specify)____________*

K3. What is the average times did the agricultural extention agent visit your household in a month? *1=none 2=regularly 3=occasionally 4=other* ______________________

K4. Was the extension advice useful to your farming experience? *1=yes 2=no 3=never used it*

L. USE OF AGRICULTURAL TECHNOLOGIES

L1. Did you make use of crop management, soil conservation and other land management practices in your maize field(s) in the previous production seasons?

Technology/ management practice	**Did you use this technology** *1=yes 2=no*	**Source of information of technology[a]**
Munlching		
Terraces/trenches		
Conservation farming		
Organic manure		
Cover crops		
Crop rotation		
Intercropping		
Fertilizers		
Row planting		
Plant spacing		
Chemicals		
Traditional ways		

[a]*1=Govt extension workers 2=farmer group members 3=NGO 4=Other farmers 5=Radio/TV 6=Demonstration/research sites 7=Other (specify)________________________________*

End time ______________________

Total time taken ____

Thank you