PRODUCTIVITY OF SMALL-SCALE MAIZE FARMERS IN LESOTHO

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DECLARATION

I, Mpho Sylvia M Maseatile, hereby declare that this dissertation is submitted by me for the degree of Master of Science in Agricultural Economics, at the University of the Free State. To the best of my knowledge, this is my own original work with the exception of such references used. This thesis has not been previously published or submitted to any University for a degree. I further cede copyright of the dissertation in favour of the University of the Free State.

Maseatile

MPHO SYLVIA M MASEATILE

DEDICATION

This work is dedicated to my family, my husband, Mr Motoho Maseatile, for his support, understanding and motivation, to my boys, **Mokuru** and **Katleho** Maseatile, for the wretched moments they spent while their mom spent time meeting a never-ending set of deadlines. To my mother, who stood by me and gave me inspiration to pursue my studies. To my late grandmother, it would have been impossible to have made it this far in life without her continuous love and undivided commitment.

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Persistence and perseverance are keys to success

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ABSTRACT

Low productivity in agriculture has been observed to be a problem against increased food security. Enhancement of agricultural productivity is a key to improved food security and it can be achieved by improving technical efficiency of maize farm households. There is little empirical work on technical efficiency of small-scale farmers in Lesotho, hence the need for this study. Maize is a staple food in the country however, its production is not keeping pace with the increasing population, thus, it is not considered suitable for food security. The study therefore investigated the potential to raise maize productivity in Leribe and Mafeteng districts of Lesotho. The primary objective of this study was to identify factors affecting the productivity of small-scale maize farmers in Lesotho, using stochastic frontier production analysis (SFA). Due to high levels of multicolinearity principal component regression was used to relate technical efficiency scores to hypothesised factors that affect technical efficiency. Primary data were used in order to provide estimates of technical efficiency and its determinants. The primary data were obtained by way of personal interviews through the use of well-structured questionnaires administered in Leribe and Mafeteng districts of Lesotho. A simple random sampling technique was used to select a sample of 150 maize farmers drawn from the two districts.

The empirical results revealed that nitrogen (N) and potassium (K) have a significant positive impact on maize production, suggesting that these variables are important intermediate inputs in enhancing agricultural productivity in the study area. Phosphorus was negative and significant implying that it led to a decrease in production. The importance of labour and seed quantity on maize output was not statistically explained, even though their estimated coefficient quantities were positive as expected. It was found from the estimated gamma (γ) of 0.196 that technical inefficiency is a significant component of the composed error term of the stochastic specification. The gamma value indicates that about 19.6% of total variation in maize output was due to technical inefficiency. The gamma value results in this study indicate that the low maize productivity levels in Lesotho are largely due to random shocks, rather than being technical inefficient. The results of the analysis further showed that the estimated level of efficiency ranged from 11% to 100% with a mean of 87%. The mean technical efficiency of 87% implies that maize farmers were not fully technically efficient, there was 13% allowance for improving efficiency using technology from best-practiced maize farmers. However, about 91.5% had the technical efficiency exceeding 60%. There was a significant difference in the levels of technical efficiency across maize farmers in the two regions. Leribe region attaining high levels of TE should be utilised as a source of knowledge that could be transferred more easily to Mafeteng region which is less efficient.

Some of the variables of interest in this study contributing to efficiency increase were age, seed quality, tractor power, farm-experience, market access, credit access and off-farm income. Gender and extension visits were not statistically significant in increasing the level of technical efficiency. The estimated coefficients of household size, primary education, animal power and farm training were positive, thus increasing technical inefficiency of farmers in the study area. The policy implication arising from this study is that stress tolerant maize varieties should be planted to address the climate change effect on maize production in the study area. Improvement of maize market infrastructure throughout the country could also be an incentive for farmers to increase maize outputs.

Keywords: Productivity; Technical Efficiency; Small-scale maize farmers; SFA

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LIST OF ACRONYMS

BOS	Bureau of Statistics
FAO	Food and Agricultural Organizations
LVA	Lesotho Vulnerability Assessment Committee
RSA	Republic of South Africa
SADC	Southern African Development Cooperation
TE	Technical efficiency
MLE	Maximum Likelihood Estimates
OECD	Organization for Economic Co-operation and Development
NCSS	National Council of Statistics Software
PC	Principal Component
PCA	Principal Component Analysis
PRC	Principal Component Regression
IITA	International Institute of Tropical Agriculture
GDP	Gross Domestic Product
DEA	Data Envelopment Analysis
SFA	Stochastic Frontier Approach
CSLS	Centre for the Study of Living Standards
AE	Allocative Efficiency
FDH	Free Disposal Hull
TFA	Thick Frontier Approach
DMUs	Decision Making Units
ARC	Agricultural Research Council
FSSA	Fertilizer Society of South Africa
TFP	Total Factor Productivity
VRS	Variable Returns to Scale
CRS	Constant Returns to Scale
LMS	Lesotho Meteorological Services
KOL	Kingdom of Lesotho
DAO	District Agricultural Officer
DEO	District Extension Officer
LHDA	Lesotho Highlands Development Authority
OLS	Ordinary Least Squares

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND AND MOTIVATION

There is a general decline in productivity of the agricultural sector in developing countries contrary to agricultural productivity in the developed world, where there is productivity progress (Yilma and Berg, 2001). Low productivity in agriculture has been observed to be a problem contributing towards increased food security. Hence, sustained growth in maize productivity is necessary to improve food security. Improvement of agricultural productivity is an important condition in increasing household food security and alleviating rural poverty (Owour, 2000). Productivity of the maize production system varies from place to place and among groups of producers, which is not surprising considering the wide geographical dispersion of maize. Productivity growth of maize in Africa has lagged behind, compared to other regions, with the result that growth in maize production has failed to keep up with population growth. Although productivity can be expressed in different ways, one commonly used measure is grain yield per unit land area (Morris, 1998).

Maize is the principal agricultural crop in many countries, which is used directly as food, animal feed and raw material for numerous industrial products and is a very important commodity in international trade (FAO, 2007). Maize production in Africa is very diverse, ranging from subsistence farmers to commercial farmers. It is expected that small, self-sufficient farmers will not adjust their maize production as fast as big farmers who have the technology and capital to do so (OECD, 2003). On the consumption side, maize is an important part of daily caloric intake and diet in Eastern and Southern Africa to feed people. Maize is the principal staple food of Sub-Saharan Africa, dominating the diets of rural and urban poor. Per capita consumption of maize in rural areas is generally higher than in urban areas (OECD, 2003).

Maize (*Zea mays* L) is a member of the grass family, Gramineae, to which all the major cereals belong. Maize was domesticated in southern Mexico around 4 000 BC (Brink *et al.,* 2006). Maize is believed to have originated in North America about 6 000 to 7 000 years ago. From its centre of origin, Mexico and Central America, maize spread gradually throughout the rest of Latin America, the Caribbean, the

United States and Canada and was later carried by European seamen to Europe, Africa and Asia. Today maize is the world's most widely grown cereal, since it has the highest grain yield potential of all the cereals, reflecting its ability to adapt to a wide range production of environments (Morris, 1998). In eastern and southern Africa, maize became a staple food, the mainstay of rural diets and the most important cereal crop; the other most important cereals are rice and wheat (Morris, 1998; IITA, 2007).

In Lesotho, the three main food crops grown are maize, wheat and sorghum, which occupy about 60%, 20% and 10% respectively. Maize is the country's prominent staple food, constituting an estimated 80% of the Basotho diet. Most of the maize is produced for family consumption, and only small surpluses are traded locally and exported (FAO, 2007). Maize in its different processed forms is an important food providing significant amounts of nutrients in particular calories and protein. Maize is mainly consumed by households in Lesotho as a thick porridge. Seasonally it is consumed fresh, both on and off the cob, either roasted or boiled and also as a snack food. However, maize productivity in the country is low due to poverty, which is closely associated with lack of resources, low productivity, inappropriate development policies and strategies (Lepheana, 1998; LMS, 2006). In general, the decline in maize production in Lesotho is attributed to a mixture of exogenous and endogenous factors such as lack of skills, inadequate infrastructure - particularly rural roads, inadequate access to agricultural institutions, for instance extension services, limited access to markets and credit (Ministry of Agriculture and Food Security, 2003).

Despite the declining agricultural productivity, about 85% of the population in Lesotho still depends partly or fully on agriculture for its livelihood. Agriculture is considered to be one of the most important sectors of Lesotho's economy and is classified as a primary sector; with about 90% subsistence farming and 10% commercial farming. Agriculture and agricultural products contribute about 38% of the total export earnings and hence one of the major sources of foreign exchange earnings for the country (LVAC, 2005). Agriculture provides nearly all of the food requirements and raw materials for the industrial sector, 60% of the total export earnings, 45% of the government revenue, and accounts for 30% of the gross domestic product (GDP). The agriculture sector is the backbone of Lesotho's economy and should therefore be the fastest growing sector.

1.2 PROBLEM STATEMENT

In the past Lesotho was able to feed itself in good years, surpluses produced were exported to other countries. Food grain exports by Basotho farmers reached a peak in the years 1910-1920. This was achieved by bringing more land under cultivation rather than by using soil fertility enhancing technologies (Mbata, 2001). During the 1920’s, maize production in Lesotho began to decline and by the 1930’s the country had become a net importer of maize. From that time, there had been a noticeable imbalance between maize supply and demand and the country continued to import maize, particularly from South Africa, in order to erase the food supply deficit. Ever since the level of maize imported into the country has been increasing. Maize yields have fallen from 1 400 kg/ha in the mid-70s to a current 450-500 kg/ha; as a result, the areas under cultivation; production and yield are very heavily dependent on food imports to satisfy local maize demand (FAO, 2007).

According to FAO data, about 19.4 million tonnes of maize were produced in SADC countries in 2007 on 13.3 million hectares, with South Africa the largest maize producer in five years. In 2003, South Africa produced 49.5% of the total maize production, followed by Tanzania with 13.3% and then Malawi with 10%. Lesotho is among the lesser maize producers in SADC countries; with 105 thousand tonnes of maize production from about 172 000 ha in 2007 with an average yield of 0.6 t/ha.

Lesotho’s economy had been declining due to the poor performance of the agricultural sector; as a result, the country is becoming more food insecure. Lesotho’s food insecurity and poverty are associated with lack of resources, low productivity, inappropriate development policies and strategies (Ministry of Natural resources in Lesotho, 2006). According to Fraser *et al*. (2003) the main elements to consider when defining food security are sufficiency, access, security and time. Maize production in Lesotho is very low and does not meet the annual demand for the staple food. The current annual demand for maize exceeds local production and the difference is met through imports and foreign assistance as food donations, indicating that Lesotho is a food-deficit country. High productivity and efficiency in maize production are critical to food security since maize is the main staple food in the country.

Although maize is a staple food in Lesotho, its production is not keeping pace with the increasing population, thus it is not considered suitable for food security because its productivity is very low. The country's goal of achieving food security in maize production will, to a larger extent, depend on the level of maize farmers' productivity. Productivity increase could be attained though its determinants which include the state of technology, the quantities and types of resources used and the efficiency with which those resources are used. Therefore, an understanding of the relationships between productivity and technical efficiency, farm-specific practices and determinants of technical efficiency would be the key to alleviating food insecurity and bringing about overall growth of the Lesotho economy. Insufficient information regarding factors affecting productivity in Lesotho hampers policy makers and agricultural advisors to design appropriate policies to improve productivity with the aim of lowering food insecurity.

Sufficient information would be extremely valuable in identifying major constraints on productivity growth and formulating strategies to overcome such constraints (Owour, 2000). Limited information makes it difficult for planners, policy makers and donors to make a comprehensive assessment of the factors that determine agricultural productivity (Owour, 2000). Since increased productivity is directly related to efficiency, it is important to raise productivity of the farmers by helping them to reduce their technical inefficiency. This can be achieved by investigating the nature of resource productivity and technical efficiency of the farmers (Shehu and Mshelia, 2007). The main focus of agricultural policy should be on how to realise the technical efficiency gains as a basis for improving productivity of the farmers, since they constitute the bulk of the country's agricultural sector. An understanding of the determinants of productivity will help policy makers with information to design programmes that can contribute to increased staple food production (Tchale, Sauer and Wombat, 2005).

1.3 RESEARCH OBJECTIVE

The main objective of this study is to identify factors affecting productivity of maize farmers in Lesotho. The main objectives will be achieved by the following sub-objectives:

1. To estimate technical efficiency of maize farmers in the country, using Stochastic Frontier Analysis (SFA).

2. To identify factors that influence variations in technical efficiency among maize farmers using Principal Component Regression (PCR).

1.4 OUTLINE OF THE STUDY

The rest of this study is organised into five chapters. Chapter 2 will present a review of relevant literature on productivity of farmers which will cover definition, measurement and determinants of productivity. Chapter 3 provides an overview of research area and farmers' characteristics. Chapter 4 discusses the methodological framework used in this study. Presentation and discussion of results will be given in Chapter 5. The last chapter, Chapter 6, deals with the summary, general conclusions and as well as some policy recommendations.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The Chapter presents a review of relevant literature on productivity of small-scale farmers. The purpose of this chapter is first to introduce the reader to the concepts of efficiency and productivity. It explains the importance and basic meaning of the productivity concept. It further discusses efficiency concept and the relationship between productivity and technical efficiency. The techniques of technical efficiency measurement are also covered. This involves the discussion of the two main techniques, the data envelopment (DEA) and stochastic production frontier approach (SFA) to support the choice of the particular model. Then factors affecting the productivity among small-scale farmers are discussed. This will contribute to a better understanding of the factors that limit the productivity among small-scale farmers and how these factors influence differentials in the levels of productivity.

2.2 IMPORTANCE OF PRODUCTIVITY

According to Haji (2008), studies on farm productivity have long been recognised in developing counties, however, little is known about the productivity of small-scale maize farmers and factors influencing it. Developing countries can benefit a great deal from inefficiency studies that show the possibility of increasing productivity by improving efficiency without increasing the resource base or new technology. Estimating the extent of inefficiency in production and identifying factors that determine these levels, is important for designing appropriate policies of intervention. Productivity is a key indicator for analysis of economic growth, which is a significant demand for policy makers (Schreyer, 2005). According to CSLS (1998), productivity is a matter of concern to government bodies, trade unions and social institutions since it improves the country’s living standards. A high standard of living can be sustained by improvements in productivity, either through achieving higher productivity in existing farms or through successful entry into higher productivity farms (Blunck, 2006).

Productivity provides the basis for improvements in real incomes and economic well-being, for instance monetary policy (inflationary pressure); and fiscal policy (financial, health education and welfare) (Schreyer, 2005). Productivity depends on the value of products and services (uniqueness and quality) as well as the efficiency with which they are produced. The greater the amount of goods and services produced in an economy or imported into such economy, the higher its average standard of living will be (CSLS, 1998; Blunk, 2006). The standard of living (wealth) in most nations is determined by productivity with which a nation's human capital and natural resources are deployed and the output of the economy per unit of labour and/or capital employed (Porter, 2001; Blunck, 2006). Increased productivity in agriculture has a number of advantages. Firstly, it increases the flow of resources from one sector to the other, thereby enhancing economic growth. Secondly, a higher level of agricultural productivity results in lower food prices that increase consumers' welfare. Thirdly, productivity growth improves the competitive position of a country's agricultural sector Haji (2008).

2.2.1 COMMON MISCONCEPTIONS ABOUT PRODUCTIVITY

Although the concept of productivity is a widely discussed subject by politicians, economists, managers and media, it is often vaguely defined and poorly understood. In practice, this lack of knowledge results in productivity being ignored by those who influence the production process. Therefore, the meaning of productivity needs to be fully understood so that it becomes easy to decide what productivity measures to use and how to interpret those measures correctly (Tangen, 2002). From Tangen's (2002) point of view, if we do not fully understand what productivity is, how can we decide what productivity measures to use? How can we interpret them correctly? How can we know what actions to take to improve productivity?

Firstly, a common mistake is to confuse productivity and production. Tangen 2002, Ministry of Agriculture and Food Security in Lesotho (2003) and Kaci (2006), states that productivity and production (output) are used interchangeably but they have different meanings. According to Smit *et al*. (2002) and Coelli *et al*. (2005), productivity is the quantity of output produced per production input in a unit of time and is a measure of how efficiently the input is used. Productivity reflects improvements in the ability to transform inputs into outputs (Heisey, 2001; Fuglie, Macdonald and Ball, 2007). Production on the other hand, refers to the total output of a commodity and is expressed in absolute numbers of units of output (tonnes, kilos and litres). This is described as the misconception between productivity and production.

As a result of this confusion, people tend to believe that increased production means increased productivity. This is not necessarily true because output may be increasing without an increase in productivity (Oyeranti, 2000; Tangen, 2002; Kaci, 2006). Productivity is the non-physical product of innovation, efficiency, management, research, weather and luck; it is a residual measure of the contribution to output growth after all other factors have been accounted for (Heisey, 2001; Fuglie, Macdonald and Ball, 2007). Productivity gains occur when resources are used more efficiently because a) output increases more rapidly than inputs, or b) there is no increase in output but there is a decline in the use of inputs (Kaci, 2006). An important point to keep in mind is that productivity is a relative concept, which cannot be said to increase or decrease unless a comparison is made, either of variations from competition or other standards at a certain point in time or of changes over time (Heisey, 2001; Tangen, 2002; Fuglie, Macdonald and Ball, 2007).

Secondly, productivity is often confused with efficiency; in economics, the terms productivity, efficiency and technical efficiency are often used interchangeably. Although there are similarities and linkages among them, they are not precisely the same thing (Coelli *et al*., 2005). When discussing the economic performance of producers, it is common to describe them as being more or less “efficient” or more or less “productive”. Productivity refers to the ratio of output to input while efficiency is a comparison between observed and optimal values of output and input (Fried *et al*., 2008). According to Driessen (2006), efficiency relates to how well an economy allocates scarce resources to meet the needs and wants of consumers. The efficiency exercise can involve comparing observed output to maximum potential output obtainable from the input, or comparing observed input to minimum potential input required to produce the output (Fried *et al*., 2008). Tangen (2002) states that, to avoid confusion surrounding the productivity and efficiency, it is important to have a clear understanding of the difference between these terms since an improper definition will often result in a misleading perceptive.

2.2.2 Relationship between Productivity and Technical Efficiency

Some individuals are more productive than others; some small businesses find and exploit a lucrative market niche that others miss, some large corporations are more profitable than others and some public agencies provide more efficient service than others. In each case, performance, both absolute and relative to the competition, can improve through time or lag behind (Fried *et al*., 2008). Fried *et al*. (2008) further state that performance itself means doing the right things which involves solving the purely technical problem of avoiding waste, by producing maximum output from available inputs or by using minimum inputs required to produce desired outputs. However, circumstances change through time and so changes in business performance involve change in productivity arising from development and adoption of new technologies that bring improvements in efficiency. Increasing efficiency is an important factor of productivity growth and is suitable in developing countries where resources are scarce and raising production through improved efficiency does not necessarily require increasing the resources (Kibaara, 2005; Alene, 2003).

The scarcity of resources is the major factor that makes the improvement in efficiency so important to an economic agent or to a society (Driessen, 2006). Productivity is closely connected to the use and availability of resources. Productivity is reduced if a firm's resources are not properly used or if there is a lack of resources. On the other hand, high productivity is achieved when activities and resources in the manufacturing transformation process add value to the produced products (Tangen, 2005). Rogers (1998) further states that productivity changes can be caused by either movements in the best practice production technology or changes in the level of efficiency, increasing efficiency would therefore imply rising productivity. Variation in productivity, either across producers or through time is thus a residual characterised as a measure of ignorance. In principle, the residual can be attributed to differences in production technology, differences in the scale of operation, differences in operating efficiency and differences in the operating environment in which production occurs (Fried *et al*., 2008). At an elementary level, the objective of producers can be as simple as seeking to avoid waste by obtaining maximum outputs from given inputs or by minimising input use in the production of given outputs (Subal *et al*., 2004).

Following seminal work by Farrell (1957) efficiency refers to economic efficiency which can be composed into two parts: Technical efficiency and allocative (price) efficiency (Haji, 2008). The technical efficiency (TE) refers to the ability to avoid waste, either by producing as much output technology and input usage allowed or by using as little input as required by technology and output production (Fried *et al*., 2008). The allocative efficiency (AE) refers to the ability to combine inputs and/or outputs in optimal proportions in light of prevailing prices (Fried *et al*., 2008). Koopmans (1951), as stated by Fried *et al*. (2008) provided a formal definition of technical efficiency: A producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one other input or a reduction on at least one output. Thus, a technically inefficient producer could produce the same level of outputs with less of at least one input, or could use the same level of inputs to produce more of at least one output. Thus, the analysis of technical efficiency can have an output-augmenting orientation or an input-conserving orientation. When discussing the economic performance of producers, it is common to describe them as being more or less “efficient” or more or less “productive” (Fried *et al*., 2008). According to Coelli *et al*. (2005), the difference between productivity and technical efficiency can be illustrated by considering a simple production process in which a single input (x) is used to produce a single output (y) using Figure 2.1 below.

OCBG represents a production frontier that may be used to define the relationship between the input and the output. The production frontier represents the maximum output attainable from each input level. A farmer is technically efficient if he operates on the frontier (i.e. he is achieving “best practice”) and technically inefficient if he operates beneath the frontier. The farmer operating at point A is technically inefficient because he could increase the output to the level of the farmer that is operating at point B without requiring more input. The measure of productivity is illustrated by the use of a ray through the origin and the slope of this ray is Y/X. If the farmer operating at point A were to move to the technically efficient point B, the slope of the ray would be greater, implying higher productivity at point B. However, by moving to the point C, the ray from the origin is at a tangent to the production frontier and hence defines the point of maximum possibility productivity. This latter movement is an example of exploiting scale economies. The point C represents the point of (technically) maximum possible productivity, which is productivity increase attained by scale economies. In that case, a farmer may be technically efficient without attaining optimal productivity level; this means he may still be able to improve his productivity by exploiting economies of scale (Coelli *et al*., 2005). Kabede (2001) also supports this in that the level of productivity depends on productive efficiency and the exploitation of scale economies.

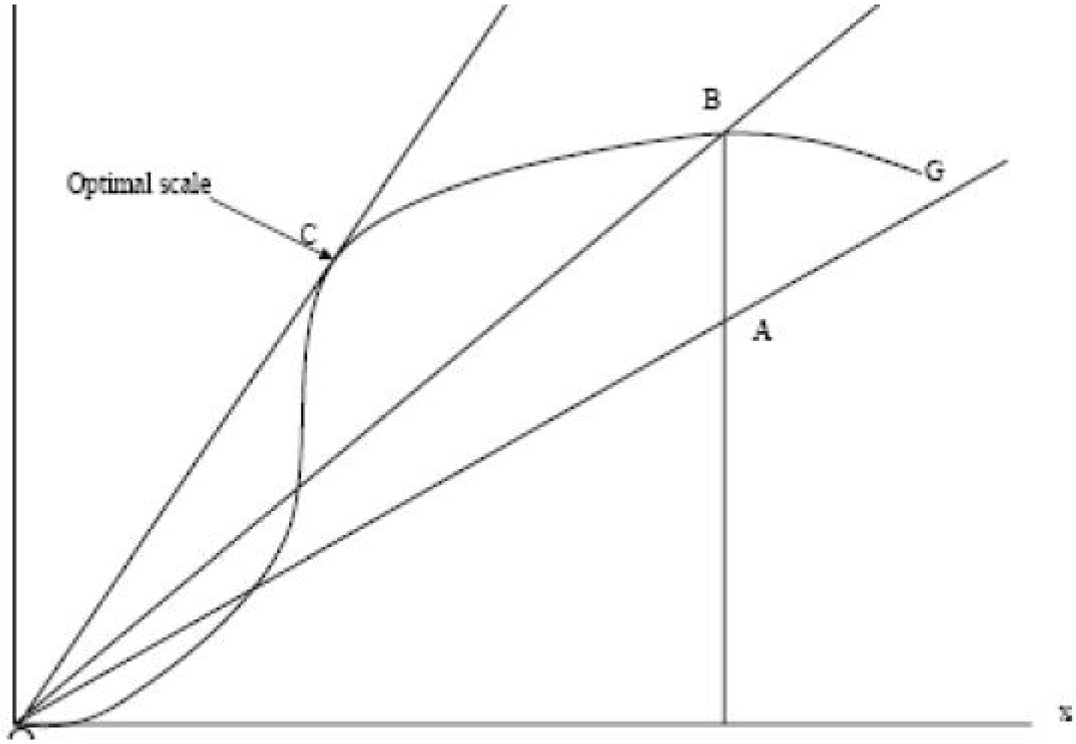

Figure 2.1: Productivity, technical efficiency and scale economies
(Coelli, Christopher and Battese, 2005)

2.3 TECHNIQUES OF TECHNICAL EFFICIENCY MEASUREMENTS

Technical efficiency measurement involves a comparison of actual performance with optimal performance located on the relevant frontier. Both are analytically rigorous benchmarking exercises that exploit the distance functions to measure efficiency relative to a frontier (Fried *et al*., 2008). On the other hand, productivity measurement is the quantification of both the output and input resources of a productive system and it must produce effective control, which in turn will produce corrective action and result in increased output (Kabede, 2001; Kaci, 2006). The goal of productivity measurement is productivity improvement, which involves a combination of increased effectiveness and a better use of available resources (Kabede, 2001). For that matter, the conceptualisation and measurement of technical efficiency relies on the specification of a production function. The production function represents the maximum output attainable from the use of a given level of inputs. The production function describes production performance and productivity is the measure of it (Haji, 2008).

There are two approaches that have been developed to measure technical efficiency, one in economics and the other in management science (Fried *et al*., 2008). According to Kabede (2001), Kibaara (2005) and Johnson (2006), the former uses parametric econometric techniques and is composed of the stochastic frontier approach (SFA), the thick frontier approach (TFA) and the distribution free approach / deterministic frontier approach (DFA). The latter uses non-parametric mathematical programming technique namely data envelopment analysis (DEA) and the free disposal hull (FDH). Both the parametric and non-parametric approaches share a common objective, that of benchmarking the performance of the rest against that of the best (Fried *et al*., 2008). Only the SFA and DEA methods will be discussed in this study since they are the most widely used.

According to Fried *et al*. (2008), the SFA and DEA methods use different techniques to envelop data more or less tightly in a different way. In doing so, they make different accommodation for statistical noise and for flexibility in the structure of production technology. It is these two different accommodations that have generated debate about the relative merits of the two approaches. However, at the risks of over-simplification, the differences between the two approaches boil down to two essential features. The econometric approach is stochastic: This enables it to attempt to distinguish the effects of noise from those of inefficiency, thereby providing the basis for statistical inference. The programming approach is non-parametric. This enables it to avoid confounding the effects of misspecification of the functional form (of both technology and inefficiency) with those of inefficiency (Fried *et al*., 2008). DEA is assessed by applying mathematical linear programming while (SFA) is estimated by using econometric (statistical) techniques (Kabede, 2001; Kibaara, 2005; Johnson, 2006).

2.3.1 DATA ENVELOPMENT ANALYSIS (DEA)

According to Rogers (1998), the DEA method is based on work by Farrell (1957) and Koopmans (1951) although its full implementation was by Charnes, Cooper and Rhodes (1978). Other summaries of data envelopment methods are given by Ali and Seiford (1993) and Coelli (1995). The mathematical programming approach to the construction of frontiers and the measurement of efficiency relative to the constructed frontiers goes by the descriptive title of data envelopment analysis (DEA). It truly does envelope a data set; it makes no accommodation for noise and so does not “nearly” envelope a data set the way the deterministic kernel of a stochastic frontier does. Moreover, subject to certain assumptions about the structure of production technology, it envelopes the data as tightly as possible (Fried *et al.*, 2008). DEA is a nonparametric model that has become increasingly popular in the analysis of productive efficiency. It is used to measure the efficiency of a decision-making unit (DMUs) by constructing a piecewise efficiency frontier. DEA is used to find the set of weights from each firm that maximises/minimises its efficiency score (Sarafidis, 2002; Ruggiero, 2007).

A major challenge faced by DEA is that it is a deterministic approach, meaning that it does not account for noise in the data; this means DEA efficiency scores are likely to be sensitive to measurements errors and random errors. This is because DEA does not require any distributional assumptions about efficiency and since no stochastic specification is imposed, all variations between production units are interpreted as inefficiency (Thanassoulis, 2001; Johansson, 2005). The fact that in DEA no functional form for the frontier needs to be specified, has the disadvantage in that there is no definition of goodness of fit that would enable comparison of different models (Sarafidis, 2002). Although DEA is easy to use and uses only the most efficient DMUs to determine the efficiency frontier, the main shortcoming of this is that if the number of DMUs is small and the number of outputs is large, DMUs can appear to be efficient although they are not; this is because the potential peer group is smaller (Sarafidis, 2002). Moreover, DEA is known to be sensitive to outliers. The outliers are observations that lie well above or below the main cluster of points leading to the presence of large residual variation. This can also lead to the specification of an incorrect frontier and DMUs can be indicated as highly inefficient when they are only mildly so or not at all (Linh, 1994).

DEA provides a way of obtaining empirical estimates of efficient production possibility surfaces. Instead of trying to fit a regression surface, DEA directs to a piecewise linear surface which is the top envelope of the observational data set (Kumbhakar *et al*., 1996). The DEA method is also not subject to assumptions on the distribution of the error term and imposes minimal assumptions on production behaviour. As a result, it becomes less sensitive to model misspecification (Linh, 1994; Hjalmarsson *et al*., 1996; Sarafidis, 2002). In addition, DEA is computationally less intensive than

SFA (at least in it's basic from) and for this reason the method has been more widely used, especially in operation research (Sarafidis, 2002).

The main reason for scepticism about DEA on the part of economists is being non-statistical in nature. This linear programming solution of the DEA problem produces no standard errors and leaves no room for hypothesis testing. In DEA, any deviation from the frontier is treated as inefficiency and there is no provision for random shocks. By contrast, the SFA model explicitly allows the frontier to move up or down because of random shocks. Additionally, a parametric frontier yields elasticities and other measures about the technology useful for marginal analysis (Ray, 2004).

2.3.2 STOCHASTIC FRONTIER ANALYSIS (SFA)

The study of SFA begins with Farrell (1957) who suggested that efficiency could be measured by comparing the realised output with the attainable maximum output. Later on, Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) simultaneously introduced stochastic production frontier models. These models allow for technical inefficiency, but they also acknowledge the fact that random shocks outside the control of producers can affect output (Kumbhakar and Lovell, 2004). The stochastic frontier approach (SFA) is based on the idea that an economic unit may operate below its production frontier due to pure errors and some uncontrollable factors (Margono and Sharma, 2004). Thanassoulis (2001) and Johansson (2005) state that, SFA has a random term to account for statistical noise such as weather, in the production process which is beyond the control of the farmer. SFA uses mainly, what are called "maximum likelihood" estimation techniques to estimate the frontier function in a given sample. In addition, SFA separates error components from inefficiency components. In particular, it requires separate assumptions to be made as to the distributions of the inefficiency and error components, potentially leading to a more accurate measure of relative efficiency.

The main strength of the stochastic frontier function approach (SFA) is its ability to measure efficiency in the presence of statistical noise and incorporate the stochastic error (Linh, 1994; Ruggiero, 2007). In short, the SFA approach is likely to be more appropriate where.

- Random influences and statistical noise are perceived to heavily influence the data;
- There is confidence that the functional form of the frontier has been well specified;
- Omitted variables may influence the result ;and
- Hypothesis testing is important (Sarafidis, 2002).

2.4 FACTORS AFFECTING PRODUCTIVITY OF SMALL-SCALE FARMERS

Agriculture in Africa is characterised by small-scale production that exhibits fluctuating production levels, low productivity and low quality. As a result, most countries in the region have become food deficit regions and are net importers of food commodities (ARC, 2006). Smallholder farmers in developing countries find it difficult to participate in commercial farming because they are faced with a number of constraints that limit their development. According to Antwi (1997) the resource constraints make increasing productivity one of the important goals of any individual and the society since production efficiency improvement is one of the most important sources of agricultural growth. Kabede (2001) states that increasing agricultural productivity has been a long-term policy objective in most countries. Hence, any attempts towards improving productivity need to consider factors affecting technical efficiency. Knowledge of the efficiency determinants indicates which aspects of farm characteristics can be addressed to improve technical efficiency. Before discussing the factors affecting TE the input factors used to define the production frontier are discussed first.

2.4.1 INPUT FACTORS DEFINING THE PRODUCTION FRONTIER

Recent literature in African agriculture, to mention a few, include Mochebelele and Winter-Wilson (2002), Fufa and Hassan (2003), Alene and Hassan (2003), Kibaara (2005), Chirwa (2003), Mkhabela (2005), Tijani (2006), Khairo and Battese (2005) Ogundari, Ojo and Ajibefun (2006), Tchale and Sauer (2007), Amos (2007) and Mushunje *et al*. (2005). From this literature, the factors that influence the production function include: fertiliser, labour, land area (farm size), seeds, animal and tractor power, soil fertility maintenance, input costs, fungicide, weeding, processing and irrigation water.

2.4.1.1 Fertiliser

Soil fertility is the ability of the soil to make plant nutrients available to the plant. A soil which has a high production potential and which at the same time is fertile can naturally produce high yields. A fertile soil on the other hand can perform poorly if its potential is low. For instance, if the fertility of soil is reduced as a result of exploitation, acidification and leaching, its full potential will not be achieved. Depending on the nature of infertility one or more of the following will have to be applied: inorganic fertiliser, manure, crop residues, lime and gypsum (FSSA, 2004).

Binam *et al*. (2004) found that farmers who are located in more fertile regions perform significantly better than those located in less fertile regions. This, therefore, reinforce the argument that improvement in soil fertility is a crucial element in increasing productivity. Tchale and Sauer (2007) results also show that high levels of technical efficiency are obtained when farmers use integrated soil fertility options compared to the use of inorganic fertiliser only. Therefore, fertiliser appears to be the most important factor of production.

2.4.1.2 Labour

Traditional agriculture is characterised by labour intensive production and excess demand for labour often occurs during periods of land preparation, weeding and harvesting. Agricultural labour consists of two categories, namely hired labour and family labour. According to Mensah (1986), as stated by Antwi (1997), the causes of labour shortages in less developed countries is largely due to the migration of labour from rural to urban areas and to neighbouring countries for greener pastures. According to Antwi (1997), labour is normally measured in man-days, man hours or in value terms. Labour availability is another often-mentioned variable affecting farmers' decisions concerning the adoption of new agricultural products or inputs. Some new technologies are relatively labour intensive and others are labour saving. For instance, manual labour is more labour intensive than other types of labour. While ox cultivation is labour saving and its adoption might be encouraged by labour shortages, mechanised farming technology, in turn, is, more labour saving than ox cultivation.

Most empirical studies found that the estimated coefficient for labour was positive and statistically significant, which implies that labour increases the level of production. This means that the larger the family size with effective members, the more labour is available for farming operations, thus increasing the production of farmers. On the contrary, Tijani (2006) and Tchale and Sauer (2007) found that the labour coefficient was negative which shows that labour is decrease production. This implies that the sampled farmers are over-utilising the labour input.

2.4.1.3 Land area (farm size)

Soil is one of the important variables in crop production. It creates a favourable medium for root growth and supplies plant nutrients to the growing plant. Any crop grown in a specific region should be to the economic benefit of the farmer. The production potential of a crop on a specific soil is used therefore, as a planning guideline in crop production FSSA (2004). Land in agricultural production is quite heterogeneous in terms of soil size, soil type, associated soil characteristics and other productivity-related factors within developing countries. Failing to account for these differences would lead to a biased measure of the land input as well as productivity levels (Nehring *et al*., 2003). The majority of studies of agricultural productivity in developing countries support the view that there is an inverse relationship between productivity and farm size. This may be a result of market imperfections, such as missing rural labour markets.

The recent literature suggests that land has a major influence on production since its estimated coefficient is positive in most studies; for instance, Mushunje *et al*. (2003) study on relative technical efficiency of cotton farmers in Manicaland Province of Zimbabwe, find positive coefficients in land significant at all levels. In addition, the output elasticity of land is found to be 0.74, which shows that it is the critical input in the production of cotton. Fufa and Hassan (2003) also find that the estimated coefficient of land is positive and significant. This indicates the positive influence of land on agricultural production. Kimhi (2003) finds a positive relationship between the yield of maize and plot size, indicating that economies of scale are dominant throughout the plot size distribution. Most studies found a positive relationship with output. However, Chirwa's (2003) study on sources of technical efficiency among smallholder maize farmers in southern Malawi, find that the estimated coefficient of land is negative. This shows that the smallholder farmers in the study area are producing maize in the uneconomic region.

2.4.1.4 Seeds

Seeds are very important in the production of crops. The level of production depends largely on the quantities of the hybrid seeds used on the farm. Kibaara (2005), Ogundari *et al*. (2006) and Tchale and Sauer (2007), among others studies, find that the estimated output elasticity of seeds is positive. This may be due to the fact that enough seeds are sown, so there is no competition for nutrients, water and light. Moreover, hybrid seeds are resistant to diseases. Nevertheless, Mushunje *et al*. (2003) find that the seed input coefficient is negative which means it reduces the level of production. Farmers seem to be sowing too much seed or possibly the germination rate is poor. This indicates that, as the quantity of seed sown by the sampled farmers increase, there tends to be reduction in yield. Sowing too much seed results in harbouring of insect-pests, which lead to disease outbreak. Spraying of pesticide is also difficult if plants are overcrowded. Most empirical studies suggest that the use of hybrid seeds and proper seed-rate increase crop.

2.4.1.5 Conclusion

Fertiliser, labour, land area and seeds are important factors of production because they seem to increase production in most cases. Increased use of these variable inputs is the source of the increased productivity. Farmers have to use these inputs as efficiently as possible to achieve a competitive agricultural sector.

2.4.2 TECHNICAL INEFFICIENCY AMONG SMALL-SCALE FARMERS

The estimates of the coefficients for technical inefficiency variables are of particular interest in this study since the inefficiency effects are significant in determining the level and variability in production. It is not only the level of technical inefficiency that is important, but the identification of the socio-economic factors that cause it (Haji, 2008). The following socio-economic variables are found to influence the level of technical inefficiency: age of household head, level of education, farming experience, family size, extension contacts, off-farm income, farm size, credit, location of the farm, gender, slope of the land, diversity, soil quality, rainfall, planting date, market access/market distance. It is important to note that a negative relationship means technical inefficiency decreases and therefore TE increases.

2.4.2.1 Age of household head

Mkhabela (2005) and Tijani (2006) find that the estimated coefficient of age is negative and significant. This implies that age reduces the level of technical inefficiency. The negative coefficient for age indicates that older farmers tend to be less inefficient than younger farmers; this is because older farmers tend to be more experienced than younger ones. One other possible reason is that older farmers have more resources at their disposal. Nonetheless, Khairo and Battese (2005) and Amos (2007) find that the estimated coefficient for age is positive, which means that older farmers are more technically inefficient than the younger farmers. Older farmers tend to be more conservative and less interested in modern and newly introduced technology. Even though there is a mixture of signs for age coefficients and supporting reasons to this, most studies support the fact that age decreases the level of technical inefficiency, for this reason the expected sign for age is negative.

2.4.2.2 Level of education

Kibaara (2005) and Mushunje *et al*. (2005) to mention a few, found that the estimated coefficient for level of education (years of school) was negative. This indicates that an increase in the number of school years decreases technical inefficiency. This means that farmers with more years of schooling tend to be more efficient in agricultural production since they respond more readily in using the new technology and produce closer to the frontier output. While Mkhabela (2003) found the coefficient of education to be positive and significant meaning it increases the level of technical inefficiency. The reason being that more educated farmers are involved in part time farming, because of education they have permanent jobs and other sources of income. This could be explained by the fact that farmers with a very high education (University and college) become less interested in farming, instead they concentrate on their salary from their employment. Thus part-time farmers are more technically inefficient because more of their time is devoted to activities other than farming. There is a controversy as to whether education increases or decreases the level of technical inefficiency, so the expected sign for education is not that clear. It could either be positive or negative, depending on the situation in the study area.

2.4.2.3 Farming experience

Mkhabela (2003), Khairo and Battese (2005) and Tijani (2006) found the farming experience coefficient was negative and significant which means that farmers tend to decrease their technical inefficiencies as they become more experienced. This may be due to good managerial skills that they have learnt over time. According to Ogundari *et al*. (2006), the negative coefficient for age and farming experience implies that the aged farmers and the most experienced farmers are more cost efficient than the younger ones, meaning that as the age and farming experience of farmers increase, the cost inefficiency of the farmers decreases. This is based on the assumption that farmers' age affects the production efficiency since farmers of different ages have different levels of experience ability to obtain and process information.

On the other hand, Chirwa (2003) and Bellouni and Matoussi (2006) find that the estimated coefficient for farming experience is positive, meaning it increases the level of technical inefficiency. At times, experienced farmers may not be willing to try new innovations so are less efficient in the supervision role of their farms. However, since the majority of the empirical evidence suggests that farming experience reduces the level of technical inefficiency, the expected coefficient for farming experience is negative.

2.4.2.4 Family size

Mushunje *et al*. (2003) and Amos (2007) find the estimated coefficient of family size to be negative which implies that family size negatively influence technical inefficiency. This suggests heavy reliance on family labour since family members are expected to provide the bulk of the labour force. The farmers keep on average family size of eight members in line with African tradition of large family size. The major reason why farmers keep larger numbers of family members is for the provision of farm labour during the peak production period. Thus, the larger the family size, the more labour is available for farming operations, thus increasing the technical efficiency of farmers.

Mushunje *et al*. (2005) study on relative technical efficiency of cotton farmers in Manicaland province of Zimbabwe, found the coefficient of family size to be positive, but statistically insignificant, in respect of the communal area (CA) sample farmers, but that of the resettlement area (RA) is negative and significantly different from zero (Mushunje *et al*., 2005). For communal area farmers, increasing family size tends to increase the level of the technical inefficiency of the farmers. The communal area farmers are characterised by large families with average family sizes, about 8 members. Such large families are polygamous and are generally characterised by young children who need the attention of the mothers, who are expected to work in their fields full time. For this reason, the belief that larger families help with labour does not apply to these farmers, thus their technical efficiency is reduced. Tijani (2006) also finds that the coefficient of family size is positive. This implies that family size increases technical inefficiency, meaning it has a negative effect on technical efficiency (reduce technical efficiency). The family size coefficient can either be positive or negative, depending on members of the family who are actively involved in farming.

2.4.2.5 Extension contacts and farmers' training class

Extension plays an important role to communicate information from research institutes and policy makers to farmers and visa versa. Extension agents can facilitate joint action among farmers (e.g. input supply, marketing, sharing of equipment and labour). Unfortunately, unfavourable structures and lack of financial resources, skills and motivation of personnel often limit the impact of agricultural extension on development (Dunkhorst and Mollel, 1999). Mkhabela (2003) finds that the estimated coefficients for extension contacts and farmers training class are negative. This indicates that increase of the farm visits by extension officers and farm-training classes decrease the inefficiency level of farmers. Because of training classes, farmers' skills increase as well as their adoption of new technology for cultivation. Khairo and Battese (2005) find that the estimated coefficient for agricultural extension is negative for farmers within the program but positive for farmers outside the program. Extension service is also one of the important factors that could improve agricultural productivity.

2.4.2.6 Credit and off-farm income

Small-scale farmers need access to capital to finance their operations and make necessary purchases. If a small-scale farmer does not have sufficient equity capital, he has to borrow money and go into debt. For a small-scale farmer to acquire a loan from traditional lending institutions such as a bank, he must have a good credit record or substantial collateral. Since most of the farmers in most developing countries have limited resources and no credit history either, they have problems accessing formal finance (Moyo, 2002). Mochebelele and Winter-Nelson's (2002) study on migrant labour and farm technical efficiency in Lesotho found that farmers who sent migrant labour to South African mines were closer to their production frontier than those who did not. That was because migrant labourers contributed 80% of factor income in Lesotho around 1983-89. Kibaara's (2005), Tijani's (2006) and Tchale and Sauer's (2007) results also reveal that credit and off-farm income variables have a negative sign and therefore reduce technical inefficiency (or increase technical efficiency). Facilitating the availability of credit for farmers can serve as useful strategy aimed at increasing agricultural productivity.

2.4.2.7 Animal power and tractor power

Compared to use of manual labour, use of animal and tractor power allows deep tillage of the soil that enhances yield. In addition, animal and tractor use is faster and also ensures timely land preparation, planting and weeding. Kibaara (2005) found that mechanisation is important, households that used tractors for land preparation increased technical efficiency by 26% (4.41 bags). While Mochebelele and Winter-Wilson (2002) study on migrant labour and farm technical efficiency in Lesotho, find that the coefficients for tractor power and animal draft power is negative and insignificant. They concluded that farmers who sent migrant labour to South African mines were closer to their production frontier than those who do not. The negative sign of animal and animal draft power in this case may mean that non-migrant households did not have enough income to buy or hire animals or a tractor. In this regard, animal and tractor power are more efficient than manual labour so they will increase the level of technical efficiency.

2.4.2.8 Conclusion

The negative sign of the parameters in inefficiency means that the associated variable reduces technical inefficiency and thus has a positive effect on technical efficiency (increased) while the positive sign of the parameters means that the associated variable increases technical inefficiency. Based on the findings of the related studies, the expectation of this study is that technical efficiency should increase with increase in age and farming experience since age and experience are expected to be positively correlated to adoption of improved technology and techniques of production. This may be due to the fact that the older farmers are more experienced. Extension contacts and farmers training class, credit and off-farm income also improves technical efficiency. Extension service could provide farmers with appropriate skills and also link the farmers with financial services in order to get credit to buy inputs.

CHAPTER 3: RESEARCH AREA AND FARMERS' CHARACTERISTICS

3.1 INTRODUCTION

The purpose of this chapter is firstly, to introduce the reader to the brief overview of the research area in terms of the physical, geographic and climatic environments of Lesotho. The presentation is then followed by outlining the procedure for the data collection method and sampling techniques of this study. Subsequently, there will be an extensive discussion on characteristics of respondents in the study areas with the main focus on demographic characteristics, farm specific characteristics especially production factors, socio-economic aspects such as extension visits and farm training, market access, credit access and off-farm income. The chapter is intended to help the reader appreciate the environment within which maize is grown in Lesotho.

3.2 RESEARCH AREA

3.2.1 LOCATION AND PHYSICAL ENVIRONMENT

Lesotho is a small mountainous country found in Southern Africa and is completely surrounded by South Africa. Figure 3.1 illustrates the location of Lesotho within SADC countries. The country's land area is approximately 30 588 km^2 of which only 12% of the land is deemed suitable for crop production while the rest of the land consists of predominantly mountains and foothills (Kingdom of Lesotho, 2005). Lesotho's terrain is created by the sheer walls of the Drakensberg and Maluti Mountain Ranges, which give sanctuary to a unique developing nation, hence, the country's popular name "Mountain Kingdom". The Kingdom of Lesotho is situated between the 28° and 31° latitudes in the south and is bordered by the 27° and 30° eastern longitudes (LMS, 2006).

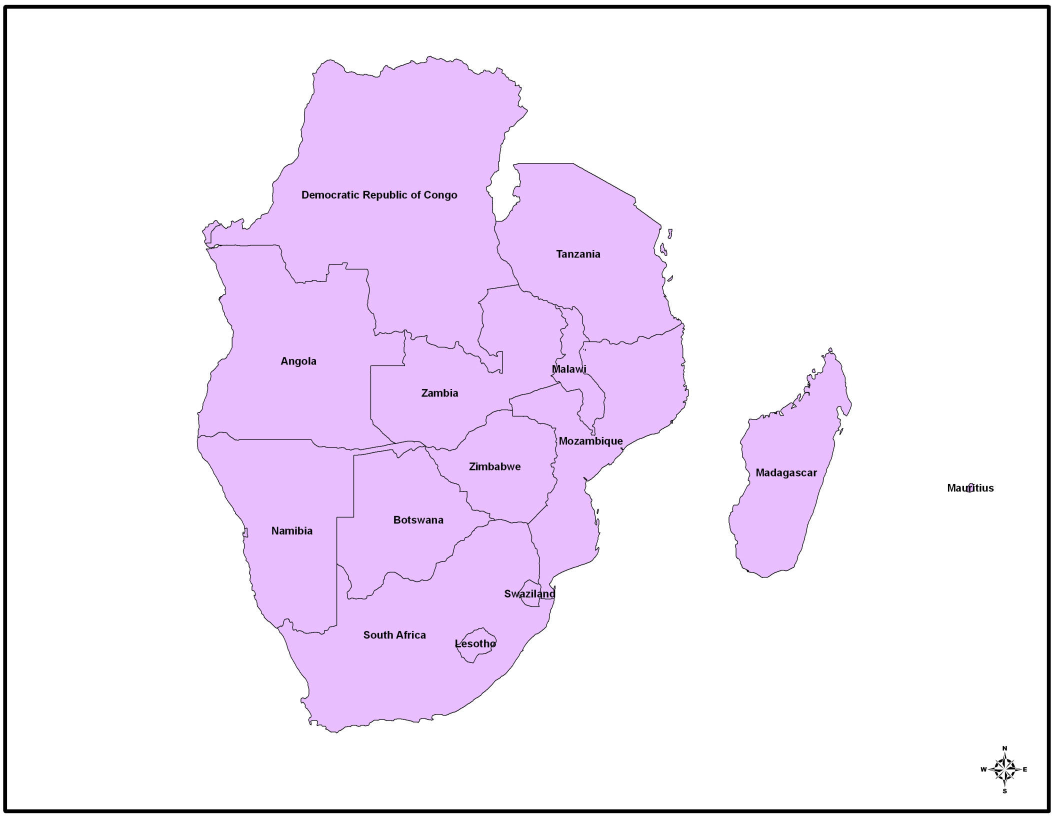

Figure 3.1: Lesotho within SADC Countries

3.2.2 AGRO-ECOLOGICAL POTENTIAL OF LESOTHO

According to the World Bank (2005), the variations in geo-morphology and topography including the micro-climatological influences have significant impact on the ecology of a region. These factors characterise the formation of distinct agro-ecological zones in Lesotho, which are: the Lowlands (17%), the Foothills (15%), the Senqu (Orange) River Valley (9%) and the Mountains (59%). The geographical features of Lesotho determine the suitability of its land for agricultural activities. They also influence the adaptability and distribution of different types of crops as well as the particular varieties of each type of crop. Water availability and temperature conditions are also undoubtedly the major factors influencing crop production in the country. These two variables set limits to the cultivable area as well as to the commencement of the growing season and its productivity (Mbata, 2001).

For administrative purposes, Lesotho is demarcated into ten districts namely; Butha-Buthe, Leribe, Berea, Maseru, Mafeteng, Mohale's-hoek, Quthing, Qacha's-nek, Mokhotlong and Thaba-tseka. These districts differ in terms of size, topography, climate and stage of development. The capital town of Lesotho is Maseru, which is found in the central part of the country (Kingdom of Lesotho, 1996).

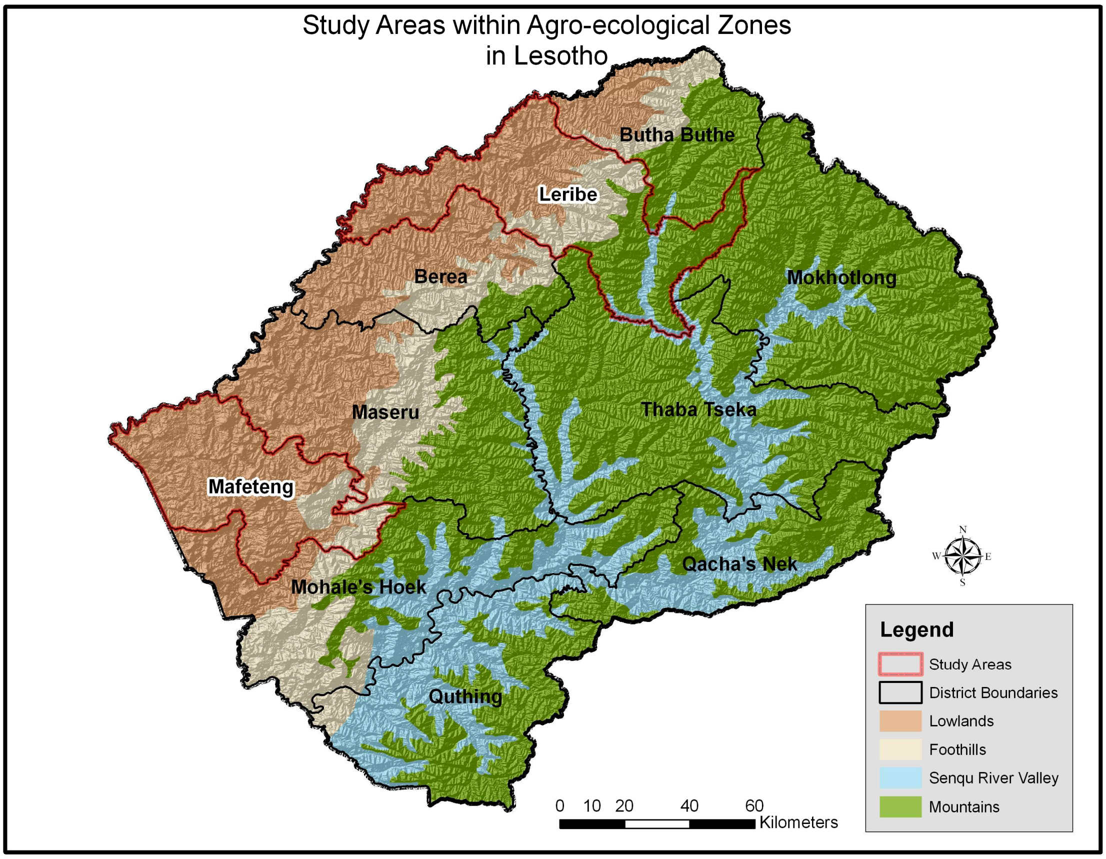

Figure 3.2: Agro-ecological Zones of Lesotho

Source: Lesotho Meteorological Services (2000)

Figure 3.2 shows the location of the study areas within Lesotho's agro-ecological zones. This study was carried out in Leribe and Mafeteng districts in the Northern and Southern parts of the country respectively.

3.2.3 CLIMATE

Lesotho has a temperate climate with cool to cold winters and hot, wet summers. Like many countries in Southern Africa, Lesotho's climate is highly variable due to high pressure zones which are caused by vast differences in the country's topography (FAO, 2005). In recent years, Lesotho has experienced unprecedented and frequent droughts that were associated with El Nino conditions. The country has also been struck by sudden snowfalls, strong winds, and floods from time to time, with devastating social impacts (LMS, 2000).

The climate of Lesotho is marked by four distinct seasons; summer, winter, autumn and spring. Summer in Lesotho is from December to February and is characterised by beautiful warm sunny days, precipitation, high and humid temperatures throughout the country and generally warmer, but cool in the highlands due to altitude. Mean annual temperatures range from 15℃ in the lowlands to 7℃ in the highlands. January is the hottest month with maximum daytime temperatures ranging from 20℃ in high altitudes to 32℃ or even higher in the low lands (FAO, 2005). Winter is from June to August and characterised by high-pressure dominance resulting in clear skies, cold and dry air, and lowest daily average temperatures during the day, especially after sunset and low precipitation. Winters are harsher in the highlands since the mountainous regions receive snow during the unusually cold winters (FAO, 2005). Figure 3.3 shows that the minimum temperatures of the two districts are below average; however Leribe temperatures are lower than that of Mafeteng throughout the cropping year. Figure 3.4 shows the maximum temperatures in the two districts. Leribe district has a higher temperature above average.

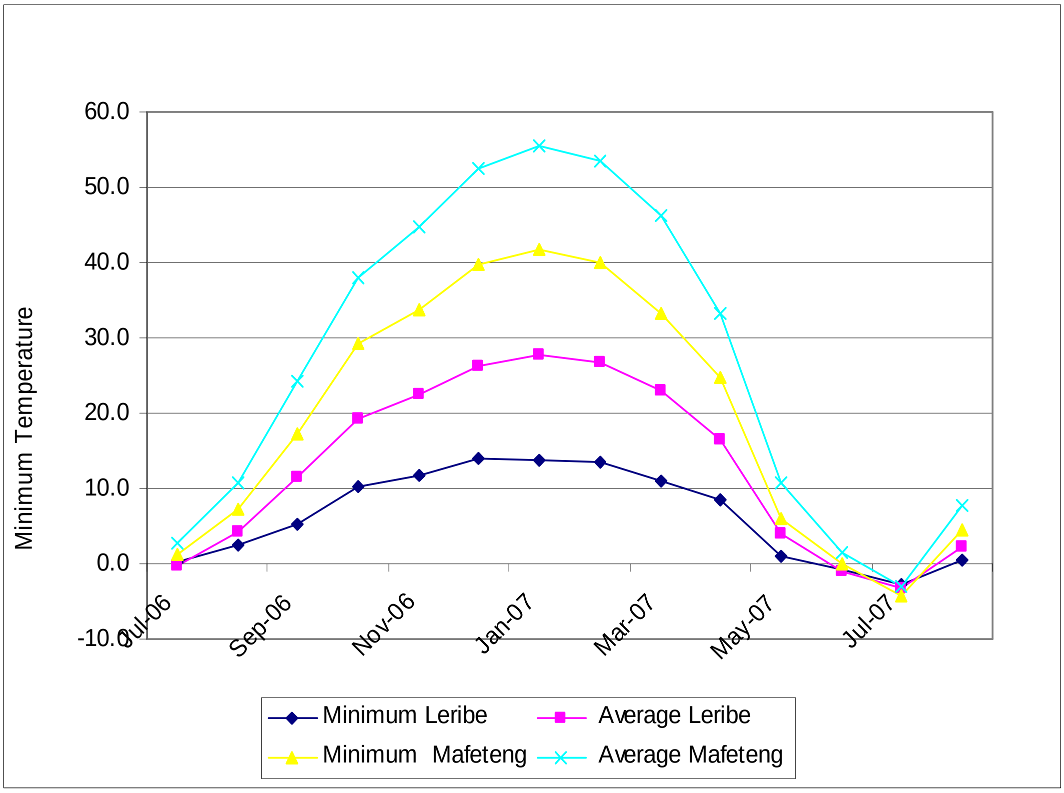

Figure 3.3: Minimum Temperatures in Leribe and Mafeteng

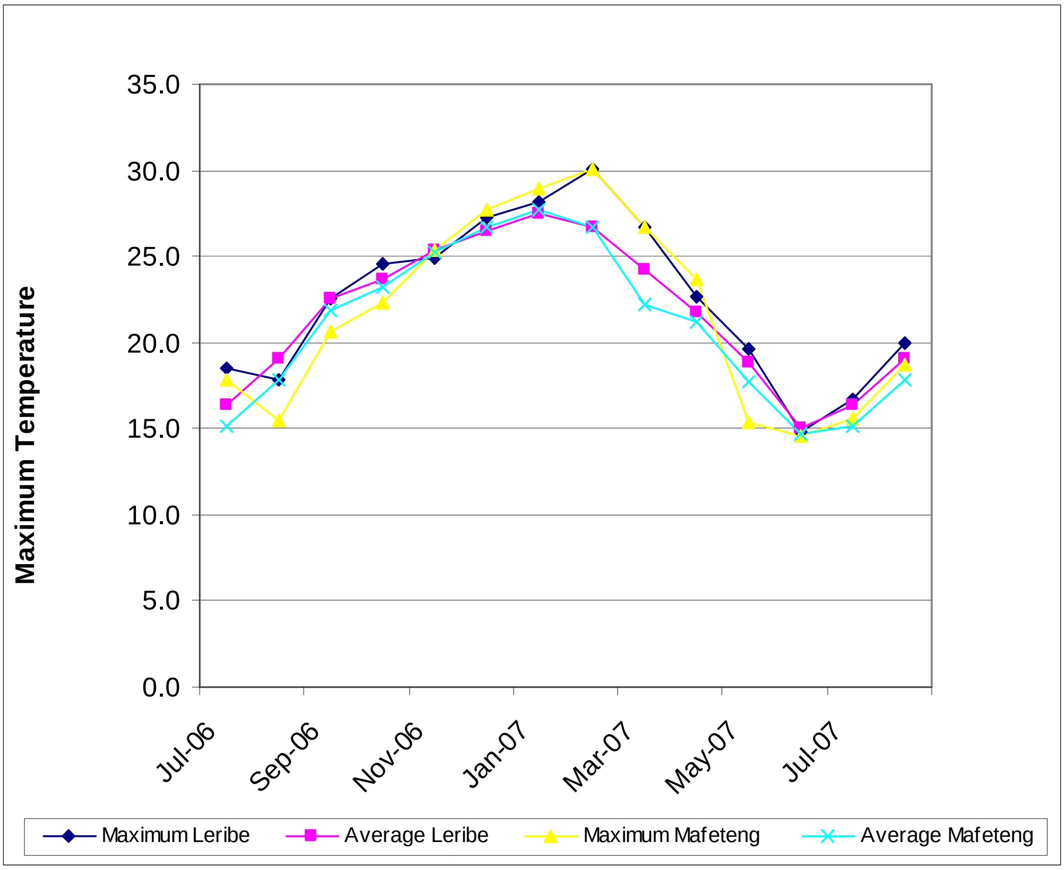

Figure 3.4: Maximum Temperatures in Leribe and Mafeteng

Lesotho's rainfall is characterised by fluctuating trends, with high variability in both quantity and time from year to year. The annual precipitation is unevenly distributed, ranging from 450 mm in the south and western lowlands to up to 1 600 mm in the northern lowlands and eastern corner of the country (Chakela, 1997). The average rainfall is approximately 780 mm, of which 85% falls between October and April. The peak rainfall period is from December to February. The lowest rainfall occurs in June when monthly totals of less than 15 mm are recorded at most stations (LMS, 2006). Although rainfall is much higher in the mountains and foothills, the cropping season is much shorter due to the early onset of frost which will be exacerbated by climate change. The distribution and reliability of rainfall are serious constraints on agricultural production. These uncertainties about climatic conditions are increasingly attributing to a more risky occupation of an already low-productivity agriculture. Thus, the choice of crop (cultivar), ecological region, and planting date need to be decided upon in the light of frost risks, the prevailing temperature regime and rainfall occurrence during the growing season (Ministry of Natural Resource, 2000).

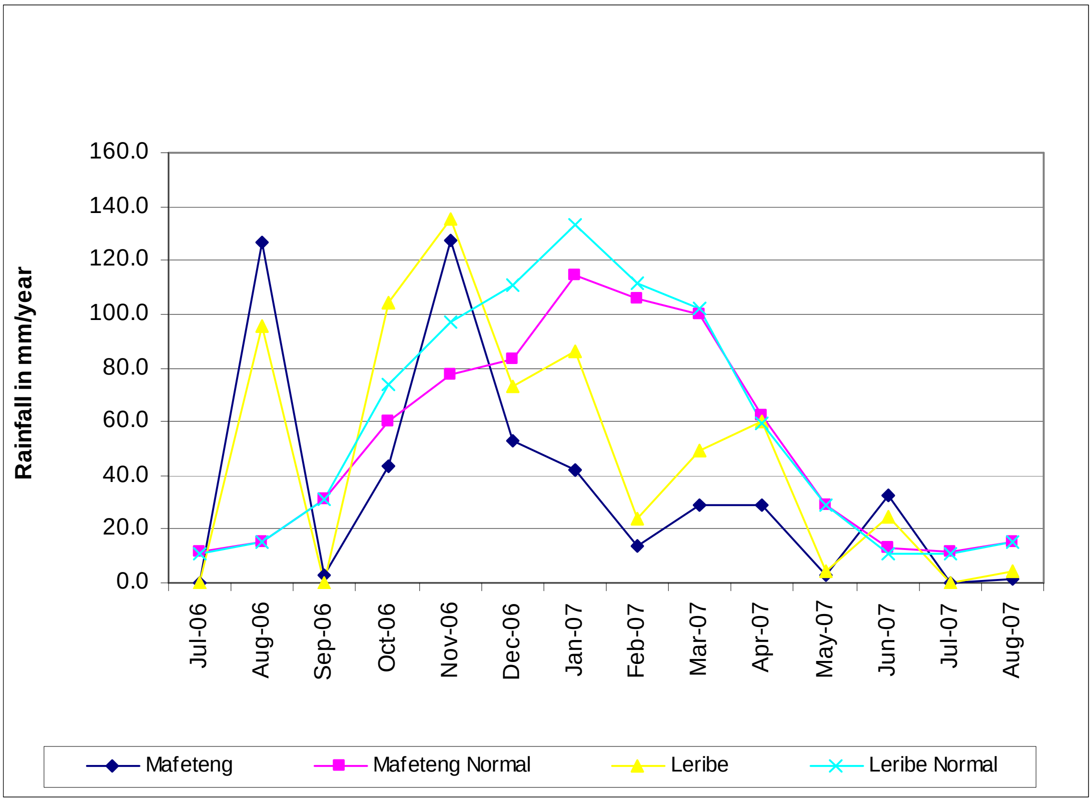

Figure 3.5: Rainfall Distribution across Leribe and Mafeteng

3.2.4 AGRICULTURAL SYSTEM

3.2.4.1 Arable land and Crop production

Total arable land in Lesotho is 283 198 ha. Leribe is the district with the highest arable land of about 52 114 ha (18%) and Mafeteng district has lower potential arable land of 37 156 ha (13%). The most important grains in Lesotho are maize, sorghum and wheat, which occupy 60%, 20% and 10% of the land respectively and cover about 80% of the total cropped area; other important crops are beans and peas. According to Battese (1998), as stated by Mushunje (2003), it may not be feasible for the researchers to attempt to collect data on all possible crops grown by the farmers, especially where farmers in the region grow a variety of crops. It is therefore necessary to target the analysis to one or two of the most important crops in the region. The research is only focusing on maize producers because maize is by far the most important crop nation-wide and a staple food in Lesotho.

Tables 3.1 and 3.2 illustrate the total maize production, area harvested and yield of maize in the study area over 10 years. The total maize production (metric tonnes) in the two districts varied from year to year; a good production year has been followed by a bad production year resulting in lower yields. However, Leribe is the district with a higher maize yield except for 1997/98 where Mafeteng's yield was high. In 2006/07 cropping season total maize produced by Lesotho was about 72 metric tonnes produced from an area of around 172 000 ha, with average yield of 0.42 t/ha. In the 2006/07 Leribe's total maize production was 26% of the total production in Lesotho, while Mafeteng's total maize production was 0.07%. The percentage yields of the two districts show that Mafeteng's maize yields are very low. This is further shown by the fact that on average, the evaluation of maize yield per hectare obtained from Leribe district is higher (1.36 t/ha) than the maize yield in Mafeteng (0.67 t/ha).The total area harvested also varied over the 10 years with Leribe having a greater area harvested than Mafeteng because Leribe has more arable land than Mafeteng, as indicated earlier.

Table 3.1: Total production and area harvested of Maize in Study Areas

	Production (metric tonnes)			Area harvested (ha)		
Cropping Year	**Leribe**	**Mafeteng**	**Lesotho**	**Leribe**	**Mafeteng**	**Lesotho**
1997/98	2399	7178	118679	18133	6407	82829
1998/99	31384	5746	124549	28437	13500	132356
1999/00	154484	14492	277685	32703	19650	157945
2000/01	28167	19619	158189	35261	30834	177503
2001/02	31140	16386	111205	28296	20216	138256
2002/03	29603	11631	85032	21692	18503	127469
2003/04	22157	10389	80998	22896	20698	127629
2004/05	8436	6220	100723	20817	18494	112302
2005/06	27562	6517	100815	41730	20343	168765
2006/07	18914	5447	72636	27300	20911	172205
Total	354246	103625	1230511	277265	189556	1397259
Average	35425	10363	123051	27727	18956	139726

Source: Bureau of Statistics (2008)

Table 3.2: Maize yield in Study Areas

	Yield (t/ha)		
Cropping Year	**Leribe**	**Mafeteng**	**Lesotho**
1997/98	0.10	1.12	1.21
1998/99	1.06	0.39	0.89
1999/00	4.55	0.63	1.63
2000/01	0.75	0.58	0.81
2001/02	1.02	0.74	0.76
2002/03	0.91	0.60	0.62
2003/04	0.96	0.49	0.63
2004/05	0.34	0.31	0.66
2005/06	0.66	0.32	0.51
2006/07	0.69	0.26	0.42
Total	11.06	5.44	8.14
Average	1.11	0.54	0.81
Standard Deviation	1.25	0.26	0.36
Coefficient of Variance	0.88	2.12	2.25

Source: Bureau of Statistics (2008)

3.2.4.2 Livestock production

The majority of households own livestock - mainly cattle, sheep and goats. Many households own horses, donkeys or chickens. Livestock is owned for purposes of draught power, payment in kind and for sale. The numbers of livestock have generally been on the decline, mainly due to diseases and stock theft, the latter being one of the main problems of the rural and agricultural communities (BOS, 2008).

3.3 DATA COLLECTION AND SITE SELECTION

As discussed earlier in this chapter, this research was carried out in two of the ten administrative districts of Lesotho. Both secondary data and primary data were used in this study. Secondary data was obtained from relevant literature on maize production, extension officers and research officers in the country and other institutions and Department of Agriculture. Primary data collected by means of structured questionnaires were used to gather information from a household survey of the sampled maize farmers in the study areas. The two districts were selected, based on their agricultural potential, accessibility, agronomic practices and levels of maize productivity within the district; high productivity, medium productivity and low productivity. In addition, these districts represent the two major maize producing districts of the country, the maize crop being the main focus of this research. Leribe is the highest maize producing district in the Northern Lowlands of the country, while Mafeteng is the highest maize producing district in the Southern Lowlands of the country. The selection was also done taking into consideration the time schedule of the study and limited financial resources available for this research.

The primary data were used to collect input-output data of the farmers defined within the maize production content in order to provide estimates of technical efficiency and its determinants. The output data include maize yield in tonnes and the input data include the quantity of fertiliser in kilograms, amount of labour (both family and hired labour) in man-days and quantity of seeds in kilograms. These variables serve as the basis for physical inputs used for producing maize per production year in the study area. Data were also collected on some main socio-economic variables such as gender, age, household size, level of education, seed quality, cattle power, tractor power, farming experience, extension visits, farm training, market access, credit access and off-farm income. The main respondents to the household survey were the principal decision makers of the household or their spouses.

3.3.1 SAMPLING TECHNIQUE AND SIZE

The sampling technique employed is the stratified sampling technique. Westfall (2009) stated that the stratified sampling method is used when representatives from each sub-group (strata) within the population, need to be represented in the sample. Random samples are then taken from each sub-group based on mutually exclusive criteria. The two districts selected were based on three different levels of maize productivity within the district; high productivity, medium productivity and low productivity. A questionnaire survey was conducted to collect relevant information on the household, farm-specific and socio-economic characteristics of maize farmers (Questionnaire in Appendix B). The sampling technique employed was the stratified sampling technique. A sample of 25 maize farmers was then randomly drawn from each of the productivity levels to represent about 33% of the maize farmers. There were 75 respondent farmers from each district, thereby making a total of 150 respondents.

Before a questionnaire could be administered, an informal discussion on the objectives of the study was held with the District Agricultural Officer (DAO) and the District Extension Officer (DEO) to help in the selection of maize producing farmers per district. The Extension Officers assisted in identifying resource centres and appropriate villages for the study and drew up lists of potential farmers representing three levels of maize productivity. The questionnaire was then pre-tested on 25 non-sample households; after the pre-test the questionnaire was modified. The final questionnaire was used to interview all 150 sample households in personal interviews conducted in February/March 2009 using a single-visit survey approach.

3.4 CHARACTERISTICS OF RESPONDENTS

The purpose of this section is to provide a brief description of the surveyed households in the study area according to demographic characteristics, farm specific characteristics, extension visits and farm training, market access, credit and off-farm income in the study area.

3.4.1 DEMOGRAPHIC CHARACTERISTICS OF THE HOUSEHOLD

Figure 3.6 shows the distribution of respondents by age and gender in Leribe district.

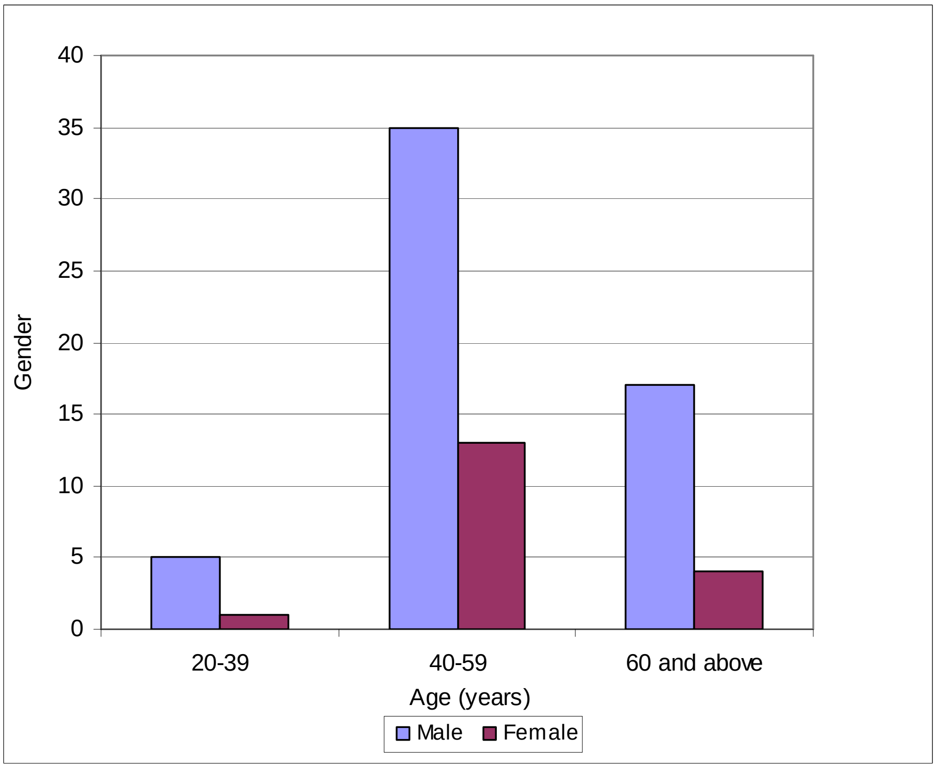

Figure 3.6: Age and Gender distribution in Leribe District

There are 57 male farmers involved in maize farming and 31 female farmers. The distribution of males involved in maize farming activities in Leribe is higher than their female counterparts. In addition, the majority of male farmers are within the age group ranging from 40-59 years, followed by the next group of elders above 60 years of age also involved in maize production. Young people with ages ranging from 20-39 have a limited interest in farming. The distribution of gender in Mafeteng district is quite different from that of Leribe as shown in Figure 3.7 below.

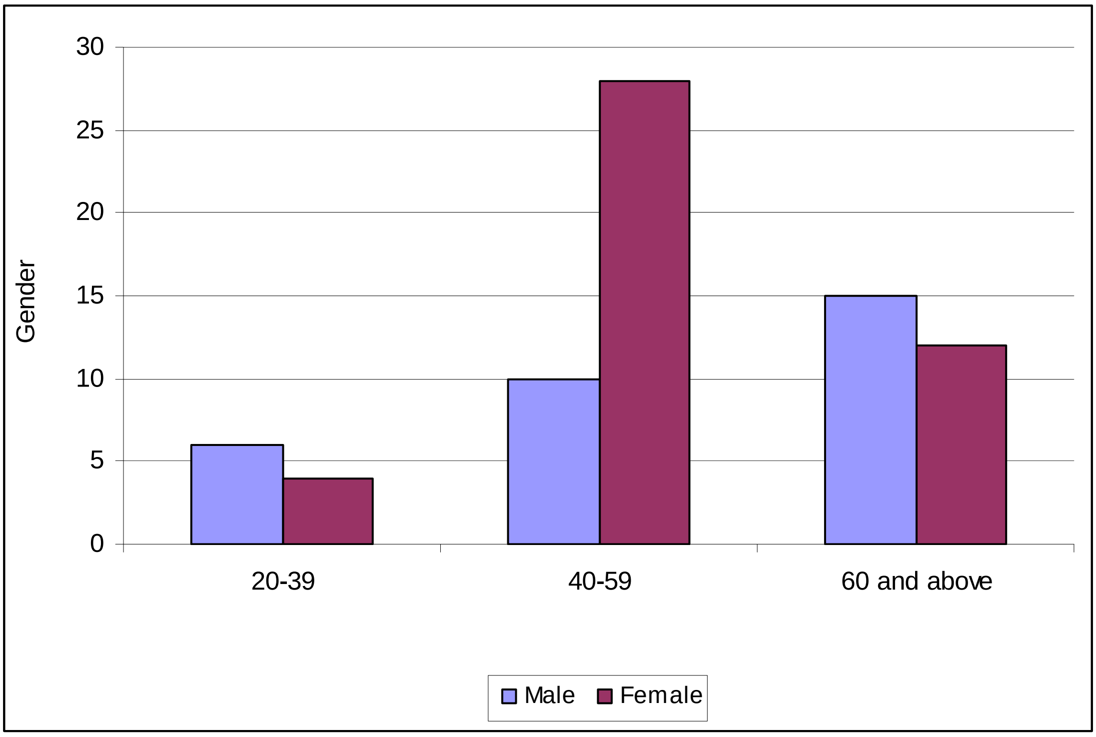

Figure 3.7: Age and Gender distribution in Mafeteng District

In Mafeteng, the number of female farmers involved in maize production is higher than males within the age group 40-59 years. However, there are more males than females amongst elders ranging above 60 years and young people of ages ranging from 20-39 years. It then follows that there is a variation in the age and gender group among Mafeteng farmers. Still, the total number of females is greater (44) than males (31). Participation of women in agriculture remains a challenge among maize farmers in Lesotho because their contribution in farming is undervalued, due to the fact that they work on their husband's farms. Table 3.3 illustrates the summary statistics with respect to household size in terms of mean and standard deviation.

Table 3.3: Summary statistics of Household size

Household Characteristics	Leribe (N=75)		Mafeteng (N=75)	
	Mean	Stdev.	Mean	Stdev.
Household size	10	5	9	4

Household size refers to the number of people living in the same household and relying on the maize produced by the head of the household. Some of the people are used as family labour to help on the farm at cropping season. On average, the household size headed by the principal decision-maker is 10 people in Leribe and 9 people in Mafeteng. The household size does not vary from an average family size in African tradition of a large family size, which is about eight people to provide farm labour during peak production periods, as stated by (Amos, 2007). Table 3.4 shows the relationship between level of education and farming experience in Leribe district.

Table 3.4: Level of education and farming experience in Leribe District

District	**Education level**	**Farming Experience in years**								**Aggregate N=150**	
		1-15		16-30		31-45		>45		Total	
		N	%	N	%	N	%	N	%	N	%
Leribe	Primary	3	4	9	12	12	16	3	4	27	36
	Secondary	5	6.7	11	14.7	4	5.3	0	0	20	26.7
	High	0	0	10	13.3	4	5.3	0	0	14	18.6
	Tertiary	5	6.7	1	1.3	3	4	1	1.3	10	13.3
	Total	13	17.4	31	41.3	23	30.6	4	5.3	71	94.6

The results on Table 3.4 show that 36% of farmers in Leribe have primary school education, 26.7% have secondary school education, 18.6% have high school education and 13% of the farmers have tertiary education (college and university). About 16 farmers with primary education have farming experience ranging from 31-45 years. The farmers who have attained a high education level are less experienced in farming. Farming experience is important for day-to-day running of maize farming activities. Educated farmers might have other full-time jobs, hence do not devote much of their time to farming. On the other hand, Table 3.5 presents the distribution of level of education farm experience among the respondents in Mafeteng District.

Table 3.5: Level of education and farming experience in Mafeteng District

District	Education level	Farming Experience in years								Aggregate N=150	
		1-15		16-30		31-45		>45		Total	
		N	%	N	%	N	%	N	%	N	%
Mafeteng	Primary	7	9.3	21	28	18	24	5	6.7	51	68
	Secondary	3	4	3	4	3	4	0	0	9	12
	High	0	0	5	6.7	2	2.7	0	0	7	9.4
	Tertiary	0	0	1	1.3	1	1.3	1	1.3	3	3.9
	Total	10	13.3	30	40	24	32	6	8	70	93.3

More than half of the sampled farmers in Mafeteng (51 people) have primary education. The farming experience within households shows that the predominant years of farming experience in the district range from 16-30 years. Also the majority of farmers with primary education have more farming experience than other levels of education. On average, 28% of farmers have primary education, while only 1.3% of farmers with tertiary education have been farming in the same range of farming experience. Although, the maize farmers in Leribe seem to be more educated than Mafeteng farmers, primary education is still enough for farmers in developing countries to be able to perform the necessary farming activities.

3.4.2 FARM SPECIFIC CHARACTERISTICS

Table 3.6 represents the physical inputs used and yields of maize obtained in the two districts, Leribe and Mafeteng. The table involves the descriptive statistics in terms of sample means and standard deviation values for each of the variables in the two districts.

Table 3.6: Summary of descriptive statistics for farm specific characteristics

Characteristics	Leribe N=75		Mafeteng N=75	
	Mean	**Stdev.**	**Mean**	**Stdev.**
Maize Yield (t)	1.7	1.5	1	0.9
Amount of Nitrogen (kg)	52	62.7	11.6	11.2
Amount of Phosphorus (kg)	16.1	15.6	7.5	6.6
Amount of Potassium (kg)	4.3	3.8	4.3	3.8
Labour (man-days)	202	199	198	147
Farm size (ha)	16.6	28.5	2.9	1.7
Seed Quality (if hybrid)	0.9	0.3	0.8	0.4
Seed Quantity (kg)	15	6.6	12	5.2
Animal Power	0.13	0.34	0.41	0.5
Tractor Power	0.44	0.5	0.03	0.16

On average, the maize yield of the sampled farmers in Leribe was 1.7 ton obtained from 16.6 ha. This was achieved by using on average, fertiliser containing the three major nutrients, 52 kg of nitrogen, 16.1 kg of phosphorus and 4.3 kg of potassium. In addition, the quantity of seed used stood at an average of 15 kg/ha, using labour of about 202 man-days. Conversely, the average yield of maize obtained in Mafeteng was 1 ton obtained from 2.9 ha, using 11.6 kg of nitrogen, 7.5 kg phosphorus, 4.3 kg potassium and 12 kg seed. The labour used was 198 man-days. Generally Leribe have higher crop yield resulting from higher input availability.

Farmers used different sources of power for farming activities. In Lesotho most farmers are still using cattle power for land preparation. The majority of the Leribe sampled maize farmers use tractor power only while Mafeteng sampled maize farmers commonly use cattle power only for land preparation. The greater percentage (44%) of the maize farmers in Leribe use tractor power only, while 13% of the farmers use cattle only and 42.7% use both the tractor and cattle power. On the other hand, 41.3% of sampled farmers in Mafeteng depend on cattle only for land preparation, while 45% of the farmers use tractor power only and the remaining 54.7% use both the tractor and cattle power. The percentage of maize farmers using tractor power is higher in Leribe than in Mafeteng. Nevertheless, the difference between farmers who use both cattle and tractor power in the two districts is not that much, but still Mafeteng shows a greater percentage of 54% compared to 42% in Leribe.

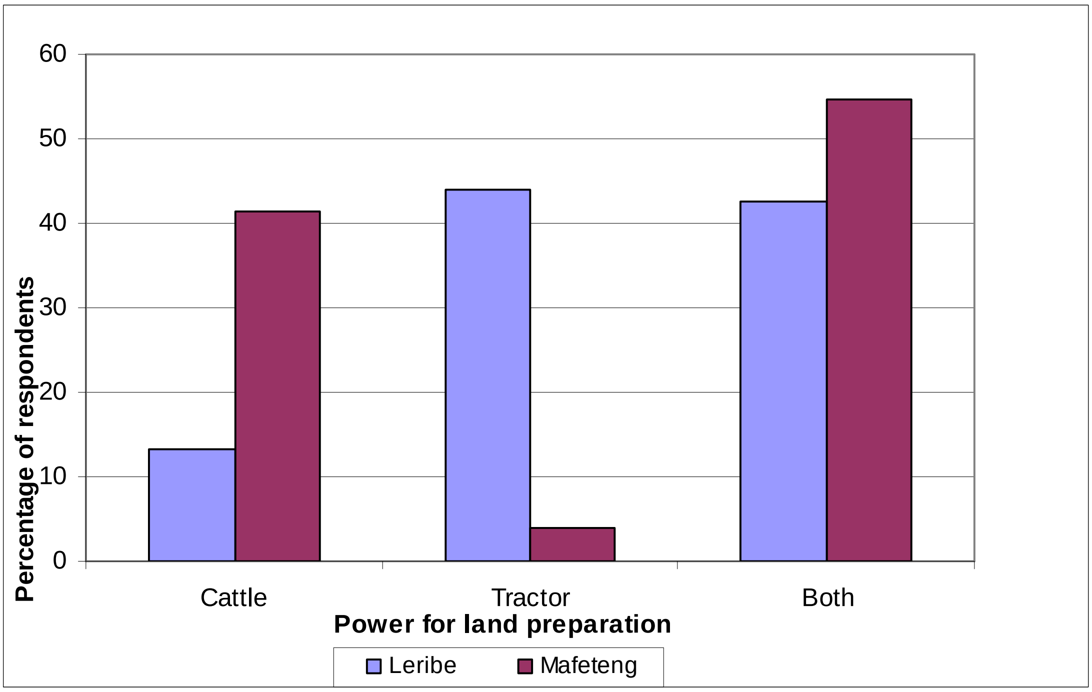

Figure 3.8: Distribution of respondents by power for land preparation

3.4.3 EXTENSION VISITS AND FARM TRAINING

Table 3.7 demonstrates availability of extension workers to the sampled farmers in the study area.

Table 3.7: Availability of Government Extension Officers

Response	Leribe N=75		Mafeteng N=75		Aggregate N=150	
	No.	%	No.	%	No.	%
NA	2	2.7	0	0	2	1.3
Yes	53	70.7	37	49.3	90	60
No	20	26.7	38	50.7	58	38.7

When asked about availability of extension officers, 71% of the respondents in Leribe were visited by extension officers and 49% of farmers in Mafeteng were visited by extension officers. The percentage difference in the responses shows that extension work is neglected in Mafeteng, the farmers are not advised accordingly and this might affect their performance. Moreover, Table 3.8 shows responses of farmers in relation to farm training.

Table 3.8: Farmers responses toward Farm Training

Response	Leribe N=75		Mafeteng N=75		Aggregate N=150	
	No.	%	No.	%	No.	%
Yes	58	77.3	36	48	94	62.7
No	17	22.7	39	52	56	37.3

Of the 75 farmers in Leribe 58 (77%) received some form of training from extension officers and 17 (23%) never received any training in the 2007/08 cropping year. In Mafeteng, 36 (48%) of 75 sampled farmers received training from extension officers, while 39 (52%) never received any training. It seems that more farmers were trained in Leribe than Mafeteng.

3.4.4 MARKET ACCESS

Figure 3.9 displays the distribution of the sampled farmers by market access in the two districts.

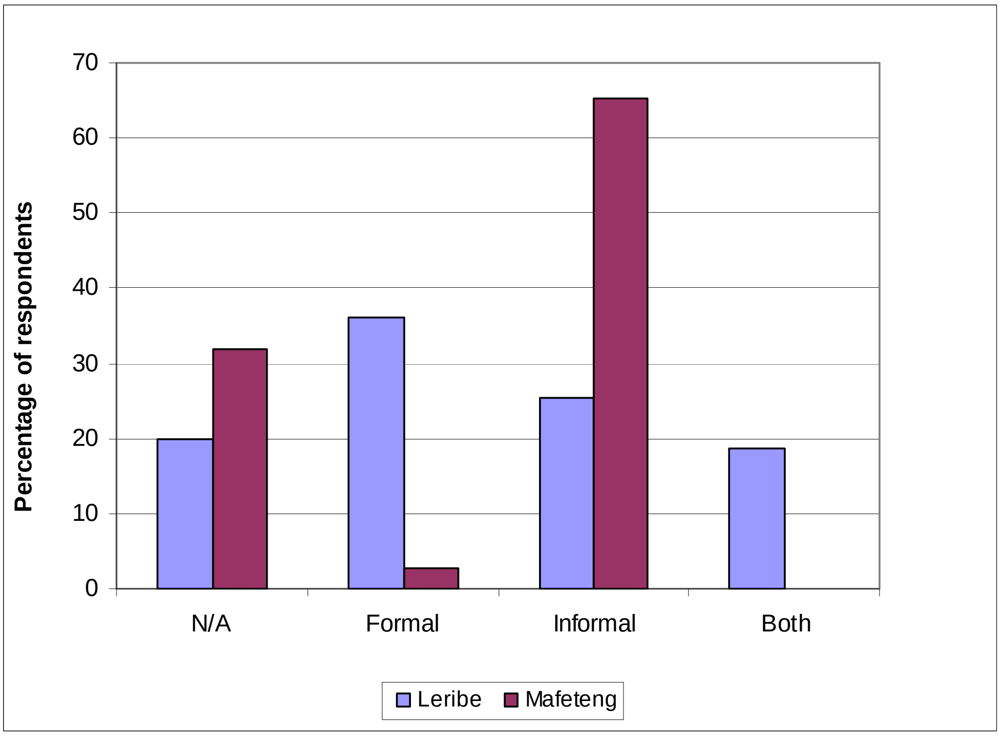

Figure 3.9: Market Access of respondents across study areas

Market access helps farmers to be more engaged in farming business. Market access also encourages farmers to produce in large quantities so that they can sell their produce and make a profit. Leribe maize farmers have 36% access to formal markets whilst Mafeteng farmers only have three percent access to formal markets. On the other hand, Mafeteng has the highest percentage (65%) of informal market access while Leribe has 25% of informal market access. The majority of sampled maize farmers (32%) in Mafeteng do not have access to any type of market, compared to 20% of Leribe farmers who do not have access to any type of the market. The maize market structure in Leribe becomes an incentive for farmers to be interested in farming and improve their maize production. Leribe maize produce is sold to Lesotho milling companies; another target market is Lesotho Highlands Development Authority. The farmers also export their maize produce to Ficksburg cooperatives in the Free State Province, South Africa. Mafeteng district is far from all these market places as a result farmers sell their maize produce to a few schools nearby and people around the village, thus have no motivation and target to increase the production of maize.

3.4.5 CREDIT ACCESS AND OFF-FARM INCOME

Table 3.9 presents the relationship between credit access and off-farm income in the study area.

Table 3.9: Off-farm income and Credit Access among respondents

		No Credit Access		Credit Access							
District	Off-farm income	**None**		**Formal**		**Informal**		**Both**		**Total**	
		N	**%**	N	**%**	N	**%**	N	**%**	N	**%**
Leribe	Yes	7	**9.3**	17	**22.7**	13	**17.3**	2	**2.7**	32	**42.7**
	No	14	**18.7**	6	**8**	15	**20**	1	**1.3**	22	**29.3**
Mafeteng	Yes	22	**29.3**	0	**0**	4	**5.3**	0	**0**	4	**5.3**
	No	46	**61.3**	1	**1.3**	2	**2.7**	0	**0**	3	**4**

The results from the Table 3.9 shows that the overall percentage of farmers in Leribe who have credit access and receive income from occupations other than farming, is 42.7%, of which 22.7% have access to formal credit and an off-farm income. Furthermore seven (9%), of the 75 farmers in Leribe, have no access to credit even though they have an off-farm income whereas 14 (18.7%) have neither credit access or off-farm income. Besides, the percentage of sampled farmers in Leribe who have access to credit and no off-farm income is 29.3%. On the contrary, the majority of maize farmers in Mafeteng do not have any off-farm income or access to credit. Of the 75 sampled farmers, 46 (61.3%) farmers do not have access to credit or any off-farm income and only four (5%) have an additional income received outside farming as well as access to formal credit. Figure 3.10 shows the distribution of additional income outside farming that the sampled maize farmers in the two districts received.

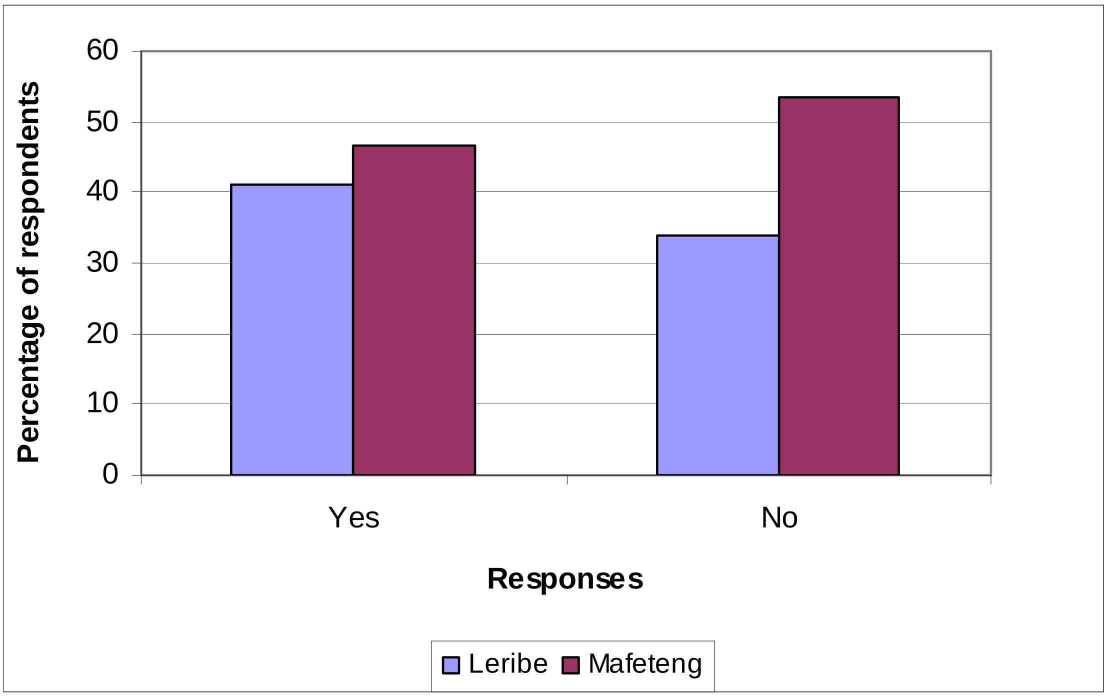

Figure 3.10: Percentage of Additional Income across study areas

Comparatively, sampled maize farmers in Leribe have more income outside farming, either from their other jobs or from family members. This serves as a security for them to get credit for buying more maize inputs, produce in large quantities and meet the target of their marketplace.

3.5 CONCLUSION

Leribe maize farmers have a comparative advantage over Mafeteng maize farmers, because they are exposed to more agricultural land and resources. The total arable land in Leribe is much more than that of Mafeteng. On average the total maize production, area harvested and yields are also higher in Leribe than in Mafeteng. Farming is mostly done by males in Leribe and by females in Mafeteng and the younger group of farmers lack any serious interested in farming. The majority of farmers with higher levels of education have less farming experience. More farmers have primary education than any other levels; still, Mafeteng farmers' primary level is higher than that of Leribe. Leribe farmers are more exposed to extension visits and farm training, market access, credit and off-farm income. As a result Leribe have higher crop yields bus also utilises more inputs

CHAPTER 4: PROCEDURES

4.1 INTRODUCTION

The aim of this chapter is to explain how the methodological procedures of the study relate to the research objectives. The chapter is divided into four main sections. The justification of the model is presented in the first section in order to give a clear understanding on the choice of the particular econometric approach. The second section presents the selected variables used to estimate the production function and technical inefficiency model. The specification and estimation of the production function model and technical inefficiency model are discussed in section three. The fourth section focuses on the explanation and procedure in using the Principal Component Regression (PCR).

4.2 JUSTIFICATION OF THE ECONOMETRIC MODEL

Early works on the productive efficiency of farms were first suggested by Farrell (1957) using a production frontier. A production frontier is specified to represent the maximum output from a given set of inputs and existing production technology. Failure to attain the frontier output implies the existence of technical inefficiency (Alene and Hassan, 2003). A frontier defines the maximum possible limit to observed production. The level of a farm's production is in relation to the frontier (which is defined as the best relative performance in a specified reference group) taken as measure of a conventional measure of its efficiency (Tchale *et al*., 2005). Coelli *et al.* (2005), state that frontiers have been estimated using many different methods over the years. Based on Farrell's work, the two principal methods that have been used are DEA and SFA, which involve non-parametric mathematical programming and parametric econometric methods, respectively.

Farrell's proposed methodology was deterministic attributing all deviations from this "best practice" level of production to inefficiency (Alene and Hassan, 2003). Aigner, Lovell and Schmidt (1977) and Van den Broeck (1977) independently proposed the stochastic frontier production function to account for the presence of measurement errors and other noise in the data, which are beyond the control of firms. The SFA technique better suits agricultural production which is largely influenced by random exogenous shocks. Nevertheless, choosing between DEA and SFA methods is quite controversial and a delicate matter, especially because these techniques are fundamentally different from each other and it is likely that they yield different results (Sarafidis, 2002; Johansson, 2005). Moreover, both techniques appear to influence the policy implications derived from the analysis, since each of these two techniques has its strength as well as major limitations (Wang, 2003; Mulwa, 2006). The choice of the technique to be used depends on the objectives of the study being done.

The great virtue of SFA to estimate technical efficiency is based on the idea that an economic unit may operate below its production frontier due to pure errors and some uncontrollable factors (Margono, 2004). It is because the stochastic frontier model assumes an error term with two additive symmetric components that accounts for pure random factors and a one-sided component which captures the effects of inefficiency relative to the stochastic frontier. The SFA model is able to separate error components from inefficiency components. The SFA acknowledges the fact that random shock outside the control of producers can affect output, thus estimate determinants of technical efficiency. In particular, it requires separate assumptions to be made as to the distributions of the inefficiency and error components, potentially leading to more accurate measures of relative efficiency (Thanassoulis, 2001; Johansson, 2005). According to Coelli et *al*. (1998) as stated by Mushunje (2005), stochastic frontiers are likely to be more appropriate than DEA in agricultural applications, especially in developing countries where data are heavily influenced by statistical noise such as measurement error and the effects of weather, variations in input quality, disease, etc. SFA model is able to simultaneously incorporate the two equations for the production function and technical inefficiency. Given such a background, the study uses SFA to empirically measure the productivity and technical efficiency of maize farmers and identifies the factors that explain the variation in the efficiency of individual maize farmers in the study area.

4.3 VARIABLES INCLUDED IN THE STUDY

The research hypothesised 18 variables to have an influence on the level of productivity in the study area. Five independent variables were used to estimate the production function model. The other 13 hypothesised variables were associated with the technical inefficiency model. Table 4.1 shows a list of the production function and technical inefficiency variables to be included in the running of the SFA model as well as their hypothesised sign.

Table 4.1: Production and Explanatory variables and their expected signs

Variable	**Measurement**	**Expected sign**
Y_i =Maize	The quantity of maize produced (ton/ha)	
Production function X_1 =Nitrogen (N)	The quantity of nitrogen used (kg/ha)	+
X_2 =Phosphorus (P)	The quantity of phosphorus used (kg/ha)	+
X_3 =Potassium (K)	The quantity of Potassium used (kg/ha)	+
X_4 =Labour(family and hired)	The quantity of labour used in (mandays)	+
X_5 =Seed Quantity	The quantity of seeds used (kg/ha)	+
Inefficiency Model Z_1 =Gender	Dummy=1 if the farmer is male, 0=if female	-
Z_2 =Age	Years of the farmers	-
Z_3 =Household size	Number of people in a household	-/+
Z_4 =Primary Education	Dummy=1 if the farmer has primary education, 0=otherwise	-/ +
Z_5 =Seed Quality	Dummy=1 if the farmer used maize hybrid seed, 0=if indigenous seeds	-
Z_6 =Cattle Power	Dummy=1 if the used cattle power only for land preparation 0=Otherwise	-
Z_7 =Tractor power	Dummy= 1 if the farmer used tractor power only for land preparation , 0=otherwise	-
Z_8 =Farming Experience	Number of years for farming experience	-
Z_9 =Extension visits	1=yes, 0=no	-
Z_{10} =Farm training	1=yes, 0=no	-
Z_{11} =Market Access	Dummy=1 access to formal market, 0=access to informal market	-
Z_{12} =Credit Access	Dummy=1 access to formal credit ,0=access to informal credit	-
Z_{13} =Off-farm income	1=yes, 0=no	-

The five hypothesised independent variables that were found to influence maize yield were those pertaining to nitrogen, phosphorus, potassium, labour and seed quantity. These variables are expected to positively influence maize yield in that a unit increase in one of the variables should increase the maize. Since maize is related to both physical production factors and other socio-economic characteristics, the technical inefficiency model will cover another objective of this study which is to determine the factors that influence variations in productivity among maize farmers in Lesotho. The variables associated with technical inefficiency include age, household size, primary education, seed quality, cattle power, tractor power, farming experience, extension visits, farm training, market access, credit access and off-farm income. The negative sign for a variable in the technical inefficiency model means that the variable reduces technical inefficiency, thus, have a positive effect on productivity while the positive sign indicates that the associated variable increases technical inefficiency and therefore have a negative effect on productivity.

4.4 SFA MODEL SPECIFICATION AND ESTIMATION PROCEDURES

The SFA model was used to determine the relationship between the dependent variable (maize output) and the independent variables as well as to determine the technical inefficiency in farmer operations in the study area. The model builds hypothesised efficiency determinants into the inefficiency error component so that one can identify focal points for action to bring efficiency to higher levels. Since the error term has two components, the stochastic production model is often referred to as a "composed error" model since it assumes an error term with two-sided additive components, namely random error that captures the random effects outside the control of the firm (the decision making unit) and a one-sided component which captures the effects of inefficiency relative to the stochastic frontier. Mushunje (2005) argues that it is of vital importance to choose the functional form well in a study, because the functional form can affect obtained results. In this study, several functional forms were explored including the Cobb-Douglas, quadratic, semi-log, transcendental and the linear function model. It is important to use the functional form which relates production of farmers to the hypothesised variables for better understanding of the functional relationship. The linear function model was chosen since it was found to fit the data best. Next, the production frontier and technical inefficiency components are discussed in detail.

4.4.1 PRODUCTION FUNCTION FRONTIER MODEL

FRONTIER version 4.1 (c) computer program (Coelli, 1996) was used to simultaneously fit both the production frontier and technical inefficiency models. The frontier model specification was developed by Battese and Coelli (1995) who proposed a stochastic frontier model where technical inefficiencies can be expressed as a function of explanatory variables and a random error (Adkin, 2003 and Coelli, 1996).

The productivity and technical efficiency of the sampled farmers was measured by estimating linear stochastic production function frontier model that was implicitly specified as:

$$\text{Y}_i = \alpha + \sum_{j}^{n=5} \beta_j \text{X}_j + \varepsilon_j \quad \text{.......} \quad (1)$$

In which, Y is the maize output of the i^{ith} farmer (i=1, 2, 3……N), j refer to the j^{th} input of maize producer i in the firm, β is the vector parameter to be estimated, ε_j implies a stochastic disturbance. The error term ε_j consists of two components, v_j and u_j. The two components of the composed error term are assumed to be independent of each other. v_j is the normally distributed random error, v - N (0, $\sigma^2{}_v$) which capture variations in output due to factors outside the control of the farmer like fluctuations in input prices, the effect of weather, luck and any other factor outside the control of the farmer. u_j is a non-negative random variable that accounts for technical inefficiency and is assumed to be independently distributed as truncations at zero of the $N(m_j\ \sigma_u^2)$, where $m_j = z_{ij}\delta$, δ is a vector of parameters to be estimated and z_{ij} is vector of variables that may influence the efficiency of the decision maker.

The variance parameters are $\sigma^2 = \sigma_v^2 + \sigma_u^2$ .... (2)

and $\gamma = \sigma_u^2 / \sigma^2$ .... (3)

So that 0≤ γ ≤1.

Given the specification of the stochastic frontier model in Equation (1), the technical efficiency of production of the ith farmer given the level of inputs is defined as:

$TE_i = \exp(-u_i)$ .... (4)

So that $0 \leq TE_i \leq 1$, and are inversely related to technical inefficiency (Khairo and Battese, 2005).

4.4.2 THE TECHNICAL INEFFICIENCY MODEL

The presence of the technically inefficiency effects were confirmed by a statistical test of the inefficiency hypothesis using the generalised log likelihood-ratio (LR) tests and the gamma estimates. The technical inefficiency model was used to identify factors that influence variations in productivity among maize farmers in the study area; specifically the model was estimated as follows:

$$u_i = \delta_0 + \sum_{n-1}^{13} \delta_n Z_i + \omega_i \quad \text{.......................................} \quad (5)$$

Where:

Z_i = vector explanatory variables associated with technical inefficiency effects,

δ =vector of unknown parameters to be estimated,

ω_i = unobservable random variables, which is assumed to be identically distributed, obtained by truncation of the normal distribution with mean zero and unknown δ^2, such that u_j is non-negative. The inefficiency of production u_j was modelled in terms of the factors that are assumed to affect the technical efficiency of farmers. Such factors are related to the socioeconomic variables of the farmers.

Since, the use of the linear production function frontier model is not conventional, generalised likelihood-ratio (LR) tests were conducted to ensure that technical inefficiency effects are present and that they are not stochastic. The LR test statistic, λ, is defined by:

$$\lambda = -2 \left[L(H_0) - L(H_1)\right] \quad \text{.......................................} \quad (6)$$

Where $L(H_0)$ is the log-likelihood value of the unrestricted model and $L(H_1)$ is the log-likelihood value under the restricted model (Coelli, 1995). The test statistic is usually assumed to be asymptotically distributed a chi-square or as a mixture of chi-square with degrees of freedom equal to the number of restrictions involved (Baten and Kamil, 2010). The null hypothesis is rejected if the test statistic is greater than the critical value, but accepted if the test statistic is smaller than the critical value.

4.5 SFA PRINCIPAL COMPONENTS REGRESSION (PCR)

National Council of Statistics Software (NCSS) 2000 was used to clean data of outliers before running the SFA. The outliers were identified using both NCSS data screening and scatter plots. The number of observations collected was reduced from 150 to 130 after removing the outliers. Maximum Likelihood Estimates (MLE) for the linear stochastic frontier production function, defined by Equation 1 above and the technical inefficiency model defined by Equation 5 were simultaneously estimated with FRONTIER version 4.1(c) (Coelli, 1996). However, the first attempt to fit the model failed as a result SFA model could not run. The situation was due to the fact that there was a high degree of multicollinearity within the data as technical inefficiency variables were strongly correlated. As a result, technical inefficiency variables were subjected to principal component analysis to solve the multicollinearity problem among the technical inefficiency variables before they could be included in the SFA model. Principal component regression (PCR) is a technique used for analysing regression data that suffer from multicollinearity. When multicollinearity occurs, least square estimates are unbiased, but their variances are large as a result they may be far from the true value. According to Montswe (2006), multicollinearity may cause lack of significance of individual variables while the overall model may be strongly significant. This may also result in wrong signs and magnitudes of the final MLE, thus leading to wrong conclusions about relationship among independent variables.

The application of the PCR procedure within the SFA framework consists of the following steps. Firstly, the variables included in the inefficiency model were subjected to principal component analysis (PCA) in order to reduce the dimensionality of the variables into a few uncorrelated principal components (PC's). The SFA was conducted with the five PC's to determine the PC's that significantly affect technical inefficiency. Two equations for the technical efficiency and technical inefficiency were simultaneously incorporated into the SFA model. The results of the SFA model indicated that only two PC's were significant. The significant PC's were then used to determine the significance of the individual variables contained in each PC. The estimated coefficients, standard errors, t-ratios and probabilities of the individual variables were calculated to establish the effect of estimated variables on the level of technical inefficiency.

4.5.1 ESTIMATION OF SIGNIFICANCE OF PRINCIPAL COMPONENT (PC) IN SFA

4.5.1.1 Extracting Principle Component

The main aim of PCA is to transform the original set of variable into a new set of variables called principal components which are linear combinations of the old variables (Mahabile *et al*., 2005). The PCA process involves calculating eigenvalues $\omega_1, \omega_2, \dots \omega_n$ from the correlation coefficient matrix, by solving the equation $|C - \lambda I|$ =0. The matrix of eigenvectors is thus given by matrix A in Equation 7 below:

$$A=\begin{bmatrix} c_{11} & c_{12} & \dots\dots & c_{1n} \\ c_{21} & c_{22} & \dots\dots & c_{2n} \\ . & . & . & . \\ . & . & . & . \\ c_{n1} & c_{n2} & \dots\dots & c_{nn} \end{bmatrix} \qquad (7)$$

The matrix A is orthogonal since its columns suit the conditions $v'_p\, v_p$ =1 and $v'_q\, v_p$ =0 for $p \neq q$

The principal components (G) are calculated as:

$$G=M^{o}A \qquad (8)$$

Equation 8 may be written in matrix notation as:

$$\begin{bmatrix} k_{11} & k_{12} & \dots & k_{1n} \\ k_{21} & k_{22} & \dots & k_{2n} \\ .. & & & \\ .. & & & \\ k_{h1} & k_{n2} & \dots & k_{hn} \end{bmatrix} = \begin{bmatrix} b^o_{11} & b^o_{12} & \dots & b^o_{n1} \\ b^o_{21} & b^o_{22} & \dots & b^o_{n2} \\ . & . & & . \\ . & . & & . \\ b^o_{h1} & b^o_{h2} & \dots & b^o_{hh} \end{bmatrix} \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1n} \\ c_{21} & c_{22} & \dots & c_{2n} \\ . & . & . & . \\ . & . & . & . \\ c_{n1} & c_{n2} & \dots & c_{nn} \end{bmatrix}$$

Where M^o is the r $\times$ n matrix of standardised variables; A is an eigenvector matrix as defined in Equation 8. There can be as many possible principal components as there are variables. The new sets of variables (principal components) are orthogonal meaning they are uncorrelated, unlike the original variables.

Once the principal components calculations were done, the percentage of variation explained by the retained PC's is shown in Table 4.3 The PC's with eigenvalues smaller than one were eliminated from the PC-output and thus the five PC factors retained had eigenvalues greater than one.

Table 4.2: Principal components retained and percentage variability explained

Principal component	Eigen value	Cumulative probability
PC_1	3.27	23.34
PC_2	2.16	38.75
PC_3	1.15	46.94
PC_4	1.10	54.81
PC_5	1.07	62.43
Sum	**8.74**	

The result shows that five of the PC's capture about 62% of the variation within the determinants of the technical efficiency.

4.5.1.2 Significance of PC in SFA

Equation 5 was re-estimated with the retained PC's as:

$$u_j = \delta_j^0 + Z^0 \rho + \varepsilon \quad (9)$$

Where, Z= M^0A and ρ =A'φ^0 in an r$\times f$ matrix of retained principal components, A is the n $\times f$ matrix of the eigenvectors corresponding to the f retained components, ρ is $f \times f$ vectors of coefficients associated with the f components. Standardised errors of the estimated coefficients ρ are represented by a $f \times 1$ vector.

Table 4.3: MLE of Linear Stochastic Production Frontier for retained PC's

Variable	Parameter	Coefficient	Std-error	t-ratio	Probability
C	∂_0	-0.1927	0.1686	-1.1425	0.2554
PC 1	∂_1	0.2339	0.0554	4.2258	0.000005***
PC 2	∂_2	-0.0371	0.0580	-0.6395	0.5237
PC 3	∂_3	0.2086	0.0797	2.6168	0.0099***
PC 4	∂_4	-0.1394	0.0411	-3.3833	0.00096***
PC 5	∂_5	0.0536	0.0377	1.4194	0.1582

Significance level ******* 1% level

Of the five PC's retained, only two were insignificant, the estimation of the significant individual variables was based on the significant PC's because they have statistical importance on the data.

4.5.2 Estimating the Significance of the Individual Variables from Significant Retained PC's

Next the estimated regression coefficients were used to determine the alpha's to be used. Then the standard errors of the regressions were also used to determine the variance associated with the estimated alphas.

$$\operatorname{var}(\hat{\alpha}) = \hat{\sigma}^2 (z'z)^{-1} = \hat{\sigma}^2 \, diag(\omega_1^{-1}, \omega_2^{-1}, \ldots \omega_n^{-1}) \quad (10)$$

Where $\hat{\sigma}^2$ is the variance of residuals, thus, standard error of α may be given by

$u^o = (s.e.\,\hat{\alpha}_1 \;\; s.e.\hat{\alpha}_2 \ldots s.e.\hat{\alpha}_i)'$ .... (11)

Variance of the principal component estimators of the standardised variables is given by:

$\mathrm{var}\left(\beta^o_{pc}\right) = \varphi^o_p \, \mathrm{U}^o$ .... (12)

Where φ^o_p contains the squares of the elements of Z^o_p, and U^o contains the squares of the elements of the matrix standard errors for coefficient matrix ρ in Equation 9. The corresponding standard errors for the estimators of principal components of standardised variables are given by:

$s.e\left(\beta^o_{pc}\right) = \left[\mathrm{var}\left(\beta^o_{pc}\right)\right]^{1/2}$ …………………………………………………………… (13)

Then the PC estimators were estimated by multiplying the square of eigenvector elements matrix with the variance matrix as follows:

$$\begin{bmatrix} z_{11} & z_{12} & \ldots\ldots & z_{1n} \\ z_{21} & z_{22} & \ldots\ldots & z_{2n} \\ . & . & . & . \\ . & . & . & . \\ z_{n1} & z_{n2} & \ldots\ldots & z_{nn} \end{bmatrix} \times \begin{bmatrix} \hat{\alpha}_1 \\ \alpha_2 \\ . \\ . \\ \hat{\alpha}_p \end{bmatrix} = \begin{bmatrix} \beta^o_{1,pc} \\ \beta^o_{2,pc} \\ . \\ . \\ . \\ \beta^o_{n,pc} \end{bmatrix} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (14)$$

The constant $\beta^o_{f,pc} = \bar{y}$. The standardised coefficients evaluate the relative importance of the explanatory variables in determining the productivity levels among farmers in the study area.

The estimated regression coefficients and standard errors were used to estimate the regression coefficients and standard errors associated with the original variables. The standard error of the principal component estimator associated with the d ^{ih} original variable is specified as:

$$s.e\left(\beta_{d,pc}\right) = s.e\left(\frac{\beta^{o}_{d,pc}}{S_{xd}}\right)$$

$$\frac{\partial \phi_i}{\partial x_{id}} = \phi_i \left(-\phi_i\right)\beta_d \qquad (15)$$

The original regression coefficient, standard errors and probabilities were then estimated by re-scaling them to take them to their original form. The appropriate transformation of the coefficients back to the original or un-standardised variables was done using:

$$\beta_{d,pc} = \frac{\beta^{o}_{d},_{pc}}{S_{xd}},\ d = 1,2,\ldots n \qquad (16)$$

And

$$\beta_{f,pc} = \beta^{o}_{f},_{pc} - \frac{\beta^{o}_{1},_{pc\bar{X}_1}}{S_{xd}} - \frac{\beta^{o}_{2},_{pc\bar{X}_2}}{S_{xd}} - \ldots - \frac{\beta^{o}_{n},_{pc\bar{X}n}}{S_{xn}} \qquad (17)$$

Where S_{xd} is the standard deviation of the d^{th} original variable X_d and $\beta^{o}_{f},_{pc},\ \beta^{o}_{1},_{pc},\ \beta^{o}_{2},_{pc},\ \beta^{o}_{n},_{pc}$ are coefficients of the standardised variables. The next chapter presents and discusses the results for the estimated production function and the technical inefficiency model.

CHAPTER 5: PRESENTATION AND DISCUSSION OF RESULTS

5.1 INTRODUCTION

This chapter presents and discusses the results obtained from the stochastic production frontier model analysis. The chapter is organised into three main sections. Firstly, the results of the MLE of stochastic production frontier are presented. Secondly, the technical efficiency distribution amongst the two regions is discussed. Finally, the factors affecting technical efficiency are determined.

5.2 MAXIMUM LIKELIHOOD ESTIMATES (MLE) FRONTIER PARAMETERS

Table 5.1 presents the MLE for the parameters of the linear production function and related statistical tests results obtained from the stochastic frontier production function analysis. The estimated production function parameters indicated that nitrogen, phosphorus and potassium significantly affect maize yield. Labour and seed quantity was found to be insignificant.

The estimated coefficients for production parameters have shown the expected positive signs, suggesting that maize output in the study area is positively influenced by these variables. This scenario is expected as the level of maize production depends largely on the quantities of these inputs. However, only the estimated coefficients of the stochastic frontier with respect to nitrogen and potassium were highly significant at one percent, while that of labour and seed quantity were not statistically significant even at 10%. The positive and significant coefficient for nitrogen and potassium indicates maize output increases with a unit increase in N and K inputs. The seed quantity being insignificant is quite unexpected but given that farmers in the study area do not know the correct amount of seeds to be used in a unit area, the result could be acceptable. Although the estimated coefficient for labour is positive as expected, it is insignificant and also has the smallest coefficient suggesting that it is the least important input in the production of maize for the study area.

Table 5.1: MLE of Linear Stochastic Production Frontier for 130 Maize Farmers

Variable	Parameter	Coefficient	Std-error	t-ratio	Probability
Production Function					
Constant	β_0	0.6464	0.2335	2.7684	0.0065***
Nitrogen (kg)	β_1	0.0139	0.0050	2.7614	0.0066***
Phosphorus (kg)	β_2	-0.1206	0.0374	-3.2208	0.0016***
Potassium (kg)	β_3	0.1849	0.0551	3.3556	0.0010***
Labour (mandays)	β_4	0.0006	0.0004	1.4631	0.1460
Seed Quantity (kg)	β_5	0.0185	0.0146	1.2682	0.2071
Diagnostic Statistics					
Sigma-square ($\sigma^2 = \sigma_{u^2} + \sigma_{v^2}$)	σ^2	0.6791	0.0842	8.0614	0.0000***
Gamma ($\gamma = \sigma_{u^2} / \sigma^2$)	γ	0.1960	0.0083	2.3738	0.0191**
Ln (Likelihood)	-156.86				
LR test	25.296				
Mean technical efficiency	0.866				
Number of observations	130				

Significance level, *** 1%, **5%

While one would expect a positive relationship between productivity and phosphorus, an inverse relationship is found. The findings indicate that the coefficient of phosphorus is negatively associated with productivity and it is statistically significant at a one percent level. A possible explanation is that the mobility of phosphorus in the soil is relatively low since it is bound to the soil particles; as a result a very small amount of phosphorus is lost from year to year. Given that farmers use manure which contains high levels of phosphorus, it is possible that the levels of phosphorus have built up to toxic levels. Another explanation could be that the uptake of phosphorus by a maize plant requires the maximum water uptake and happens almost exclusively through the process of diffusion (FSSA, 2007). The fact that maize is planted under dry land conditions in the study area, will affect availability of phosphorus in the soil for plant use.

The estimated sigma-square (σ^2) in this study is 0.68 and is statistically different from zero at one percent. The result indicates that the one-sided error term dominates the symmetry error indicating a good fit and the correctness of the specified distributional assumptions. The estimate for the variance parameter gamma (γ) value is 0.196 and is statistically significant at five percent. The significance of the gamma parameter (γ) measures the total variation of output from the frontier which can be attributed to technical inefficiency (Yilma and Berg, 2001). The value of the estimated gamma parameter in this study suggests about 19.6% of the variation on the maize output among the sampled farmers was due to technical efficiencies while 80.4% of the variation is due to random shock. In other words, the shortfall of observed maize output from the frontier output in the study area is primarily due to random shocks (factors beyond the farmer's control).

5.2.1 HYPOTHESIS TESTING

To test the presence of technically inefficiency effects a statistical test of the inefficiency hypothesis using the generalised log likelihood-ratio (LR) tests and the gamma estimates as indicated in Chapter 4 was used. Table 5.2 gives the generalised LR tests for the presence of technical inefficiency effects.

Table 5.2 Generalised Likelihood Ratio (LR) Tests

Null Hypothesis	LR value	Test statistic	Critical value	Decision
$H_0: \gamma = \delta_0 = \delta_1 \ldots \delta_5 = 0$	-156.86	25.296	11.91	Reject H_0
$H_0: \gamma = 0$	-163.697	11.63	5.14	Reject H_0

To test the hypothesis of the technical inefficiency effects the restriction was imposed as:

$$H_0: \ \gamma = \delta_0 = \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0 \qquad (18)$$

The chi-square computed was 25.296 while the critical value, χ^2 (0.05) was 11.91. The null hypothesis of no inefficiency effects in maize production was strongly rejected. The null hypothesis was rejected in favour of the alternative hypothesis because the estimated test statistics of 25.296 were larger than the critical value of 11.91.

The null hypotheses specify that technical inefficiency effects are not stochastic and are tested by enforcing the following restriction:

$H_0 = \gamma$ =0.. (19)

The null hypothesis was also rejected because the estimated test statistic of 11.63 is greater than the critical value range 5.14 to 7.05, implying that technical inefficiency effects are random. It can therefore, be concluded that technical inefficiency effects are present in the model, making the use of the stochastic production function appropriate.

The presence of technically inefficiency effects was confirmed by a statistically test of the inefficiency hypothesis using the generalised ratio tests. The zero hypothesis of no inefficiency effects in maize production was strongly rejected, which indicates that the production frontier estimated is stochastic. The estimated sigma-square was highly statistically significant at a one percent level indicating a good fit and the correctness of the specified distributional assumptions. Although significant, the 0.196 value for the variance gamma (γ) parameter in this study is far from one, suggesting that all of the residual variations are not due to the inefficiency effects, but to random shocks. It can therefore, be concluded that the technical inefficiency effects associated with the production of maize by the sampled farmers are very low. Nevertheless, the gamma which is statistically significant suggests that the traditional (OLS) function is not an adequate presentation.

Although the results of the inefficiency model are of particular interest in this study, there were 20% technical inefficiency effects, thereby establishing that low levels of technical inefficiency exist. The implication is that the overall decline in maize productivity is due to about 80% random shocks emerging from factors beyond farmers' control. The study raises an important concern that the success of techniques to improve maize production and yield stability depend on the good management of the production factors which are most limiting to maize yield over time. Hence, the major concern towards improving the capacity of maize farmers to increase the current technical efficiency level should be based on quantifying such random shocks. The three major factors beyond farmers' control arising from this study are attributed to the effect of climate change, severe soil erosion and poor management of water resources.

Lesotho is highly vulnerable to climate change because many socio-economic activities depend on climate, especially rainfall. The impact of rainfall changes on maize cultivation critically depends on the timing with respect to the crop growth cycle. Changes in rainfall patterns affect maize cropping, planting dates, dry spell length, frequency of dry days, rainfall intensity and total rainfall during critical stages of the maize growth cycle.

Some agricultural practices in Lesotho destroy soil structure, result in soil erosion and take away top soil which has a lot of humus and essential nutrients required for plant growth. The situation suggests that it is therefore important to employ conservation agricultural practices that will improve the prevailing maize productivity under a range of soil and rainfall conditions. Water is the limiting factor for rain-fed maize production in the dry land regions. Rain-fed maize production is required when rainfall is limited or irregularly distributed, especially during the main cropping season. Better management of water and rainwater harvesting will be useful for maize production. The availability of water will be useful for the uptake of nutrient elements like phosphorus, which appeared to be negative and significantly correlated to maize output.

5.3 TECHNICAL EFFICIENCY SCORES

The aim of this section is to present and discuss the frequency distribution of the technical efficiency estimates obtained from the stochastic frontier model. Table 5.2 presents summary statistics of the technical efficiency scores at which the farm households operate.

The summary statistics results from Table 5.2 show that the respondents had high technical efficiency levels. The predicted technical efficiencies from pooled data (all) ranged from 11% to 100% with a mean of 87%. The results are interpreted as follows: the mean technical efficiency of 87% indicates that on average, the respondents are able to obtain over 80% of potential output from a given mix of production inputs. Therefore, in the short-term, there is a potential for maize producers to increase their efficiency by about 13% by utilising existing farm resources better and adopting improved technology and techniques.

Table 5.2: The summary statistics of TE scores of sampled farmers in the study area

District	Mean	Stdev.	Minimum	Maximum
Leribe(N=75)	0.95	0.07	0.70	1.00
Mafeteng(N=55)	0.76	0.24	0.11	0.99
All(N=130)	0.87	0.19	0.11	1.00

Moreover, it is evident that the two regions have a wide range of technical efficiency levels. The mean technical efficiency of 95% in Leribe implies that, in the short-term, there is a potential for maize producers to increase their production by about 5% by operating at full technical efficiency levels, utilising existing farm resources and adopting the technology and techniques. On the other hand, Mafeteng’s mean technical efficiency of 76% is low compared to Leribe, suggesting that the scope of Mafeteng maize farmers to increase the levels of efficiency using existing resources is 14%, which is quite higher than that in Leribe. The differences between the levels of TE in the two regions are further illustrated by the minimum and maximum efficiency scores. The minimum and maximum efficiency scores in Mafeteng are 11% and 99% respectively, while the technical efficiency in Leribe ranges from 70% to 100%. The cumulative probability distribution for the technical efficiency scores estimated for both the two districts and for each district is presented in Figure 5.1

Figure 5.1 further illustrates that there is a wide gap between levels of efficiency in the two regions regarding the lowest and highest level of estimated technical efficiency. The cumulative probability distribution between the two districts shows that Leribe sampled farmers belong to the most efficient category (70-100%) while the greater percentage of Mafeteng farmers belong to the lowest levels of technical efficiency (11-99%). Even though there is a wide gap between the lowest and highest levels of estimated technical efficiency, the majority of the farmers in the study area are highly efficient because about 91.5% belonged to the most efficient category (60-100%).

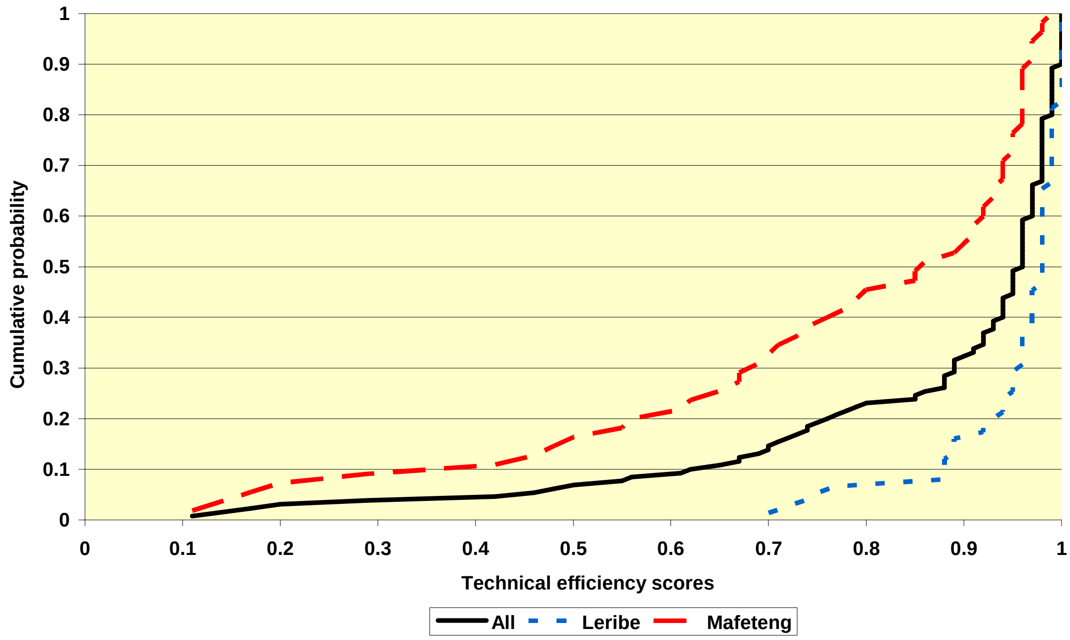

Figure 5.1: Cumulative Probability for Technical Efficiency scores

The technical efficiency scores in the study area are fairly comparable with findings from the studies conducted in other African countries. The mean technical efficiency of 87% in this study is in line with the mean technical efficiency of maize producers in Ethiopia which was found to be 76%. Omonona, Egbetokun and Akanbi (2010) find mean technical efficiency of 87% for farm resources-use and technical efficiency in Cowpea production, Nigeria. The average technical efficiency found by Tijani (2006) among rice farmers in Ijesha, Nigeria was 86%. Mochebelele and Winter-Nelson (2000) found average technical efficiencies of about 64% and 76% among non-migrant and migrant farms in Lesotho.

5.4 DETERMINANTS OF TECHNICAL EFFICIENCY

Analysis of the estimated coefficients of the inefficiency model tells us the contribution of the variables to technical efficiency in the study area. The sources of inefficiency were examined using the estimated coefficient associated with the inefficiency effects in Table 5.4.

Table 5.3: Determinants of Technical Efficiency in Maize Production Lesotho

Variables	Parameter	Coefficient	Std error	T-stat	Probability
District	δ_0	-0.3297	0.1085	-3.0393	0.0029***
Gender	δ_1	-0.0661	0.0555	-1.1918	0.2356
Age (years)	δ_2	-0.0827	0.0195	-4.2467	0.0000***
HHsize	δ_3	0.0001	0.0005	0.1129	0.9103
Primary	δ_4	0.0672	0.0552	1.2170	0.2259
Seed Quality	δ_5	-0.2117	0.0368	-5.7520	0.0000***
Animal Power	δ_6	0.1705	0.0815	2.0936	0.0383**
Tractor Power	δ_7	-0.7151	0.1885	-3.7936	0.0002***
Farmexperience	δ_8	-0.0566	0.0106	-5.3208	0.0000***
Extension Visits	δ_9	-0.0024	0.0475	-0.0515	0.9590
Farmtraining	δ_{10}	0.0213	0.0071	2.9910	0.0034***
Market Access	δ_{11}	-0.0098	0.0019	-5.1806	0.0000***
Credit Access	δ_{12}	-0.0050	0.0011	-4.6989	0.0000***
Offfarm income	δ_{13}	-0.00000	0.0000	-5.6041	0.0000***

Significance level, *** 1%, **5%

The negative sign on estimated parameters in the technical inefficiency model implies that an associated variable reduces inefficiency, meaning it has a positive effect on technical efficiency (increased) as a result it increases productivity level. A positive sign indicated that the reverse is true. The estimated coefficient signs of the variables from the inefficiency model with respect to age, seed quality, tractor power, farm-experience, market access, credit access and off-farm income, are appropriately highly significant at 1%. The result suggests that these variables reduce technical inefficiency, thus increasing technical efficiency. Although the coefficient signs for gender and extension visits have a negative sign, they are insignificant so their effect on the level of technical efficiency is not statistically explained. The rest of the variables, including household size, primary education, animal power and farm-training turned out to be positive, indicating that the associated variables led to an decrease in technical efficiency of farmers in the study area.

The coefficients of age and farm experience are estimated to be negative as expected and highly significant both at 1% level, suggesting that they negatively influence inefficiency. This result is in agreement with the expectation regarding age and farm experiences are positively correlated. The negative coefficient for age and farm experience implies that the older farmers and the most experienced farmers in maize production are more technically efficient than younger ones, meaning that as the farmers' age and farming experience increases in the study area, the technical inefficiency of the farmers' decreases. The result is supported by Omonona, Egbetokun and Akanbi (2010) who found that a unit increase in farming experience leads to a better assessment of the importance and complexities of good farming decision-making, including efficient use of input. Ogundari *et al*. (2006) also revealed that farmers' age affects the production efficiency since farmers at different ages have different levels of experience and ability to obtain and process information.

Other factors that may lead to such negative coefficients of farm experience may include that experienced farmers tend to be more efficient because of good managerial skills, which they have learnt over time. Extension Officers should be aware of the experienced farmers as a resource with potential to train the less experience farmers (Mkhabela, 2005). Moreover, Oluwatayo (2008) states that it is the general opinion that experienced farmers would be more efficient, have a better knowledge of climatic conditions and market situations and are expected to run a more efficient and profitable enterprise. Finally, the other reason contributing to age and farmers experience increasing TE is that older farmers have more resources at their disposal (Mushunje *et al.*, 2003).

The estimated coefficient of both household size and primary education is positive and not statistically different from zero, implying that an increase in household size and level of education led to an increase in technical inefficiency in this study. The results prove the prior expectation that technical efficiency could either increase or decrease with household and education level thus, the two variables will not be discussed further in this study.

Unexpectedly, the predicted dummy coefficient for farm training is positive and highly significant at a one percent level. The finding is contrary to what was expected, because farm training was expected to have a negative influence on technical inefficiency (decrease inefficiency). However, the finding just explains the average score of farm training scores between trained and untrained farmers. The research did not go into detail to find the quality and effect of the training provided; the result could mean that farm training provided was insufficient or that farm training was targeted towards people with low technical efficiency levels.

The coefficient of the dummy representing the use of hybrid seed is negative and statistically significant at one percent level, suggesting that the use of hybrid seed decreases technical inefficiency. The result is in agreement with the expectation regarding seed quality and maize output thus, seed quality is associated with the positive influence on technical efficiency in maize production. In other words, the supply of high yielding maize varieties will have a significant effect on maize production in the study area. The scenario is expected because farmers using hybrid seeds are more efficient than those using indigenous seeds. The finding is consistent with a study by Oyewo *et al*. (2009), who found that seed quality improved output of maize produced. Other studies, to mention a few who reported similar findings, include; Chirwa (2003) on maize farmers in Malawi, Kibaara (2005) on technical efficiency in Kenya’s maize production and Oyekale and Idjesa (2009) on adoption of improved maize seeds, Nigeria.

The estimated coefficient of a dummy representing tractor power is appropriately signed in this study and statistically significant at 1%, while that of animal power is positive and statistically different from zero at 5%. The implication is that sampled farmers using tractor power tend to be technically more efficient than those using animal power. Tractor power appears to be the most important factor of production. This could mean that the use of tractors play a significant role towards increasing maize output since tractors help to hasten farm operation improve the effectiveness of cultivation.

The estimated coefficients of gender and extension visits are negative and insignificant. The results suggest that they are not important in explaining technical efficiency of the sampled farmers in the study area. The policy implication is that government should monitor techniques for extension officers to be committed to their work and have a good attitude about farming, so that they can be part of farmers’ problems and have a passion to help the farmers. The variable for gender is in contrast with the prior expectation that gender decreases the level of technical inefficiency.

The estimated coefficients for market access, credit access and off-farm income are expectedly negative and highly significant at 1%. The result implies that farmers with market and credit access are less technically inefficient, thus have a positive relationship with TE. The negative sign estimated for market access suggests that improvement in market access increases agricultural productivity; firstly, by facilitating specialisation and exchange transactions in rural areas, and secondly, through intensification of input uses (Kamara, 2004). The negative coefficient of credit accessibility indicates that an increase in farm income may facilitate the purchase of more farm inputs to intensify production and improve the welfare of maize farmers in the study area. In other words, farmers who have access to credit are found to be more efficient than those who do not. This collaborates with the fact that credit facilities (financial and non-financial) improve farmers' efficiency (Ajewole and Folayan, 2008).

Similarly, the negative coefficient for off-farm income suggests that farmers tend to decrease their technical inefficiency as they earn more off-farm income. This could be attributed to the fact that off-farm income might be a proxy for agricultural credit. The finding suggests that an increase in off-farm income may facilitate the purchase of more farm inputs to intensify production and improve welfare of maize farmers in the study area, thus they become closer to the frontier. Moreover, the negative sign for farm experience and off-farm income means that farmers tend to decrease their technical inefficiencies as they become more experienced and earn more off-farm income (Khairo and Battese, 2005). To this end, better access to credit through improving rural financial markets can serve as a useful policy aimed at improving the technical efficiency of maize farmers, thus increasing agricultural productivity.

In general, the estimated coefficients in relation to age, seed quality, tractor power, farm-experience, market access, credit access and off-farm income are the significant determinants of technical efficiency in the study area, therefore, have a positive effect on productivity. Surprisingly, farm training increases the level of technical inefficiency and as a result has a negative relationship with technical efficiency in this study. The finding is in contrast with the assumption that farm training will have positive effects on the level of efficiency as it provides skills that can improve their overall efficiency. Moreover, the dummy representing districts has a negative coefficient and statistically significant at one percent level, which suggests that the Leribe district is more efficient than the Mafeteng district. The result suggests that the levels of technical efficiency differ considerably between the two regions. Leribe is more efficient because it has more resources available for use in maize production, while Mafeteng has fewer resources and as a result, tend to be less efficient.

CHAPTER 6: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

6.1.1 BACKGROUND AND MOTIVATION

Productivity of maize production systems vary from place to place and among groups of producers. Productivity of maize in Africa has lagged behind compared to other regions, with the result that maize production has failed to keep up with the demand of the growing population. Maize production in Africa is very diverse, ranging from subsistence farming to commercial farming. It is expected that small, self-sufficient farmers will not adjust their maize production as fast and to a lesser degree, than commercial farmers who have the technology and capital to do so (OECD, 2003).

In Lesotho, agriculture is the largest single sector of the economy even though it only contributes about 17% of the GDP (FAO, 2007). Lesotho's economy had been declining due to the poor performance of the agricultural sector; as a result the country is becoming more food insecure. About 90% of farmers in the country practices subsistence agriculture while the remaining 10% is engaged in commercial farming (Ministry of Agriculture and Food Security, 2007). The three main food crops grown in Lesotho are maize, wheat and sorghum and maize is the most prominent staple food, constituting an estimated 80% of the Basotho diet and it is mainly produced in the lowlands. Although maize is a staple food in Lesotho, its production is not considered adequate for food security because its productivity is very low (Lepheana, 1998). The majority of maize farmers in the country are small-scale farmers with very low productivity and average yields of less than 1 ton/ha (FAO, 2007). Maize productivity in the country is low due to poverty, which is associated with lack of resources, inappropriate development policies and strategies (Ministry of Natural Resources in Lesotho, 2006).

According to Porter (2001), productivity is one of the major determinants of the standard of living. Enhancement of agricultural productivity is an important condition in increasing household food security and alleviating rural poverty. Sufficient information would be extremely valuable in identifying major constraints on productivity growth and formulating strategies to overcome such constraints (Owour, 2000). Limited information makes it difficult for planners, policymakers and donors to make a comprehensive assessment of the factors that determine agricultural productivity (Owour, 2000). There is a general decline in productivity of the agricultural sector in developing countries contrary to agricultural productivity in the developed world, where there is productivity progress (Yilma and Berg, 2001). Since increased productivity is directly related to efficiency, it is important to raise productivity of the farmers by helping them to reduce their technical inefficiency. This could be achieved by investigating the nature of resource productivity and technical efficiency of the farmers (Shehu and Mshelia, 2007). An understanding of the determinants of productivity will help policy-makers with information to design programmes that can contribute to increasing staple food production potential (Tchale, Sauer and Wobst, 2005).

6.1.2 PROBLEM STATEMENT AND OBJECTIVES

Lesotho's economy had been declining due to the poor performance of the agricultural sector; as a result the country is becoming more food insecure. High productivity and efficiency in maize production are critical to food security since maize is the main staple food in the country. Maize production in Lesotho is very low and does not meet the annual demand for the staple food. The current annual demand for maize exceeds local production and the difference is met through imports and foreign assistance as food donations, indicating that Lesotho is a food-deficit country.

Although maize is a staple food in Lesotho, its production is not keeping pace with the increasing population thus, it is not considered suitable for food security because its productivity is very low. The country's goal of achieving food security in maize production to a larger extent will depend on the level of maize farmers' productivity. Productivity increase could be attained though its determinants which include the state of technology, the quantities and types of resource used and the efficiency with which those resources are used. Therefore, an understanding of the relationships between productivity and technical efficiency, farm-specific practices and determinants of technical efficiency would be the key to alleviating food insecurity and bringing about overall growth of the Lesotho economy. Insufficient information regarding factors affecting productivity in Lesotho hampers policy-makers and agricultural advisors to design appropriate policies to improve productivity with the aim of lowering food insecurity.

In Lesotho, little empirical work has been undertaken to study productivity and technical efficiency of small-holder farmers. Of the few studies that have analysed technical efficiency in Lesotho, Mochebelele and Winter-Nelson (2002) conducted a study on technical efficiency of small-holder farmers who sent migrant labour to South African mines. The study concluded that farmers who sent migrant labour to South African mines were more technically efficient than the farmers who did not, because they have more income available to buy inputs. The study did not consider many other household and socio-economic characteristics that may affect technical efficiency of the maize crop in particular. Therefore, this study will help by providing information that could raise productivity of the maize farmers and help them to reduce technical inefficiencies. The main objective of this study is to identify factors affecting productivity of maize farmers in Lesotho. The main objectives will be achieved by estimating technical efficiency of maize farmers in the country using SFA and by identifying factors that influence variations in technical efficiency among maize farmers using PCR. This study will provide necessary policy recommendations designed to increase agricultural productivity among maize producers.

6.1.3 LITERATURE REVIEW

Productivity is the quantity of output produced per production input in a unit of time (Coelli *et al*., 2005), while efficiency relates to how well an economy allocates scarce resources to meet the needs and wants of consumers (Driessen, 2006). Increasing productivity and efficiency within the agricultural sector, particularly among small-scale producers, require a good knowledge of the current production, as well as technical inefficiency in the sector. Following seminal work by Farrell (1957), efficiency refers to economic efficiency which can be composed into: technical efficiency and allocative (price) efficiency. Technical efficiency (TE) refers to the ability of the farmer to produce maximum output from a given level of inputs while allocative (price) efficiency refers to the ability to combine inputs and outputs in optimal proportions given input price (Linh, 1994; Haji, 2008). Any attempts towards improving productivity need to consider factors affecting production and technical inefficiency (Kabede, 2001).

The literature suggests several alternatives for measuring TE. The two popular approaches use different techniques to envelop data more or less tightly in different ways. In doing so, they make different accommodations for statistical noise and for flexibility in the structure of production technology. The differences between the two approaches boil down to two essential features. The programming approach (DEA) is non-parametric. DEA enables researchers to avoid contributing the effects of misspecification of the functional form (of both technology and inefficiency) to technical inefficiency. The econometric approach is stochastic, enabling the approach to distinguish the effects of noise from those of inefficiency, thereby providing the basis for statistical inference. It is these two different accommodations that have generated debate about the relative merits of the two approaches (Fried *et al*., 2008). The stochastic frontier production function (SFA), which is often used for technical efficiency studies, was first independently proposed by Aigner *et al*. (1977) and Meeseun and Van den Broeck (1977). The study will use SFA for its major strength over DEA is that SFA is able to separate the error component into technical inefficiency and stochastic effects. It is also able to estimate the production and technical inefficiency simultaneously.

There are various studies which used the stochastic frontier production function to examine the issues of productivity and technical efficiency among small-holder farmers in African agriculture. However, only a handful of studies focus on Sub-Saharan Africa (SSA). The few studies that have analysed efficiency in SSA agriculture include: Mochebelele and Winter-Wilson (2002), Fufa and Hassan (2003), Alene and Hassan (2003), Kibaara (2005), Chirwa (2003), Mkhabela (2005), Tijani (2006), Khairo and Battese (2005) Ogundari, Ojo and Ajibefun (2006), Tchale and Sauer (2007), Amos (2007) and Mushunje *et al*. (2005). Most of the empirical studies show that variables found to have a significant positive impact on production: fertiliser, labour, land area (farm size), seed quantity and hybrid seeds. The socio-economic variables found to influence the level of technical inefficiency are: age of principal decision-maker, level of education, farming experience, family size, extension contacts and farmer training, credit, off-farm income, cattle power and tractor power.

6.1.4 RESEARCH AREA

Lesotho is a small mountainous country found in Southern Africa and is completely surrounded by South Africa (Kingdom of Lesotho, 2005). The Kingdom of Lesotho is situated between the 28° and 31° latitudes in the south and is bordered by the 27° and 30° eastern longitudes (LMS, 2006). For administrative purposes, Lesotho is demarcated into ten districts. This study was conducted in two districts of Lesotho, namely Leribe and Mafeteng districts in the Northern and Southern part of the country respectively. Total arable land in Lesotho is 283 198 ha. Leribe is the district with the highest arable land of about 52 114 ha (18%) and Mafeteng district has less arable land 37 156 ha (13%). The two districts are representative of the major districts producing maize in the country, which is the main focus of this research. Leribe is the highest maize producing district in the Northern Lowlands of the country, while Mafeteng is the highest maize producing district in the Southern Lowlands of the country.

The two districts were selected based on three different levels of maize productivity within the district: high productivity, medium productivity and low productivity. A questionnaire survey was conducted to collect relevant information on the household, farm-specific and socio-economic characteristics of maize farmers. The sampling technique employed was the stratified sampling technique. A sample of 25 maize farmers was then randomly drawn from each of the productivity groups to represent about 33% of the maize farmers. There were 75 respondent farmers from each district, thereby making a total of 150 respondents. However, due to outliers and multicollinearity that existed within the data, a total of 130 responses were considered good for the use in the study. The data were collected in February/March 2009, through personal interviews.

Leribe maize farmers have a comparative advantage over Mafeteng maize farmers, because they have access to more agricultural land and resources. On average the total maize production, area harvested and yields are also higher in Leribe than in Mafeteng. Farming is mostly done by males in Leribe and by females in Mafeteng and the younger group of farmers has a limited interested in farming. The majority of farmers with higher levels of education has less farming experience. Moreover, Leribe maize farmers are more exposed to extension visits and farm training, market access, credit and off-farm income than Mafeteng maize farmers.

6.2 EMPIRICAL PROCEDURE

The study uses SFA to empirically explain the variation in the productivity and measure the level of technical inefficiency of sampled maize farmers in the study area. The research hypothesised 18 variables to have an influence on the level of productivity in the study area. Five independent variables that were hypothesized to influence maize yield were those pertaining to nitrogen, phosphorus, potassium, labour and seed quantity. The other 13 hypothesised variables associated with technical inefficiency include age, household size, primary education, seed quality, cattle power, tractor power, farming experience, extension visits, farm training, market access, credit access and off-farm income. Several functional forms were explored in this study including the Cobb-Douglas, quadratic, semi-log, transcendental and the linear function model. The linear production function model was used since it was found to fit the data best.

The presence of the technically inefficiency effects were confirmed by a statistically test of the inefficiency hypothesis using the generalised log likelihood-ratio (LR) tests and the gamma estimates. The LR tests were conducted to ensure that technical inefficiency effects are present and that they are not stochastic. The study used FRONTIER version 4.1 (c) (Coelli, 1996) which simultaneously fit both the production frontier and technical inefficiency models. PCR was used with the SFA to take care of the multicollinearity between the variables in the inefficiency model. Firstly, the variables included in the inefficiency model were subjected to principal component analysis (PCA) in order to reduce the dimensionality of the variables into a few uncorrelated principal components (PC's). The SFA was conducted with the five PC's to determine the variables that significantly affect technical inefficiency. Two equations for the production frontier and technical inefficiency were simultaneously incorporated into the SFA model. The results of the SFA model indicated that only two PC's were significant. The significant PC's were then used to determine individual variables contained in each PC. The estimated coefficients, standard errors, t-ratios and probabilities of the individual variables were calculated to find out the effect of estimated variables on the level of technical inefficiency.

6.3 SUMMARY OF ESTIMATED RESULTS AND CONCLUSIONS

6.3.1 TECHNICAL EFFICIENCY

The MLE production function results revealed that maize yield has a positive response to nitrogen, potassium, seed quantity and labour. However, only nitrogen and potassium variables were positive and statistically significant implying they appeared to be the major production factors in raising maize output and maize farmers' efficiency in the study area. The results further show the negative and significant relationship between phosphorus and maize yield in the study suggesting that the use of more phosphorus decreases maize yield, which is an indication of over-utilisation of phosphorus in maize production. Although the estimated parameters of seed quantity and labour are positive as hypothesised, they are insignificant.

The estimated γ value was significant at 19.6% indicates that 19.6% of the deviations from the frontier was caused by inefficiency effects. However, the gamma value in this study is very far from one suggesting that productivity of the maize farmers in the study area is largely influenced by about 80.4% random shock rather than technical inefficiency. Other studies reveal that there was a high total variation in the technical inefficiency. Shehu and Mshelia (2007) found a gamma value was 0.89 and Ekunwe and Emokaro's (2009) were 0.86. It is therefore concluded from the gamma value results in this study that the low maize productivity levels in Lesotho is largely due to random shocks rather than farmers being technically inefficient. The estimated sigma-square was also highly statistically significant at one percent level indicating a good fit and the correctness of the specified distributional assumptions. On average, the TE scores for pooled data was about 87% which suggests that, in the short-term, there exists room for raising the present productivity and technical efficiency level by 13% through adopting the technology and techniques used by the best practiced maize farms.

6.3.2 DETERMINANTS OF TECHNICAL INEFFICIENCY

The negative sign on estimated parameters in the technical inefficiency model implies that an associated variable reduces inefficiency, meaning it has a positive effect on technical efficiency (increased) and as a result it increases productivity. A positive sign indicated that the reverse is true. Some significant determinants of technical efficiency are age, seed quality, tractor power, farm-experience, market access, credit access and off-farm income indicating that these factors are quite fundamental in influencing agricultural productivity and increasing the technical efficiency of maize production in the study area. Gender and extension visits were not statistically significant in decreasing the level of technical inefficiency.

The results revealed that it takes technology such as the use of hybrid seeds and tractor power for maize farming activities to improve the technical efficiency of maize farmers in the study area. Greater emphasis should thus be placed on knowledge of the hybrid maize seeds combined with the efficient use of fertiliser and better agronomic practices which would further raise the current level of maize productivity and technical efficiency.

Other determinants, including animal power and farm-training turned out to be positive and statistically significant, indicating that they increase technical inefficiency of the farmers in the study area. The inverse relationship of farm training on technical inefficiency could mean that training was offered to the farmers' who really need training and not because the training was insufficient. Therefore, the farmers should be encouraged to attend regular training in order to gain the relevant experience in running a maize farm and further increase their technical efficiency.

The negative and significant coefficients with respect to market access, credit access and off-farm income imply that these are the important variables in raising the productivity of maize farmers. Improvement in provision of agricultural credit along with off-farm income will increase maize inputs supply systems, thus improve technical efficiency of maize farmers.

Off-farm income is necessary in maize farming because it enables the farmers to buy more farm inputs which result in increased crop yields. Besides, the availability of inputs and technologies is to no avail unless farmers have the means to obtain and use them. The farmers' access to credit enhances their timely acquisition of production inputs that would enhance productivity through efficiency. The determinants of technical inefficiency results from this study are similar to the findings of other studies, Kibaara (2005), Tijani (2006) and Mkhabela (2003) to mention a few.

The dummy representing the district was negative and significant at 1% implying that Leribe maize farmers were often found to make use of the inputs more effectively. The results further show that Leribe maize farmers, with a mean technical efficiency of 95%, tend to be more technically efficient than Mafeteng maize farmers with a mean technical efficiency of 76%. Even though it is evident that there is a wide gap between the lowest and highest level of estimated technical efficiency in the two districts, the majority of the farmers in the study area are highly efficient because about 91.5% belonged to the most efficient category (60-100%). The difference in the levels of technical efficiency across maize farmers in the two regions indicates that the Leribe region attaining higher levels of TE, should be utilised as a source of knowledge that could be transferred more easily to the Mafeteng region.

6.4 CONCLUSION

The findings of this study acknowledge the fact that nitrogen and potassium are critical inputs in increasing production, while there was a negative relationship between phosphorus and maize output in the study area. Although labour and seed quantity had positive coefficients, they were not statistically significant in explaining the efficiency of maize production in the study area. Furthermore, about 19.6% of total deviation in maize output from the frontier was attributed to technical inefficiency and 80.4% to the stochastic nature of production in the regions.

The conclusion is that failure to recognise the effect of production uncertainty must stem allocation efforts to increase farmers maize production through increases in technical efficiency alone. Government must allocate resources towards decreasing the impact of production risk to increase maize production significantly. The three major factors beyond farmers' control arising from this study are attributed to the effect of climate change, severe soil erosion and poor management of water resources.

The average technical efficiency of 87% indicates that the sample maize farmers are not fully technically efficient; therefore, there is a 13% allowance of efficiency improvement by addressing some important policy variables that will influence farmers' levels of technical efficiency and productivity in the study area. The difference in the levels of technical efficiency across maize farmers in the two regions indicates that the Leribe region attaining higher levels of TE should be utilised as a source of knowledge that could be transferred more easily to the Mafeteng region which is the less efficient one. Age, seed quality, tractor power, farm-experience, market access, credit access and off-farm income were found to be positively related to technical efficiency, while household size, primary education, animal power and farm training were found to be negatively associated with the technical efficiency level. Therefore, using hybrid seeds and tractor power, improving market access and credit access of the sampled maize farmers in the study area could help in increasing the present levels of productivity and technical efficiency of maize farmers.

6.5 RECOMMENDATIONS, POLICY IMPLICATIONS AND WAY FORWARD

Policy implications drawn from the result include a review of agriculture policy with regard to interventions towards improved maize market infrastructure throughout Lesotho. Consequently farmers should be exposed to formal market access as an incentive to produce more and raise the current level of efficiency. Furthermore, farm training should be considered by policy-makers or those saddled with the responsibility of designing programmes towards maize farming improvement in the studied area, if positive results are desired. Farm training empowers farmers with new innovations and discoveries.

The results further reveal that the production of maize is influenced by factors beyond farmers' control. Despite the maize being so important, its production is dependent on climatic conditions. The impacts of climate change on agriculture may add significantly to the development challenges of ensuring food security and reducing poverty. The policy implication arising from this situation is that there is a need for development or use of stress tolerant maize varieties that will adapt better to the changes in climate. Moreover, conservation agriculture (CA) such as zero tillage, mulching and ridge till, proper crop rotation, cover crops, reduced or minimum tillage, should be used in the country since they offer the potential to increase maize production compared to conventional production systems. CA has been proposed to improve soil and water conservation, reduce soil erosion and increase maize productivity. Practicing conservation agriculture may at first seem daunting however, once farmers take up the challenge they will find the benefits are very rewarding.

For further research, studies which try to determine how random shocks affect maize production in the study area will minimise the effects of such shocks. It is therefore recommended that a study that assesses the effect of climate change and conservation agriculture practices on hybrid maize production in the study area should be done. It may add significantly to the development challenges of ensuring food security and improving productivity of maize in the country.

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APPENDIX A RELATED STUDIES ON PRODUCTIVITY AND STOCHASTIC FRONTIER APPROACH

There is a wide body of empirical research on the productivity and technical efficiency of farmers, both in the developed and developing countries (Kabede, 2001). Several studies have been done to measure productivity and levels of efficiency among small-scale farmers in Africa.

Alene and Hassan (2005) derived the productive efficiencies of traditional and hybrid maize producers in eastern Ethiopia using an efficiency decomposition technique that was extended to account for scale effects. The results revealed high efficiency among both traditional and hybrid maize producers. High inefficiency among hybrid maize producers was consistent with the argument that food production gains from improved agricultural technologies have not been realised in poor countries like Ethiopia, due mainly to poor support services, including extension, education, credit and input supply.

Mahabile and Panin (2005) attempted to identify factors responsible for differences in the productivity of cattle managed by private and communal livestock farmers in the region of Botswana. Results of regression analysis suggest that secure land tenure was a fundamental determinant of agricultural credit use. Respondents with private farms and larger herds use more agricultural credit than those who rely on open access communal grazing to raise cattle. Secure tenure was also a fundamental determinant of investment in fixed improvements. Respondents with private farms and higher levels of liquidity from long-term credit and off-farm wage remittances tend to invest more in fixed improvements. Liquidity from short-term credit and wage remittances were most important direct determinants of expenditure on operating inputs. Herd productivity, in turn, increases with greater investment in operating inputs and fixed improvements, and is therefore positively (but indirectly) influenced by secure land tenure.

Asogwa, Umeh and Ater (2006) in a technical efficiency analysis of Nigerian cassava farmers, multiple regression result showed that there was a significant relationship between technical efficiency and cassava output, annual farm income, annual gross margin, processing unit, farming experience, education and extension contact.

Hence, policy measures that would guarantee an increase in farm income and gross margin of cassava as well as to provide cost effective improved cassava processing technology, increase the access of cassava farmers to quality education and extension services and will lead to an increase in technical efficiency in cassava production in Nigeria.

Lambarraa, Serra and Gil Roig (2006) evaluated technical efficiencies in the Spanish olive sector using the stochastic frontier production model. Technical efficiency effects were assumed to be a function of firm-specific variables. A primal approach was used to decompose Total Factor Productivity (TFP) growth. Results indicated that farm location, age of the manager, tenure regimes of land and whether the farm had adopted organic farming techniques, affect efficiency levels. The results also show an average productivity of about 1.0% per year during the period of study, with technical efficiency change, allocative efficiencies and scale effects being the most relevant sources of TFP growth.

Ogundari, Ojo and Ajibefun (2006), in an empirical study of economies of scale and cost efficiency of small-scale maize production in Ondo State of Nigeria using the stochastic frontier cost function, say that the past studies were exclusively focused on technical efficiency of farmers in Nigeria. The results showed that there was a relative presence of economies of scale among the farmers meaning that an average farm in the sampled area produced at a minimum cost considering the size of the farm, which was an indication that they were operating in stage II of production (stage of efficient utilisation of resource). The results further collaborated by the mean cost efficiency of 0.16 obtained from the data analysis showed that an average farm in the sample area was about 16% above the frontier cost, indicating that they were relatively efficient in allocating their scarce resources. The result of the analysis indicated that the presence of cost inefficiency effects in the maize production was depicted by the significant estimated gamma coefficient of about 0.81.

Kurkalova and Jensen (1998) deployed grain production and input use data in physical units together with overall farm operations information that were used to estimate a stochastic frontier model in which inefficiency effects are modelled as a function of farm-specific variables and time. The results illustrate that the process of transformation of Ukrainian agriculture started in 1990 was costly in terms of technical efficiency; efficiency declined over the 1989-1992 period. The relative abundance of labour and distance to the nearest city were both found to have a positive effect on technical efficiency. The estimation suggested that the investment of farm labour resources into infrastructure improves technical efficiency in grain production with an increase of the share of non-agricultural workers. The results highlight the importance of analysis of production at the farm level because production efficiency varies across farms and this should be taken into account for both research and policy considerations.

Wubeneh and Ehui (2006) used stochastic production frontier technique to measure the efficiency of the small-holder dairy producers in the central Ethiopian highlands. The results confirmed the existence of systematic inefficiency in milk production. The average efficiency level of the farmers is only 79% implying that milk output can be increased on average by 21% with existing technology, by training of dairy farmers in increased production techniques. The efficiency in production of individual farmers can be improved by training farmers in proper feeding, calving, milking, cleaning of cows, storing milk and marketing, as well as other management skills.

A study by Ike and Inoni (2006) on yam production in South Eastern Nigeria identified the determinants of yam production in Enugu State region, South-eastern Nigeria, using a stochastic frontier production function, which incorporates a model of inefficiency effects. The results indicate that labour and material inputs are the major factors that influence changes in yam output. The effects of selected farmer-specific socio-economic characteristics on observed inefficiencies among the farmers were also examined. Farmer-specific variables, such as education, farming experience and access to credit, were the significant factors implicated for the observed variation inefficiency among yam producers. The stochastic frontier production function was estimated for yam production in Enugu State, Nigeria with land, labour and material inputs as explanatory variables. Labour and material inputs were however, found to be the significant factors that influence yam output.

Amos (2007) estimated the productivity and technical efficiency of cocoa production in Ondo State, Nigeria using the stochastic frontier production function analysis. The result of the analysis showed that farmers were experiencing increasing returns to scale in the use of the farm resources. The efficiency level ranged between 0.11 and 0.91 with a means of 0.72. There existed some inefficiency among the sampled farmers. The major contributing factors to efficiency were age of farmers, level of education and family size. The study observed that there was an opportunity for an increase in farmers' efficiency and concluded that policies that would directly affect these identified variables should be pursued vigorously.

Bellouni and Matoussi (2006) used the stochastic frontier approach to estimate technical efficiency obtained from the two samples of farmers of private and water user associations in the Nefzaoua Oases region (Tunisia). Technical inefficiency effects were modelled as a function of farm-specific socioeconomic factors. Results suggested that both systems are technically inefficient. On average, the private system is found to be slightly more efficient than the associative one. Output elasticities of all inputs were found to be positive and significant except for the farmyard manure. Water salinity has a considerable negative impact on date productivity. For the technical inefficiency model, none of the socioeconomic variables seemed to matter.

Kibaara (2005) used the stochastic frontier approach to estimate technical efficiency in Kenya's maize production. The results indicated that the mean technical efficiency of Kenya's maize production was 29%; however, the range was from 81 to 98%. There was a distinct intra and inter-regional variability in technical efficiency in the maize producing regions. In addition, the technical efficiency varies by cropping system; the mono-cropped maize fields have higher technical efficiency than the intercropped maize fields. The number of years of school in formal education the farmer had, the health of household head, gender of household head, use or non-use of tractors and off-farm income impact on technical efficiency. The use of hybrid maize seed increases technical efficiency by 36% (6.14 bags). Mechanisation was also important. Households that used tractors for land preparation increased technical efficiency by 26% (4.41 bags). An additional year of school increased technical efficiency by 0.84% (0>14 bags). However, technical efficiency increased at a decreasing rate with an increase in the number of years of school. The model also suggested that a maize producer needs only an elementary education (5 years of school) to be technically efficient.

Bailey (1989) investigated the economic efficiency of Ecuadorian dairy farms by estimating technical, allocative, and scale efficiencies using stochastic frontier methodology. A stochastic production frontier was estimated and measures of efficiency for individual farms were calculated. All three inputs, land, labour and capital had a positive and significant impact on output. However, capital had the largest coefficient (elasticity). That indicates that the largest impacts on output on average would be experienced if additional capital was invested in the farms. Labour had the smallest output elasticity. That result was expected since a small amount of capital was used on many of the farms. Empirical results showed that technical inefficiency exists for all of these farms, ranging from 11.8% to 12.8%. Large and medium-sized farms were found to be allocatively more efficient than the small farms as a group. Estimates of scale inefficiency showed that most of these farms were producing output at a level below the optimum.

Ajibefun, Daramala and Falusi (2001) used the stochastic frontier production function to estimate technical efficiency of small-scale food crop farmers in Ondo State, Nigeria. The results of their analysis indicated that rural farmers with a mean technical efficiency of 0.69 are more technically efficient than the urban farmers who have a mean technical efficiency of 0.58. Land, which appeared to be a major production constraint among the urban farmers, was highly significant in raising farm output. Farmers' age, level of education, experience and farm size under crop production were found to influence the technical efficiency of the farmers. While age had a negative influence on the level of technical efficiency of the farmers, education, farming experience and farm size under production were found to enhance the level of technical efficiency of the farmers. The results of tests of hypotheses indicated that the estimated translog frontier model was an adequate representation of the data on the sample farmers. The tests of hypotheses also showed that farmer specific variables (age, level of education, experience) as well as farm size under crop production were all important variables that influence the efficiency of the farmers. The results also showed that both rural and urban farmers considered in that study had increasing returns-to-scale. The implications were that education was also an important policy variable that could be targeted for increasing the current level of technical efficiency of the farmers. While age of farmers and experience appeared to influence the technical efficiency of the farmers, the result has to be cautiously interpreted, as there could be a correlation between the two variables. Older farmers would generally have more farming experience.

Margono and Sharma (2004) used the stochastic frontier methodology to investigate the technical efficiency and total factor productivity (TFP) growth in Indonesian provincial economies. In addition to the estimation of provincial technical efficiency, factors that contribute to technical inefficiency were also examined and the TFP growth was decomposed into technological progress, the scale component and the change in technical efficiency. The results revealed that average technical efficiency was only around 50%. Their results revealed that the mean years of schooling and sectoral differences affected technical efficiency. The TFP grew, on average, in the range from 1.65% to 5.43% with an average growth of 3.59%. In twenty out of twenty-six provinces the TFP growth was driven by efficiency changes while in four provinces the TFP growth was driven by technological progress. They further noted that the Asian crisis affected the TFP growth and the western provinces suffered from the crisis more than the eastern provinces.

Johansson (2005) used both data envelopment analysis (DEA) and the stochastic frontier approach (SFA) to estimate technical, allocative and economic input efficiency scores for an unbalanced panel of Swedish dairy farms. By comparing the results, it was concluded that when the entire dairy farm was studied the DEA was more appropriate to use since it did not require any particular parametric form to be chosen. The average DEA technical, allocative and economic efficiency indices were eventually found to be 0.77, 0.57, and 0.43 respectively. The influence of size on the efficiency scores was analysed and significant evidence indicating a positive relationship between size and efficiency was found. It was finally concluded that the main challenge facing the Swedish dairy farms was to enhance their cost minimising skills.

Sharma *et al*. (1999) used the parametric stochastic efficiency decomposition technique and nonparametric data envelopment analysis (DEA) to derive technical, allocative and economic efficiency measures from a sample of swine producers in Hawaii. Efficiency measures obtained from the two frontier approaches were compared. Firm-specific factors affecting productive efficiencies were also analysed. Finally, swine producers' potential for reducing cost through improved efficiency was also examined. The mean technical, allocative and economic efficiency indices under the specification of variable returns to scale (VRS), were respectively 75.9%, 75.8% and 57.1% for the parametric approach and 75.9%, 80.3% and 60.3% for DEA; while for the constant returns to scale (CRS) they were respectively 74.5%, 73.9% and 54.7% for parametric approach and 64.3%, 71.4% and 45.7% for DEA. Thus, the results from both approaches reveal considerable inefficiencies in swine production in Hawaii. The removal of potential outliers increases the technical efficiencies in the parametric approach and allocative efficiencies in DEA, but,overall, contrary to popular belief, the results obtained from DEA are found to be more robust than those from the parametric approach. The analysis of the role of various firm-specific factors on productive efficiency shows that farm size had strong positive effects on efficiency levels. Similarly, farms producing market hogs are more efficient than those producing feeder pigs. Based on these results, by operating at the efficient frontier, the sample swine producers would be able to reduce their production costs between 38% and 46% depending upon the method and returns to scale considered.

Alene (2003) assessed the impact of improved production technologies and Ethiopia's New Extension program on the production efficiency of smallholder farmers in eastern Ethiopia. The study used the extended stochastic efficiency technique to analyse the technical, allocative and economic efficiencies of farmers in the dry and wet highlands agro-climatic zones. Although the results indicated a positive impact of improved maize technology on maize production efficiency, it was found that there were considerable inefficiencies of maize production under both traditional and improved technology. Production inefficiency in traditional maize production was more attributed to technical inefficiency, suggesting that improvements in technical efficiency provide a greater opportunity to increase maize production. For maize production under improved technology, the results showed that production inefficiency was equally attributed to both technical and allocative inefficiencies. The results suggested that both technical and allocative efficiencies must be raised to increase maize production under improved technology. The results thus indicated that the New Extension Program had no positive impact on production efficiency of farmers in the dry land zone. Education, credit, previous participation in previous extension programs, greater security of tenure, the share of the leading cropping system in each zone, and off-farm income, were generally found to have a positive impact on food production efficiency.

Khairo and Battese (2005) estimated the stochastic frontier production function for maize farmers within and outside the New Extension Program in order to study their technical inefficiencies and identify some of the factors contributing to variations in the productivity of maize farmers in the Harari Region of Ethiopia. It was found that there were technical change and changes in technical inefficiencies of maize farmers between 1994/95 and 1997/98. The average technical efficiencies of maize farmers were 73% and factors such as agricultural extension, formal education and off-farm incomes were important factors affecting technical inefficiencies of maize farmers within the program. They conclude that policies enhancing the managerial and decision-making capacity of maize growers contributed towards increasing their technical efficiencies and the objective of achieving increased maize production.

Binam, Tonye and Wandi (2004) estimated technical efficiency among small-holder farmers in the slush and urban agricultural zone of Cameroon to identify sources of inefficiency among farmers. Results showed the mean level of technical efficiency to be 77%, 73% and 75% respectively, for groundnut monocrop, maize monocrop and maize-groundnut farming systems. The efficiency differences were explained significantly by credit, soil fertility, social capital, distance of the plot from the access road and extension services.

In Lesotho, little empirical work has been undertaken to study productivity and technical efficiency of smallholder farmers. Of the few studies that have analysed technical efficiency in Lesotho, Mochebelele and Winter-Nelson (2002) conducted a study on technical efficiency of small-holder farmers who sent migrant labour to South African mines. The study concluded that farmers who sent migrant labour to South African mines were more technically efficient than the farmers which did not because they have more income to buy the inputs. The study did not consider many other households and socioeconomic characteristics that may affect technical efficiency of maize crop in particular. Therefore, this study will help by providing information that could raise productivity of the maize farmers and help them to reduce technical inefficiencies. The results of this study are expected to identify factors that determine productivity and assess the extent of inefficiency levels. This will give appropriate policy recommendations designed to increase agricultural productivity of small-scale maize farmers in Lesotho.

APPENDIX B QUESTIONNAIRE

All information provided will be treated as STRICTLY CONFIDENTIAL	
PRODUCTIVITY OF SMALL-SCALE MAIZE FARMERS IN LESOTHO	
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GENERAL INFORMATION

Questionnaire nr.		**District**		**Productivity level**	
INSTRUCTION: Ask to speak to the principal decision maker, i.e. the person who has knowledge of day-to-day activities in maize production.					

A. DEMOGRAPHIC INFORMATION OF THE HOUSEHOLD

A.1 Gender of the principal decision maker	
Male	1
Female	2

A.2 Age of the principal decision maker	Years

A.3 Household size at the time of interview (include absentees)	
1-3	1
4-6	2
7-9	3
10-12	4
13-15	5
> 15	6

A.4 Household composition at the time of interview (include absentees)	
Males	**Number**
Male 18-35	
Male 36-65	
Male >65	
Females	
Female 18-35	
Female 36-65	
Female 36-65	

Female >65	
Children	
Younger Children (<10)	
Older Children (10-17)	
Total number of people	

B. HUMAN CAPITAL ENDOWMENTS

EDUCATION

B.1 Do you have any formal education	
Yes	
No	

B.2 If yes to B.1, what is your highest level of education completed?	
Primary	1
Secondary	2
High school	3
College	4
University	5
Other (specify)	7

KNOWLEDGE AND FARMING EXPERIENCE

B.3 Please indicate whether you have the following language abilities						
	Speak		**Read**		**Write**	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**
English	1	0	1	0	1	0
Sesotho	1	0	1	0	1	0

B.4 Please indicate your arithmetic abilities	
None	1
Little	2
Average	3
Good	4

B.5 How many years have you been farming?	Years

B.6 How many years have you been engaged in maize production	Years

C. LAND OWNERSHIP AND FARM SIZE

C.1 How much land in (acres) do you have access to for agricultural purposes?	Acres

C.2 For owned land how was land acquired?	
a) Inherited	1
b) Bought	2
c) Allocated by village authorities	3
e) Other (specify)	4

C.3 Please indicate the total amount of land (in acres) for the following land ownership

Land access categories	Farm size (Acres)
Private owner	
Rental	
Sharecropping	
Block farming	

C.4 How many acres did you use for maize production in 2007/08 growing season?	Acres

D. RESOURCES

INPUTS

D.1 Did you get any subsidies for maize cultivation in 2007/08?	
Yes	1
No	2

D.2 If yes to D.9, in what form did you get subsidies in 2007/08 growing season?	
Cash / Chegue	1
Inputs (seeds, fertilisers, herbicides and pesticides)	2
Land preparation	3
Harvesting	4
Other (specify)	5

D.3 If no to D.9, what was the reason?	
Do not know about subsidies	1
Do not belong to the ruling party	3
Subsidies are given to people who are not working (who cannot afford to buy inputs)	4
Other(specify)	5

D.4 Which type of maize seeds did you use in 2007/08 growing season?	
Indigenous seeds	1
Hybrids seeds	2
Both	3

D.5 If hybrid seeds, please indicate the type used	
PHB(specify)	1
PNR(specify)	2
SNK(specify)	3
Other(specify)	4

D.6 Did you make use of any of the following inputs on your farm in 2007/08 growing season?		
	Yes	**No**
1. Fertiliser	1	2
2. Herbicides	1	2
3. Pesticides	1	2

D.7 If yes to D.6, how did you acquire them?(include hybrid seeds)				
1. Hybrid seeds	1	2	3	4
2. Fertiliser	1	2	3	4

3. Herbicides	1	2	3	4
4. Pesticides	1	2	3	4

D.8 If no to D.6, what is the reason?		
They are expensive		1
They are not available in local markets		2
Cannot get credit to buy them		3
No information on how to acquire them		4
Do not know about them		5
Other reasons(specify)		6

D.9 Which type of fertilisers did you use on your farm in 2007/08 growing season?			
Type of fertiliser	**Quantity (kg/Acre)**	**Cost (R/kg)**	
Organic			
1. Compost			1
2. Animal manure			2
3. Effective Micro-organism (EM)			3
Inorganic			
4. NPK (ratio)			4
5. LAN			5

D.10 At what stage did you find it necessary to apply fertiliser in 2007/08 growing season?		
Type of fertiliser	**Before sowing**	**After germination**
Organic		
1. Compost	1	2
2. Animal manure	1	2
3. EM	1	2
Inorganic		
4. NPK	1	2
5. LAN	1	2

D.11 Which method of fertiliser application did you use in 2007/08 growing season?				
Type of fertiliser	**Broadcasting**	**Side dressing**	**Mixed with seeds**	**Other (specify)**
Organic				
1. Compost	1	2	3	4
2. Animal manure	1	2	3	4
3. EM	1	2	3	4
Inorganic				
4. NPK(specify)	1	2	3	4
5. LAN	1	2	3	4

LABOUR

D.12 How many family members and relatives worked in maize production unpaid in 2007/08 growing season?	People

D.13 Did you employ permanent labourers on your farm in 2007/08 growing

season?	
Yes	1
No	2

D.14 If yes to D.13, how many permanent labourers /year?	Labourers

D.15 Did you employ casual labourers on your farm in 2007/08 growing season?	
Yes	1
No	2

D.16 If yes to D.15, how many casual labourers worked in your maize farm in the last growing season (2007/08)?	
Weeding	Labourers
Harvesting	Labourers

D.17 How many days/year casual labourers worked on your farm in 2007/08 growing season?	
Weeding	Days
Harvesting	Days

D.18 Please indicate the source of power used for the following activities in 2007/08?				
Activity	**Manual**	**Cattle**	**Tractor**	**Other (specify)**
1. Ploughing	1	2	3	4
2. Harrowing	1	2	3	4
3. Sowing	1	2	3	4
4. Applying Fertiliser	1	2	3	4
5. Applying Herbicides	1	2	3	4
6. Applying Pesticides	1	2	3	4

D.19 On what basis did you have access to these sources of power?			
	Own	**Rent**	**Other (specify)**
1. Handsprayer	1	2	3
2. Cattle	1	2	3
3. Tractor	1	2	3

D.20 Please indicate number of the cattle used per acre in 2007/08 growing season	Cattle

D.21 Please specify capacity of the tractor used in 2007/08 growing season	
Small power engine (60kw-75kw)	1
Medium power engine (75kw-85kw)	2
Big power engine >85	3

E. INFORMATION AND TRAINING
The extension officer must leave you alone with the farmer at this stage (arrange this with him/her before the visit)

EXTENSION CONTACTS AND TRAINING

E.1 Who do you consult when you need advice on maize production	
Government extension officer	1
NGO's extension officer	2
Research officer	3
Fellow farmers	4
Other(specify)	6

E.2 Are the following extension officers available when you need them?		
	Yes	**No**
Government extension officers	1	2
NGO extension officers	1	2
Research officers	1	2

E.3 How many times were you visited by one of the extension officer in the last growing season season (2007/08)?			
	Government extension officers	**NGO extension officers**	**Research officers**
1. Daily	1	1	1
2. Weekly	2	2	2
3. Monthly	3	3	3
4. Quarterly	4	4	4
5. Once in a while	5	5	5
6. Never	6	6	6
7. Other (specify)	7	7	7

E.4 Do you think the extension officer provided you with enough knowledge needed for maize production?	
Yes	1
No	2

E.5 Have you received any agricultural training by extension officer?	
Yes	1
No	2

F. MAIZE PRODUCTION

F.1 Please indicate type of maize farming system you practice?	
Subsistence	1
Commercial	2
Both	3

F.2 When did you start planting maize in 2007/08 growing season?	
August	1
September	2
October	3
November	4
December	5

F.3 Was your maize irrigated?	
Yes	1
No	2

F.4 How many bags (10 kg) of seeds did you use per acre?	kg/acre

F.5 What was the price of seeds used in 2007/08?	R/kg

F.6 What was the distance between maize rows?	cm

F.7 What was the distance between maize plants in (cm)?	cm

F.8 What was the seed depth in (cm)?	cm

F.9 What type of soil was used for maize production in 2007/08?	
Sand soil	1
Clay soil	2
Loam soil	3
Don't know	4
Other (specify)	5

F.10 How often do you do soil analysis?	
Every year	1
Every three years	2
Since Block farming	3
Once in a while	4
Never	5
Other (specify)	6

WEEDS, PESTS AND DISEASE CONTROL

F.11 Please indicate type of weeds that commonly affect maize in your area?	

F.12 Please indicate type of pests that commonly affect maize in your area?	

F.13 Please indicate type of diseases that commonly affect maize in your area?	

F.14 Which method of weeds, pests and disease control did you use in 2007/08 growing season?

Activity	**Method of Control**				
	Hand	**Cultural**	**Mechanical**	**Chemical**	**Other (specify)**
Weeds	1	2	3	4	5
Pests	1	2	3	4	5
Diseases	1	2	3	4	5

F.15 What was the cost of each of the following inputs in 2007/08 growing season?		
Input	**Cost**	
Herbicides (specify)		1
Pesticides (specify)		2
Disease chemical (specify)		3

F.16 How much of the following did you apply in 2007/08 growing season?		
Input	**L/acre**	
Herbicides		1
Pesticides		2
Disease chemical		3

YIELD AND STORAGE OF MAIZE

F.17 In what form did you use your maize in 2007/08 growing season?	
Green/fresh maize	1
Dry maize	2
Both	3

F.18 When did you harvest your green maize in 2007/08 growing season?	
January	1
February	2
March	3
April	4

F.19 How much green/fresh maize did you consume in 2007/08 growing season?	cobs

F.20 When did you harvest dry maize in the last growing season (2007/08)?	
May	1
June	2
July	3
August	4

F.21 Please indicate method used to harvest dry maize in 2007/08 growing season	
Handpicking	1
Mechanical	2

F.22 On what basis do you have access to the machinery used for harvesting	
Own	1
Rent	2
Other (specify)	3

F.23 How many bags (70 kg) of dry maize were harvested in 2007/2008 growing season?	kg/acre

F.24 Please indicate the amount of maize used for the following		
Produce	**Amount (kg)**	
Consumption		1
Sold		2
Stored		3

Animal feeds		4

G. MARKETING MANAGEMENT

G.1 Do you sometimes produce surplus?	
Yes	1
No	2

G2. Please indicate type of market you have access to for your maize produce	
Formal Market	1
Informal Market	2
Both Formal and Informal Market	3
None	4

G.3 If formal, please indicate your market place	
Lesotho Milling Companies	1
Lesotho Highlands Development Authority (LHDA)	2
Ficksburg Cooperative	3
School /Shops	4
Other (Specify)	5

G.4 How did you sell your maize produce in 2007/08?	
Cash	1
Credit	2
Exchange with Animals	3
Other (specify)	4

G.5 Please indicate the quantity sold and selling price of maize in 2007/08			
	Quantity	**Selling price**	
Nearby villages (70kg)			1
Lesotho Milling Companies (ton)			2
Lesotho Highlands Development Authority (ton)			3
Ficksburg Cooperative (ton)			4
Schools/Shops			5
Other (Specify)			6

G.6 Is there any produce that you could not sell in 2007/08 growing season?	
Yes	1
No	2

G.7 If yes to G5, what was the reason?	
Not profitable enough	1
Not enough buyers	2
Market too far away	3
Did not know where to sell	4
Could not meet required maize quality	5
LHDA market already closed	6
LMC prices were too low (determined by SUFFEX)	7
Other	8

H. CREDIT ACCESS AND OFF-FARM INCOME

ACCESS TO CREDIT

H.1 Did you make use of external capital for maize production in 2007/08 growing season?	
Yes	1
No	2

H.2 If yes to H.1, name the source of external capital	
Formal Sources (commercial banks, ministry of agriculture, etc.)	1
Informal Sources (credit unions, farmer's associations, stokvels, etc.)	2

H.3 Do you need credit for your maize enterprise?	
Yes	1
No	2

H.4 Is credit available to you as small-scale farmers?	
Yes	1
No	2

H.5 If no to H.4, what is the reason?	
Do not need extra money to buy inputs	1
The interest rate is too high	2
Bank doesn't lend money to individual farmer due to insufficient security(e.g. land)	3
Poor repayment ability of the farm	4
Do not know how to organizing credit	5
Other (specify)	6

OFF-FARM INCOME

H.6 Do you have any occupation other than farming?	
Yes	1
No	2

H.7 If yes to H.6, please state that other occupation

H.8 Please state income you receive from this	R

H.9 Does anyone in the household have any other form of income which is also used for farming operations?	
Yes	1
No	2

H.10 If yes to H.9, please state income received	R