ANALYSING THE EFFECTS OF ACCESS TO TRACTOR SERVICE ON TECHNICAL EFFICIENCY OF SMALL-SCALE MAIZE FARMERS IN THE MPUMALANGA PROVINCE: A CASE STUDY OF THE MASIBUYELE EMASIMINI PROGRAMME

BY

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A MINI DISSERTATION SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE MASTER OF SCIENCE IN AGRICULTURE (AGRICULTURAL ECONOMICS)

DEPARTMENT OF AGRICULTURAL ECONOMICS AND ANIMAL PRODUCTION

SCHOOL OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES

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DECLARATION

I, Sechube Mmakhashu Patience, declare that the dissertation hereby submitted to the University of Limpopo for the degree Master of Science in Agriculture (Agricultural Economics). The content of the dissertation is my original work and has not previously been submitted by me for a degree at this or any other university. The content of the dissertation is my original work and all materials contained therein have been duly acknowledged.

Signed by: **…………………..** Date: **………………...**

Student Number: **……………**

DEDICATION

This work is dedicated to my late grandfather, Nelson Mametja and my grandmother Essie Mametja. It is also dedicated to my parents, Mmathari and David Mohlala, as well as my entire family members.

ACKNOWLEDGEMENT

More than anything, I want to thank God for his grace, guidance, protection and comfort throughout and making it possible for me to enrol and complete the Master’s program. The Lord is my Shepherd.

There are also not enough words to describe how thankful I am to my parents, Mmathari and David Mohlala. I thank them for their endless amounts of love and support, for listening to me cry, no matter what time of the day, and for all advice. I would not have made any without them. Thank you Mama and Papa.

In addition, I would like to thank my friend, Mongezi Rens, who encouraged me to enrol in the program, even going far to apply for funding and helping with data collection. He and I make a dream team.

Words can neither qualify nor quantify the assistance and guidance I have received from my supervisors; Professor A. Belete and Professor J.J. Hlongwane. The work presented in this study was made possible by their liberal supervision. Thank you once more.

Finally, I would like to express my sincere gratitude to the National Research Foundation for their financial support. This work is based on the research supported wholly by the National Research Foundation of South Africa.

NRF
National Research Foundation

ABSTRACT

Small-scale farmers are the drivers of many countries in Africa and play an important role in livelihood creation among the poor in rural areas (DAFF, 2012). The efficient use of scarce resources in promoting agricultural production has encouraged a considerable amount of research in determining efficiency differentials of small-scale farmers (Chiona, 2011); especially those engaged in maize as a staple commodity in many parts of the world.

The study examined the effect of access to tractor service on technical efficiency of small-scale maize farmers following the implementation of the Masibuyele Emasimini programme in the Mpumalanga province. The objectives of the study were to: (i) Compare and identify the socio-economic characteristics of small-scale maize farmers in the three selected districts of the study, (ii) analyse the socio-economic factors influencing small-scale maize farmers' access to tractor service, and to (iii) measure technical efficiency of farmers who have access to tractor service. The data collection was carried out in three districts of the Mpumalanga province, that is, Ehlanzeni, Nkangala and Gert Sibande. Farmers producing maize were purposively selected for the study because maize is the most staple food produced in the province, especially on a small-scale level. To effectively cover the study area, a simple random technique was used for sampling with a semi-structured questionnaire administered to 101 farmers. The three districts are heterogeneous in technical aspects, and were therefore treated separately in terms of data collection, analysis and report of findings. The data were further analysed using descriptive statistics, the logistic regression and Cobb-Douglas production function model to address objective one, two and three mentioned above, respectively.

The results of the logistic regression model indicated that out of the 9 (Nine) socio-economic variables included in the analysis, 6 (Six) of them (Farmer's association, irrigation, farmer's level of education, gender, ownership of land and household size) were found to be significant and influencing access to

tractor service by small-scale maize farmers. Technical efficiency levels revealed that farmers with access to tractor service were more technically efficient than those without access in all districts of the Mpumalanga province. For example, the average technical efficiency for small-scale farmers with access to tractor service in the Ehlanzeni district was 0.68; about 41% higher than those without access with an average technical efficiency of about 0.27. The Cobb-Douglas results on the other hand, revealed that farmers in the Mpumalanga province are experiencing technical inefficiency in maize production due to decreasing returns to scale. Access to tractor service was also negatively insignificant towards maize production in both the Ehlanzeni and Nkangala district, and was found to have a positive but insignificant effect in Gert Sibande.

Policy implications are that to improve the efficiency of tractor service (rendered by the Masibuyele Emasimini programme) towards maize production; government should focus on significant factors influencing the access of the following by small-scale maize farmers and the factors are machinery, irrigation, gender, and ownership of land, farmer's level of education, farmer's association, and household and land size per district.

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DAFF: Department of Agriculture, Forestry and Fisheries

DALA: Department of Agriculture and Land Administration

DARDLEA: Department of Agriculture, Rural Development, Land and Environmental Affairs

DEA: Data Envelopment Analysis

GDP: Gross Domestic Product

GSDM: Gert Sibande District Municipality

IDPED: Integrated Development Plan of Ehlanzeni District

IDPND: Integrated Development Plan of Nkangala District

MEGDP: Mpumalanga Economic Growth Development Plan

NDM: Nkangala District Municipality

SFA: Stochastic Frontier Analysis

CHAPTER 1
INTRODUCTION

1.1 Background of the study

"Agriculture is the foundation of developing economies" (du Plessis, 2010). It contributes approximately 70% of employment, 40% of export earnings, and 30% of Gross Domestic Product (GDP) and up to 30% of foreign exchange earnings in the Sub-Saharan Africa (SSA) (IFAD (International Fund for Agricultural Development, 2002) cited by Chiona (2011), which dominantly consists of developing countries, among others; South Africa. The agricultural sector in the Mpumalanga province of South Africa employs the majority of the workers, with approximately 182 645 employed compared to mining, manufacturing and construction sector with only about 87 679; 68 699; 17 949 employees, respectively (Van Dyk, 2000). Although the sector contributes less than 10 percent to the GDP in Mpumalanga, it is important to note that the province produces approximately 25 percent and more of the annual South African maize crop from only 17 percent of the productive land (Van Dyk, 2000).

Maize (*Zea mays*) is the most important staple food and feed grain of majority of the South African population, and is produced widely on a small-scale as well as commercially. It is cultivated late spring or early summer, with favourable planting times in November and December, although planting can begin as early as October and extended to January, and then harvested from May up to end of August. However; rainfall distribution and other climatic weather conditions determine the planting season and gestation period (DAFF (Department of Agriculture, Forestry and Fisheries, 2017).

Approximately 43% of maize produced in South Africa is white, which is used primarily for human consumption and the remaining 57% of yellow maize is used for animal feed production. Free State and North West are the main white maize producing provinces, producing approximately 69% of white maize, with Mpumalanga and Free State producing about 64% of the yellow maize (DAFF, 2017).

The figure below shows the contribution of South African provinces to maize production during the 2015/16 production season.

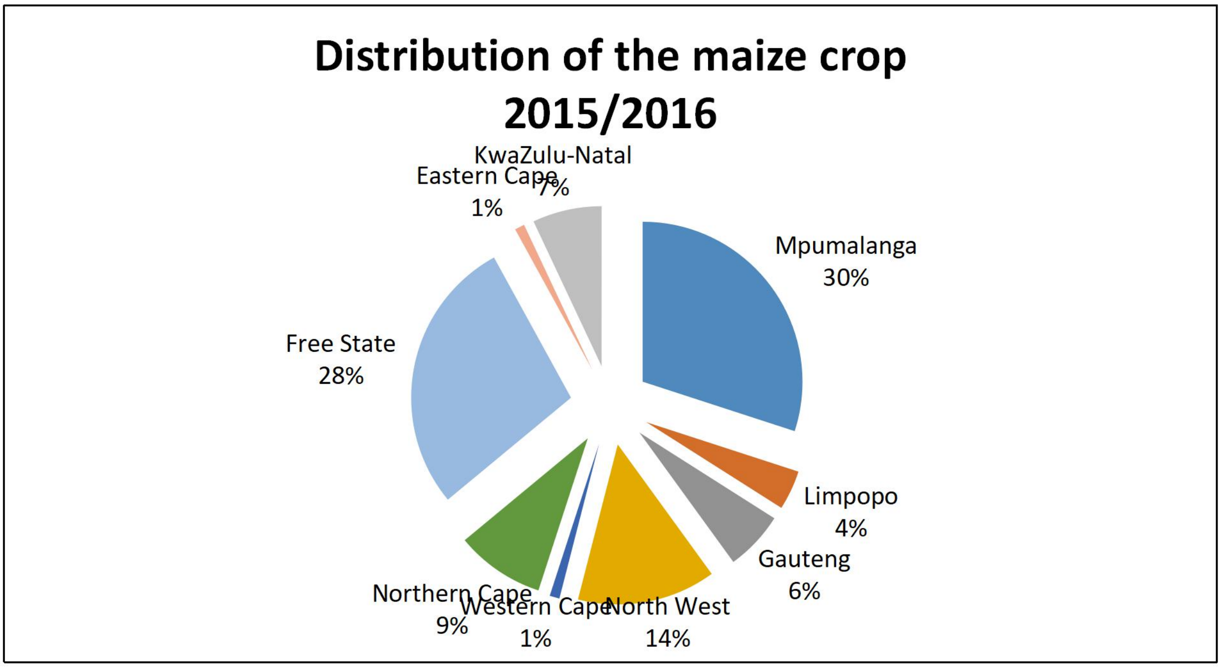

Figure 1.1: Distribution of maize crop by province in South Africa

Source: Compiled by DAFF (2017)

The Mpumalanga province is the main producer of maize in South Africa as depicted on the graph above, with a value of approximately 30%.

The following graph also depicts the imports and exports of maize to and from South Africa, respectively, during the past five marketing seasons (May to April).

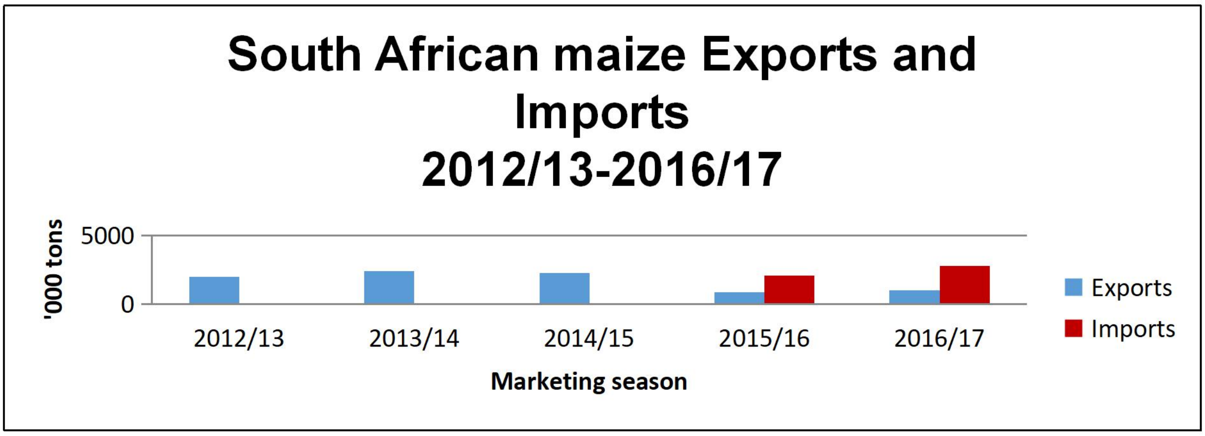

Figure 1.2: South African maize exports and maize

Source: Compiled by DAFF (2017)

As a result of the drought that occurred in 2016, maize production declined in South Africa (as demarcated on the graph above), forcing the country to import approximately 2800 million tons of maize from other countries to make up for the shortfall and meet domestic demand (DAFF, 2017). This puts emphasise on the importance of maize as a staple commodity and agriculture in general to ensure food security.

The Mpumalanga department of Agriculture has as a result taken an initiative to scale down some of the programmes such as Masibuyele Emasimini due to limited rain in most parts of the province. The department allocated most of its resources from other service deliveries to drought assessment to carry out a drought intervention strategy. The drought has also forced officials to change the programme's strategy executed in the past, to providing farmers with drought resistant crops and boreholes in the strategic year 2016/17 (Department of Agriculture, Rural Development, Land and Environmental Affairs (DARDLEA, 2016).

The programme (Masibuyele Emasimini-Back-to-tilling the land) was established in 2005/2006, and was later broadened in 2007/2008 to include three selected areas of each of the provincial districts (Enhlazeni, Gert Sibande and Nkangala district), including the Bushbuckridge municipality (Department of Agriculture and Land Administration (DALA, 2007/08-2009/10). Its initial strategy was to reduce poverty and hunger, promote and support household income generation and food production through the provision of small implements and production inputs, inter alia; access to tractor service, fertilizers, seeds and weeding chemicals to previously disadvantaged farmers, particularly small-scale farmers (DALA, 2007/08-2009/10). Thus; leading to a prosperous agricultural development and addressing past inequalities in the allocation of arable land. The measurable objective of the programme is to help subsistence and household food producers to use the land productively.

Estimates have also shown that the Mpumalanga's agricultural sectors' productivity level has been fluctuating, with some years of stagnancy and years of increasing and decreasing productivity levels.

The graph below demarcates the GDP share of the agricultural sector from 2004 to 2014.

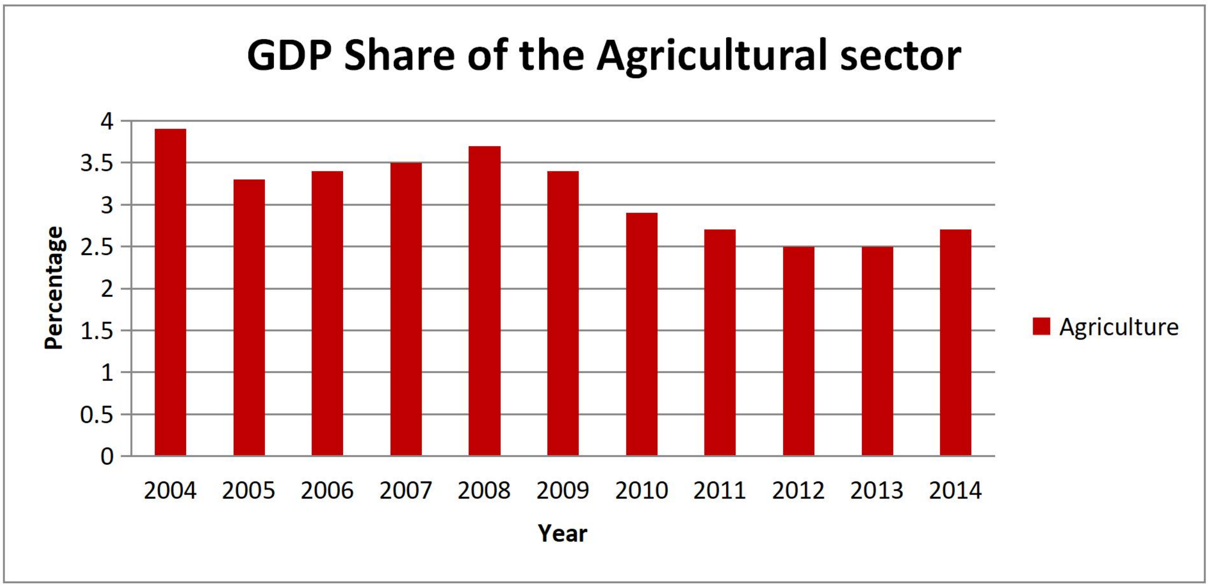

Figure 1.3: GDP share of the Agricultural sector in Mpumalanga province

Source: Compiled by Wilhelm (2016), Mpumalanga Provincial review

GDP decreased from 3.9% in 2004 to 3.3% in 2005. It then increased to 3.7% in 2008, remained stagnant in 2012 and 2013 at a value of 2.5%.

Given the above trends, it is imperative to determine whether tractor service provided by the programme is technically efficient in the production of maize, which will ultimately enable public officials to redirect more resources to technically efficient inputs. The Cobb-Douglas production function model was therefore; employed to determine the effect of access to tractor service on technical efficiency of small-scale maize farmers and identify whether the production variables have a positive or negative effect on small-scale maize production, technical efficiency from the input-output relationship, and the returns to scale.

1.2 Problem statement

Small-scale farmers are the drivers of many countries in Africa and play an important role in livelihood creation among the poor in rural areas (DAFF, 2012). The efficient use of scarce resources in promoting agricultural production has encouraged a considerable amount of research in determining efficiency differentials of small-scale farmers (Chiona, 2011), especially those engaged in maize as a staple commodity in many parts of the world.

Despite the importance of small-scale production for household food security, the productivity of the sub-sector is low with poor yields. Therefore, there is a need to increase productivity of the farmers to ensure long-term food security (DAFF, 2012).

A number of smallholder farmers struggle to access markets regardless of government support. Recently a study by Shabangu (2015) found that smallholder farmers in Mpumalanga face challenges in securing farm inputs, specifically tractors and irrigation equipment. It's evident that even with governments' assistance, there still remains a gap in provision of access to tractor services by farmers in the study area. It is however uncertain whether there exists a positive relationship between technical efficiency and access to tractor service as farmers still harvest maize for both consumption and sale for the informal market even after the implementation of the programme. This is a deviation to some of the key objectives behind Masibuyele Emasimini, which are to increase market access of agricultural products in the province through increased production; inter alia (DALA, 2007/08-2009/10). It is a fact that an increase in production would eventually persuade farmers to start searching for new and bigger markets.

A firm is said to be technically efficient if it produces maximum output from a given set of inputs (Naqvi and Ashfaq, 2014), and the use of tractor is likely to benefit farmers through this increased yield (Mabuza *et al*., 2013). Thus; to successfully determine the effects of access to tractor service on technical efficiency, it is important to first identify the factors influencing access to tractor service provided by the programme and thereafter look at the influence of this tractor on technical efficiency.

1.3 Rationale

Various studies have been conducted on the access and use of tractor rendered by government programmes with the aim of widening the knowledge on limiting factors towards tractor. Despite the knowledge from these studies, there remains a gap on studies which investigate the impact of government support programmes on smallholder farmers**.**

Tractor is a vital input in agriculture, it serves as a means of enhancing human productivity and increases production beyond the ability of human labour (Ajah, 2014). It is also an important element in farming used for various activities such as tilling, ploughing and planting. The use of tractor and its implements has had a great impact on agricultural development in many parts of the world. For example; Approximately 95% of America's arable land is mechanised, with only 24% of the total population engaged in farming, yet farmers are able to produce both for the domestic country and countries abroad (Ajah, 2014). Moreover; following the introduction of the government programme Masibuyele Emasimini in Mpumalanga province, the number of farmers engaged in maize production increased (Bushbuckridge Local Municipality (BLM, 2017) and this definitely provides evidence of the importance of tractor within the agricultural sector in the province.

There is a need to investigate the effects of access to tractor service on technical efficiency among small-scale maize farmers following the implementation of the programme in Mpumalanga province. This is necessary because if tractors are accessible but not efficient, then the government would not get the maximum benefit from its investment, and if they are not accessible but efficient then it is imperative for the department to make them accessible to every farmer. The findings and recommendations of this study will be helpful to policy makers in the Mpumalanga Department of Agriculture and other relevant stakeholders in their attempt to mobilise small-scale maize farmers in the line of commercialisation.

1.4 Aim and Objectives of the study

1.4.1 Aim

The aim of the study is to analyse the effects of access to tractor service on technical efficiency among small-scale maize farmers following the implementation of the Masibuyele Emasimini programme in the Mpumalanga Province.

1.4.2 Objectives

The objectives of the study are to:

I. Identify and compare the socio-economic characteristics of small-scale maize farmers among the three districts of the study area.
II. Analyse socio-economic factors influencing small-scale maize farmers' access to tractor service in the Mpumalanga Province.
III. To measure technical efficiency of small-scale maize farmers who have access to tractor service.

1.5 Hypotheses

I. Socio-economic characteristics of small-scale maize farmers do not differ among the three districts'.
II. Socio-economic factors of maize small-scale farmers do not influence access to tractor services in the Mpumalanga province.
III. Access to tractor service does not have an effect on the technical efficiency of small-scale maize farmers.

1.6 Organisation of the dissertation

The rest of the dissertation succeeding the above chapter which highlighted the importance of the agricultural sector to Africa in general and the South African Mpumalanga province in particular as well as the importance of maize as a staple commodity in the province together with the trends in production; is organized as follows: Chapter two gives an overview of both access to tractor service and technical efficiency of small-scale maize farmers derived from various studies in the world. It also provides definitions of key concepts, clearly highlighting the different types of efficiency. Chapter three presents an overview of the study area, data collection methods and analytical techniques with their advantages and limitations as well as a detailed discussion of the variables used in the study. Chapter four focuses on empirical analysis and presentation of findings per district, that is, Ehlanzeni, Nkangala and Gert Sibande district, and the last chapter; chapter 5, provides a summary, conclusion and recommendations of the study as a whole.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

Literature review involves identifying and analysing various research studies containing information relating to a particular research problem under investigation (Gay, 1981) cited by Alistakius (2016). The literature presented reviews studies relating to research objectives, through the inclusion of empirical studies analysed by various authors.

The first part of the chapter includes the definition of key concepts derived from the research topic, these are; technical efficiency, small-scale, and access to tractor service. The definition of technical efficiency is compared to allocative efficiency and efficiency in general. The second phase involves the review of past studies on the effects of access to tractor service on technical efficiency among small-scale maize farmers, which was structured using the funnel method recommended by Hofstee (2006). The first category on the funnel is a review on access to tractor service and includes works that are relevant to the study but not specifically addressing the research problem, and contains a lot of works. The next layer includes literature on technical efficiency in general, followed by a layer on technical efficiency affecting small-scale maize farmers directly. This layer is dealt with in more detail as it relates more closely to the research problem (dependent variable). The last but not least category on the funnel focuses on literature relating to the effect of access to tractor service on technical efficiency among small-scale maize farmers. This category includes less related works as it directly relates to the research problem under investigation, and therefore; emphasises the originality of the research topic.

2.2 Definition of key concepts

2.2.1 Concept of Economic Efficiency

Economic efficiency is a situation in which society obtains maximum benefits from scarce resources Alistakius (2016), and is divided into two components: Technical and Allocative efficiency.

Technical efficiency is the ability of a farmer to produce maximum output from a given amount of inputs. According to Kibirige (2008), a farmer is said to be technically efficient if he or she produces at the production frontier level. It is also referred to as the input oriented measures of technical efficiency wherein a farm is said to be more technically efficient if it produces more output than the other farm using the same level of resources (Huang and Bagi, 1994) cited by Naqvi and Ashfaq (2014). According to Naqvi and Ashfaq (2014), management inefficiency is correlated with technical inefficiency, which is the inability to produce maximum output from a given amount of inputs.

Allocative Efficiency also known as the output oriented measures, on the other hand takes price into consideration. It measures the ability of the farmer to choose the least cost input combination given the available technology (Chiona, 2011). Allocative efficiency is calculated as the ration of minimum costs of certain inputs. Inefficiencies may come from the lack of accurate and timely information and incorrectly perceived prices (Chiona, 2011).

According to Ali and Chaudhry (1990) cited by Naqvi and Ashfaq (2014), efficiency can be enhanced by government investment in timely inputs delivery, provision of extension officers for dissemination of information, infrastructure, farm management services and farmer's skills.

2.2.2 Small-scale production

According to DAFF (2012), small-scale farmers are defined in multiple ways depending on the country, context and ecological zone. The South African agricultural sector is composed of mainly two categories of farmers; subsistence (small-scale) found in the former homelands and large-scale farmers. In the South African context, small-scale farmers are equated to a backward, non-productive, non-commercial subsistence agricultural sector (Kirsten and van Zyl, 1998). Oettle *et al.* (1998) also adds that small-scale farmers are those producing agricultural output at relatively small sizes of land.

Another definition exists which looks at relative smallholder farmers. The term 'smallholder' is used interchangeably with 'small-scale', and these farmers are defined as those owning small plots of land on which they grow subsistence crops and few cash crops relying mostly on family labour (DAFF, 2012). These farmers are characterised by simple, outdated technologies, low returns, and women playing an important role in the production of food.

2.2.3 Access to tractor service

According to the programme 'Masibuyele Emasimini', farmers that occupy a farm size of 1 to 5 hectares, rent land from the state and irrigate have access to tractor service to ensure food security. Moreover, most farmers that irrigate land are part of a farmers' association, to ensure efficient water usage.

2.3 Review of previous studies on access to tractor service

Ajah (2014), analysed the factors limiting small-scale farmers' access and use of tractors to agricultural mechanisation. Simple random technique and semi-structured questionnaire were used for data collection and further analysed through the use of descriptive statistics. The findings of the study indicated that the high cost of hiring tractors, poor access road to the farm, inadequate sources of hiring points, and destruction of land boundary were the factors limiting access and use of tractors. Out of the 337 farmers interviewed, 216 of them reported that high cost of hiring tractor was the major limiting factor to the access and use of tractor, with destruction of land boundary being the least limiting factor. The study also found that private organisations were a vital source of rendering tractor service, while government-owned institutions remained insignificant.

Literature provides a few recommendations to enhance the access to tractor service by small-scale farmers. According to Paman *et al.* (2010), tractor hiring points should be encouraged, however; farmers as private owners instead of government. Tractor hiring points serve as a source of income and are one of the effective ways of promoting private ownership among small-scale farmers. In support of this, the FACASI (Farm Mechanisation and Conservation Agriculture for Sustainable

Intensification) Project (2014) suggests that farmers be grouped together to increase the chances of obtaining credit from financial institutions for the purchase of tractors. These tractors will be owned by members in the group and further used for hiring to other farmers.

Conversely, according to khapayi and Celliers (2016) and Ajah (2014), government plays a crucial role in ensuring that factors constricting farmers' development from subsistence farming to commercialisation are met. Thus, according to Ajah (2014) government should increase the number of tractors and further regulate them to increase their accessibility. Regardless of the study's findings that government-owned institutions remained insignificant in making tractor available to small-scale farmers, due to reasons such as lack of implements and poor maintenance of tractors, even with good finance.

Similarly, Mottaleb *et al.* (2016), studied the factors associated with small-scale agricultural machinery adoption. Multinomial probit model results indicated that machinery adoption was positively associated with household assets, credit availability, electrification and road density. The study also emphasises on the role of government to focus on improving pre-requisites such as infrastructure and credit availability to induce the adoption of agricultural machinery.

On the other hand, Mabuza *et al.* (2012) argued that the provision of tractor service by government will only lead to high overhead and transaction costs due to small farm sizes owned by small-scale farmers. Thus; farmers who own a large number of draught animal should utilise them, and policies in land tenure be reviewed. This argument was derived from the use of cross section data, multinomial logit model as well as a random and systematic technique to analyse the socio-economic factors influencing the choice of land cultivation technologies (tractors, draught and hoes) used by smallholder farmers. Results revealed that households with a high wealth index, large maize area (land size), and irrigation facilities were likely to adopt to improved agricultural technologies such as tractor.

Given the above recommendations, the study will contribute to science by determining the effects of access to tractor service rendered by the Masibuyele Emasimini programme on technical efficiency among small-scale farmers, which will ultimately reveal whether government owned institutions are significant in the provision of agricultural inputs, inter alia; tractor.

2.4 Review of previous studies on technical efficiency in general

Jaime and Salazar (2010) conducted a study on participation in organisations, technical efficiency and territorial differences of small wheat farmers in Chile. The aim of the study was to analyse the determinants of technical efficiency of wheat small farmers and to evaluate its relation to a variety of variables, including farmer participation in organisations, for several territories with different agro-climatic conditions. Results from the Stochastic Frontier production function indicated that education, farm size, degree of specialisation and dependence of activity had an inverse relationship with technical inefficiency, with age being positively significant. Implying that younger farmers are more responsive to improved technologies as opposed to older farmers.

However; a study by Lwiza (2013), to analyse technical efficiency in agriculture and its implication on forest conservation in Tanzania, found farm size to be negatively significant. Implying that an increase in farm size, reduces technical efficiency, and the possible reason he gave was that most farmers in Tanzania used conventional inputs such as hoes which made them inefficient as the farm size increased. One can also argue that as the farm size increases, farmers become more encouraged to use capital inputs such as tractor, thus; increasing their farming efficiency. The Cobb-Douglas model on the other hand, which determines the technological relationship between output and farm inputs found capital to be positively significant. The use of farm implements and machinery (tractor) enable the farmer to cultivate large plots of land and therefore harvest more output (Lwiza, 2013). Out of three variables analysed, namely; capital, farm size and labour, capital was the only significant input.

According to Kiprop *et al.* (2015), land fragmentation is an issue in many parts of the world, where people operate a number of non-contiguous plots at the same time and depends mainly on factors such as market factors, external policy, agro-ecological conditions and socio-economic characteristics. Household size for example oblige farmers to divide their land to balance agriculture and settlement, to an extent that the agricultural land becomes too small to sustain agricultural practices and therefore leading to a decline in agricultural productivity.

Kiprop *et al.* (2015) made use of the Cobb-Douglas model to analyse technical efficiency among smallholder farmers in Kisii County of Kenya. Findings indicated that land fragmentation had a negative significance on output, an increase in land fragmentation decreases agricultural output. It is not economical to increase output on fragmented lands due to the difficulty to enlarge the land size or even use mechanisation (Kiprop *et al.*, 2015). The variable was measured through the use of the Januszewki index (JI), which has a range of 0 to 1,- the smaller the JI value, the higher the degree of land fragmentation. Planting fertilizer and certified seeds were positively significant towards agricultural output.

Similarly, a study by Msuya *et al.* (2008), which examined productivity among smallholder maize farmers in Tanzania, also found land fragmentation (measured by the number of plots), although insignificant, negatively influencing technical efficiency. Farmers using hand hoes were more efficient than those using tractor. This was linked to land fragmentation, small and fragmented land holdings make it difficult to obtain economies of scale for small-scale farmers using tractor (Msuya *et al.*, 2008) and (Kiprop *et al.*, 2015). Thus; given the current land holding in Tanzania, investing in highly mechanized inputs may not translate to high levels of productivity. Both authors recommend that policies target variables that have a positive influence on efficiency, for example, hand hoes.

Yet; the aim of policies is to develop the agricultural sector through the use of modern inputs such as tractor. Thus; encouraging the use of conventional methods that are highly labour intensive (hand hoes) may not be the way to go. Instead, government should review land tenure policies that prevent the subdivision of land holdings. Nonetheless, the study showed that land and materials were positively significant with family labour negatively influencing maize production (Msuya *et al.*, 2008). Labour was disintegrated into both family and hired labour, with hired labour positively influencing production, although insignificant. The negative relationship between family labour and maize production was due to the large size of household members spending too much time at the field perhaps as a result of limited employment opportunities outside the agricultural sector (Msuya *et al.*, 2008).

The study recommends that various activities should be created through agricultural based industries to reduce the concentration of family labour in the production of agricultural products.

Ngoe *et al.* (2016) investigated technical efficiency of smallholder cocoa farmers in South West Cameroon. The Cobb-Douglas production function was specified using the following explanatory variables, seeds, labour (man days) quantity of fertilizer (kg), and quantity of agrochemical (kg). Results showed cocoa output to be determined by agrochemical quantities and labour, which were both positively significant at 10% significance level. Although insignificant, seeds used had a negative influence on output, implying that a unit increase in seeds decreases cocoa output. This is in contrary to Kiprop's *et al.* (2015) results who found certified seeds to be positively significant towards agricultural output. The negative relationship may be due to delays in weeding, pruning and lack of adequate shade control Ngoe *et al.* (2016).

2.5 Review of previous studies on technical efficiency affecting maize

A study by Abdulai *et al.* (2013) applied the stochastic frontier methodology to examine the technical efficiency of maize production for 2011/2012 cropping season. Multi-stage sampling procedure was used to obtain 360 maize households for the study. Results of the Cobb Douglas production function revealed that farm size, seeds, fertilizer, and weedicides were all positively significant, with labour being positive but insignificant. The positive relationship between the above explanatory variables and output entail that a unit increase in the variable inputs would increase output. Weedicides had the highest partial elasticity as weeds are a major challenge to output because they compete with crop plants for nutrients and water, inter alia (Abdulai *et al.*, 2013). Out of the six variables examined, only three were statistically significant and negatively influenced technical inefficiency, that is, agricultural mechanization, experience and gender.

The study also revealed a returns to scale value of 1.383 which indicates an increasing returns to scale and thus; inefficiency. This implies that farmers were operating in stage one of the production function, that is, an increase in the use of variable inputs over a fixed bundle of resources led to a more than proportionate increase in output. Small-scale maize farmers should therefore be supported in the provision of variable inputs to move them quickly to an optimal stage of production, which is stage two of the production function.

Abdulai *et al*. (2018) also assessed technical efficiency of maize production in Northern Ghana, but this time using a non-parametric method, that is; the Data Envelopment Analysis (DEA) instead of the commonly used parametric Stochastic Frontier Analysis (SFA). Data was collected in three regions of the Northern Ghana (Northern, Upper East and Upper West) for the 2011/2012 cropping seasons. The DEA revealed a positive relationship between technical inefficiency and agricultural mechanisation as well as education. Entailing that a unit increase in these variables would increase inefficiency in the production of maize. The DEA also indicated a higher mean technical efficiency value of 77 percent as opposed to the SFA with a value of 74 percent. Both studies by Abdulai *et al*. (2013 and 2018) nonetheless, showed an increasing returns to scale on the use of inputs.

This is in contrary to Baloyi's (2011) study that revealed a decreasing returns to scale with a value of 0.398. Implying that an increase in the use of variable inputs over a fixed bundle of resources lead to a less than proportionate increase in output, which is stage three of the production process. Only three variables were significant, with land (farm size) and fertilizer positively significant, and capital having a negative influence on output. Labour and seeds were both negatively and positively insignificant towards maize output, respectively.

A study conducted in Ghana revealed similar results. Abdallah and Abdul-Rahman focused on examining technical efficiency of maize in Ghana. The returns to scale, which measures the proportional change in output when all inputs in the model are changed in the same proportion was 0.78, also indicating a decreasing returns of scale (Abdallah and Abdul-Rahman, 2017). Out of the five variables in the Cobb-Douglas production model, namely; revenue, farm size, seed, labour cost and agrochemical, only three variables were significant at 1% and positively influencing production, that is, farm size, labour cost and agrochemical. Entailing that a 1% increase in each of these variables, will lead to an increase in maize output by the respective input coefficient.

Similarly to Baloyi (2011), Alistakius (2016) also found capital to be negatively significant towards maize output in Karagwe district, with fertilizer and land having a positive significance, and a returns to scale of less than one (0.299). In Alistakius' study (2016), the cost of purchasing seeds was used to represent capital, while Baloyi (2011) used the cost of tractor hours. The negative relationship between capital and maize output may be due to the fact that the input was over utilised in the production process to the point that it added less and less to additional output. Moreover, Land and fertilizer were both positively significant, with labour insignificant and having a negative influence on output. Labour was measured by man days and represented both family and hired labour.

Sapkota *et al.* (2017) explored the determinants of technical efficiency on maize seed production in Palpa District, Nepal. The efficiency measure were regressed on a set of independent variables which included seed (kg), farm yard manure (FYM) (kg), labour (man-days), chemical fertilizer (kg), tillage by tractor (hour) and bullock (day). The relationship between maize seed production and inputs such as seed, FYM, and labour were found positively significant whereas chemical fertilizer and tillage by tractor were found influencing positively but insignificant, with bullock being negatively insignificant (Sapkota *et al.*, 2017).

Mokgalabone (2015) investigated technical and allocative efficiency of small-scale maize farmers in Tzaneen municipality of Mopani District: a Cobb-Douglas and Logistic regression approach. Land, seeds, fertilizer and capital were positively significant at 1% significance level, implying that a percent increase in these variables increases maize production by the respective elasticity value (coefficient) of the explanatory variables. Expenses were also significant, however; having a negative influence towards maize production. The sum of betas, which measure returns to scale was above one, with a value of 1.081, indicating an increasing returns to scale and inefficiency. This also entails that the cost per unit of input used in the production process is less than the return on maize output, there's therefore potential for farmers to increase production.

Additionally, a study by Chiona (2011) to analyse technical and allocative efficiency in Zambia revealed low levels of both technical and allocative efficiency, contrary to Mokgalabone (2015), who found a high value of returns to scale. Technical efficiency scores ranged from 0.005 through 1, with allocative efficiency ranging between 0.0005 and 1. Only 0.23 percent of farmers were technically efficient, with an allocative efficiency of only 0.27 percent. Entailing that on average, the level of inputs and costs can be reduced by 85 and 88 percent, respectively, without decreasing output (Chiona, 2011).

2.6 Review of previous studies on the effects of access to tractor service on technical efficiency

Various studies have been conducted on access to tractor service (rendered by both government programmes as well as private sectors) and technical efficiency, separately. However; little or no analysis has been made on the effect of access to tractor service on technical efficiency, evident by the amount of available literature. This hinders the reformulation of agricultural policies to enable development within the sector.

A paper by Martey *et al.* (2015) assessed the impact of credit on smallholders' technical efficiency. Data was collected using cross-sectional data from 233 maize-producing households in Northern Ghana. Stochastic frontier production was also used to analyse the factors that determine technical inefficiency of farm households, as well as the Cobb-Douglas production function proposed by Battese and Coelli (1995) to understand the relationship between output and input levels (Martey *et al.*, 2015). The treatment effect estimation approach was further used to determine the impact of credit on technical efficiency as a result of its ability to provide consistent estimates of impact outcomes (Imbens and Wooldridge, 2009) cited by Martey *et al.* (2015).

Descriptive results established that farmers with access to credit had relatively higher household size and extension access, while non-credit farmers were more educated, had higher market access and travelled longer distance to the nearest market. It was also observed that producers with access to credit had higher technical efficiency compared to non-credit farmers, with a technical efficiency score of 0.67 and 0.53, respectively. The Cobb-Douglas production function revealed that fertilizer, land, seed and herbicides were positively significant, implying that by increasing these variables, maize output was likely to increase as well. Out of the five explanatory variables, only one was positively insignificant, that is, labour. Land had a higher elasticity value reflecting the high land use intensity in Northern Ghana (Martey *et al.*, 2015), and a returns to scale of 1.41. A percentage increase in all inputs will lead to an increase in output by 1.41 percent. Age, proportion of economically active members, access to production credit, access to market, per capita income and distance to the nearest market significantly determined technical efficiency.

Given that credit positively impacts technical efficiency, the study recommends that financial institutions reduce their interest rate charges to enhance participation by farmers in the credit market.

Additionally, Abdul-Salam and Phimister (2015), evaluated efficiency effects of access to information on small-scale agriculture with empirical evidence from Uganda. The Cobb-Douglas and Stochastic frontier production function were integrated to measure technical efficiency of farmers. Moreover; the Rasch was combined with the Logistic regression model to quantify the ability of small-scale farmers to access information. The Cobb-Douglas production function revealed parcel size, labour and pesticides to be positively significant, implying that an increase in these variables is likely to increase maize output. Coefficients for technical efficiency demarcated that the coefficient for information index (electricity, radio, phone, internet, extension and PC) was negative and significantly different from zero, indicating that the parcels (information index) managed by farmers with higher access to information are more technically efficient.

The study argues that economic growth in agriculture is on average at least twice as effective in eradicating poverty as growth outside the agricultural sector (World Bank, 2008) cited by Abdul-Salam and Phimister (2015). The recommendation drawn from the paper was therefore; the need to enhance technical efficiency through improved access to information.

2.7 Summary

In light if the above review, access to tractor service was influenced by the cost of hiring tractor, access road to the farm, sources of hiring points and road density. The efficiency of maize production depended on seeds, fertilizer, farm size, weedicides, labour, capital and farm yard manure. The study will measure the effect of access to tractor service rendered by the Masibuyele Emasimini programme on technical efficiency of small-scale maize farmers in the Mpumalanga province. This will be achieved through the use of the Logistic regression and Cobb-Douglas model. This will be in line with the study made by Abdul-Salam and Phimister (2015) (among other authors), who used both models for binary observations and technical efficiency, respectively

CHAPTER 3

METHODOLOGY AND ANALYTICAL PROCEDURES

3.1 Introduction

This chapter provides a concise description of the location, data collection methods and analytical techniques employed in the study. It also presents a detailed description of the variables selected to analyse both access to tractor service and technical efficiency of small-scale maize farmers in the Mpumalanga province.

3.2 Study area

The study was conducted in all districts of the Mpumalanga province, namely; Ehlanzeni, Gert Sibande and Nkangala district. Mpumalanga is a province of South Africa, commonly known as *the place where the sun rises*. It lies in the Eastern South Africa, bordering Swaziland and Mozambique. The province covers an area of approximately 76 495km square (7 645 460 ha) or 6.3 percent of the country, with agriculture utilising most of the land area, about 68 percent of the province (Mpumalanga Economic Growth Development Plan (MEGDP, 2011). On this 68% of agricultural land, 15 percent is used for cultivation and grazing covering 53 percent of the land area, the remaining 32 percent is used for nature reserves, forestry plantations, and human settlements. The primary use of land in the province is for agricultural production, mining, industries, forestation, ecotourism and nature reserves (MEGDP, 2011).

The three districts are heterogeneous in rainfall distribution, growing season, topography, soil and vegetation, and were therefore; treated separately in terms of data collection and analysis and report of findings: -

The Ehlanzeni District is situated at the North Eastern part of the Mpumalanga province bordered by Mozambique in the east, the Limpopo province to the north, the

Nkangala district to the west, as well as Gert Sibande and Swaziland to the south. It consists of five municipalities, namely; Bushbuckridge, Mbombela, Nkomazi, Thaba Chweu and Umjindi as well as a population size of approximately 944 699 (DALA, 2007/08-2009/10). The main economic activities in the district are agriculture, forestry and tourism (Integrated Development Plan of Ehlanzeni district (IDPED, 2015)

The average mean annual rainfall for the district varies between 750 and 860 mm, with rainfall lasting from October to March (IDPED, 2015) giving a maize growing season of approximately 151 to 180 days.

The Ehlanzeni district is also characterised by a sub-tropical climate making it suitable for the cultivation of fruits such as mangoes, bananas, avocados, guava, granadilla and tomatoes. Maize, nuts, tobacco and sugar are also some of the crops cultivated in the area.

The topography of the district is made up of escarpments, plains, hills, high and low mountains, making it suitable for tourism as well (IDPED, 2015).

The Gert Sibande District on the other hand, is situated at the South Eastern part of the Mpumalanga province, bordered by the Ehlanzeni district on the North Western part, Nkangala and the Gauteng province on the Western part. It consists of seven municipalities: Albert Luthuli, Dipaleseng, Govan Mbeki, Lekwa Mkhondo, Msukaligwa and Pixley Ka Seme, with a population of approximately 1 458 647 (DALA, 2007/08-2009/10).

The district has the largest agricultural sector in Mpumalanga province, producing mainly maize, soy-beans, sunflower, grain, sorghum, wheat, mutton (cattle and sheep), dairy and wool. Agricultural potential in the district is medium to high, with crop production occurring on higher potential soils (DALA, 2007/08-2009/10).

Rainfall ranges from 550 to 1600 mm per year and a growing season lasting from September to March, which clearly indicates that the district has high potential for both crop and animal production (DALA, 2007/08-2009/10).

The topography of the Gert Sibande district is described by an undulating landscape consisting of intermittent hills and situated on the Grasslands of the Mpumalanga province. The rise and falls (undulations) increase from the west to east direction of the Drakensberg and Swaziland. As a result of the topographical characteristics, the district consists of various water management areas- Vaal, Pongola, Olifants, Crocodile and the Tugela river (Gert Sibande District Municipality, (GSDM, 2017).

The Nkangala District is situated in the Mpumalanga province bordering 6 (six) municipalities, namely; Dr Js Moroka, Victor Khanye, Steve Tshwete, Delams, Emakhazeni, Thembisile Hani and Emalahleni, with a population of about 1 464 102 (DALA, 2007/08-2009/10).

Agriculture is the least contributing sector in the Nkangala district, with mining contributing the most. However; the sector is still a major provider of food through the production of priority commodities – maize, sunflower, vegetables, soya beans, sorghum, tobacco, piggery, livestock, cotton, poultry and wheat (Integrated Development Plan of Nkangala District (IDPND, 2017).

The topography of the Nkangala district is characterised by a rise and fall landscape consisting of rocky outcrops along the Olifants and Wilge River and the mountainous areas in the north-west. The rocky outcrops move further in an east west direction along the northern boundary of the district, which then separates the Dr Js Moroka and Thembisile local municipalities (Nkangala District Municipality (NDM, 2017).

The district consists of mostly medium soil, which is found in the central and western part of Nkangala (Steve Tshwete, Emalahleni, and Victor Khanye local municipalities) and a small part of Dr JS Moroka in the north-west, as well as the central portion of Emakhazeni. Only a portion of Thembisile Hani municipality is made up of high potential soil (NDM, 2017).

Figure 3.1 below shows the map of the three districts in the Mpumalanga province. As can be seen, the Ehlanzeni district is indeed situated at the North Eastern part and Gert Sibande at the South Eastern part of the Mpumalanga province. The Nkangala district is surrounded by both Ehlanzeni in the North-east and Gert Sibande to the South.

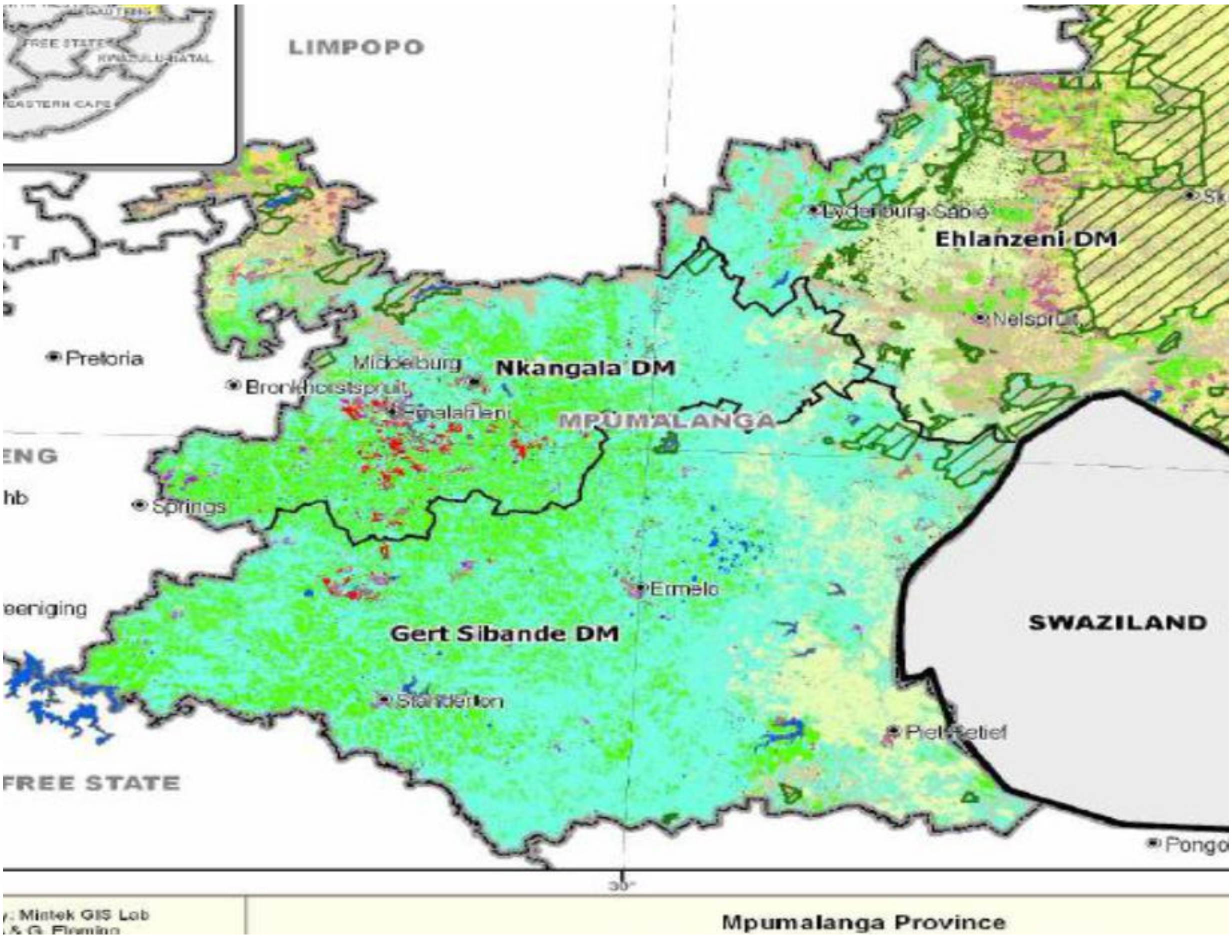

Figure 3.1: A map of Mpumalanga Province showing the study area

Source: Mpumalanga Economic Growth Development Plan (MEGDP, 2011)

3.3 Data collection

Data were collected through first-hand investigation (primary data) together with cross-sectional survey as the research design. This type of design is cost-effective as data is collected at one point in time from a sample, eliminating the need for further follow ups (Visser, 2013). A personally administered semi-structured questionnaire was also employed to gather data, allowing the researcher to supplement information obtained from respondents with those gained from observation of non-verbal actions (Kumar, 2005).

3.3.1 Sampling procedures

According to Mdlaso (2016) citing Bless and Smith (2000), the minimum statistical sample size required to obtain reliable results is at least 30 units. The data collection was carried out in three districts of the Mpumalanga province. Farmers producing maize were purposively selected for the study because maize is the most staple food produced in the province, especially on a small-scale level. To effectively cover the study area, a simple random technique was used for sampling with a semi-structured questionnaire administered to 150 small-scale maize farmers (50 for each district). The study however used only a total of 101 properly filled questionnaires from Ehlanzeni (41), Nkangala (30) and Gert Sibande (30).

3.4 Analytical methods

3.4.1 Descriptive Statistics

Descriptive statistics was applied to identify and compare the socio-economic characteristics of small-scale maize farmers among the three districts. The technique provides an easy way of summarising large observations of quantitative data into a clear and understandable manner (Knupfer and McLellan, 1996) through tables, charts, graphs and measures of central tendency.

3.4.2 Logistic regression model

In order to analyse the factors influencing small-scale maize farmers' access to tractor service, a logistic regression model was used. The researcher is predicting a dichotomous outcome, where the Y (dependent) variable is generally binary, that is, on the values 1 or 0 (Wilson and Lorenz, 2015) denoting the likelihood that an event will take place and the likelihood that an event will not; respectively, known as the odds ratio. The study's dependent variable depicts the likelihood that small-scale maize farmers either have access to tractor service or do not; influenced by dichotomous and continuous independent variables. Among the binary models i.e. linear probability, Probit, Tobit and Logit model; the latter is known for its simplicity and ease of interpretation (Fox, 2010). The inclusion of too many variables in the logit model however; may result in over fitting (Geng, 2006) wherein it becomes difficult to determine the relationship between the dependent and independent variables resulting in a small coefficient of multiple determination.

According to Hosmer and Lemeshow (2000), cited by Mokgalabone (2015); the Logistic regression model is a regression analysis for predicting the outcome of a categorical variable (a variable that can take on a limited number of categories) based on one or more explanatory variables, wherein the probabilities describing the possible outcome of a single trial are modelled as a function of independent variables using a logistic function.

The model can either be Binary or Multinomial, the former refers to a situation in which the dependent variable has two possible outcomes (e.g. Yes versus No) usually coded as ''1'' or ''0'' as indicated above. The multinomial Logistic regression on the other hand conducts analysis when the dependent variable is nominal or categorical with more than two levels. It explains the relationship between one nominal dependent variable and one or more explanatory variables.

3.4.2.1 The general logit model (Wilson and Lorenz, 2015) is given by the formula: Logit (p) = ln $\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots \ldots \ldots + \beta_n X_n + \mu$

Where:

P_i = Probability that a small-scale maize farmer has access to tractor service

$1 - P_i$ = Probability that a small-scale maize farmer has no access to tractor service

$\frac{P_i}{1-P_i}$ = the odds ratio, β_i = estimated parameters, μ_i = disturbance term

3.4.2.2 Model Specification of the Logistic regression model:

$$Ln(ACCUTS) = \beta_0 + \beta_1 GENDF + \beta_2 AGEF + \beta_3 FEDU + \beta_4 FARMS + \beta_5 HHS + \beta_6 EXTV + \beta_7 IRR + \beta_8 OWNL + \beta_9 FASS + \mu_I$$

3.4.2.3 Description of Logistic regression variables:

Gender - women are perceived to be more responsive towards innovation and thus tend to adopt to mechanization than males (Chipande, 1987) cited by Mabuza *et al.* (2012). The study will make use of a dummy variable to determine whether gender has an influence on the accessibility of tractor service by small-scale farmers, where males are accorded with a value one and female zero.

Age - younger small-scale farmers are assumed to be more open to new ideas, and understand the benefits of using tractor as an agricultural machinery as opposed to older farmers who fear change and therefore prefer using conventional methods (Sanni, 2008) Mabuza *et al.* (2012). The variable is treated as a continuous variable.

Formal education - education enhances farm productivity by improving the quality of labour and induces the adoption of innovations in a changing technological environment. This variable was therefore included as a dummy where farmers who have formal education are coded with a value 1 and those who do not, 0.

Farm-size - policies in land tenure should be reviewed in order to increase the size of arable land among small-scale farmers before inducing them to adopt to tractor-use (Mabuza *et al*, 2013), indicating that farm-size is an imperative continuous variable that influences the accessibility of tractor-service.

Household size - households with a large number of household members are likely to use human power by the use of hoes (Savadogo *et al.*, 1998) Mabuza *et al.* (2012), as opposed to those households who have few members. The variable was therefore captured as a continuous variable.

Extension visits - there's a positive relationship between extension visits and adoption of mechanization. The increase in the level of extension officers by government to enhance farmers' awareness and the benefits derived from mechanization should be prioritized. Extension visits were captured as a dummy variable wherein farmers who received extension visits were scored with a value 1, and 0 to those who did not receive any visits.

Irrigation - results obtained from Amadi (2013) study, indicates that there is a direct-proportional relationship between adoption of mechanization and access to irrigation facilities. As irrigation facilities increase, the adoption of mechanization also increases. The variable was also captured as a dummy, 1 if the farmer irrigates maize and 0 otherwise.

Ownership of land - countries such as Swaziland, land is given to households by the king however, land cannot be sold nor leased (Armstrong, 1986) Mabuza *et al.* (2012). Thus households can only use land but not own it. Farmers that own land are denoted with the value 1 and those who don't own land are denoted with the value 0, as this is a dummy variable.

Farmer's association – farmers that are grouped together make it easier for government to render inputs and this enhances the access of those inputs. This variable was treated as a dummy variable, wherein those who are part of an association are denoted with the value 1, and 0 otherwise.

Table 3.1 Description of variables

Variables	Description of variables	Measurements
Logistic Regression Model		
Dependent variable		
ACCTS	1, if farmer has access to tractor service, 0 Otherwise	Dummy
Independent variable		
GENDF	1, if farmer is male, 0 otherwise	Dummy
AGEF	Age of farmer	Years
FEDU	1, if the farmer has formal education, 0 otherwise	Dummy
FARMS	Farm size	Hectares
HHS	Household Size	Number
EXTV	1, if farmer receives extension visits, 0 otherwise	Dummy
IRR	1, if farmer irrigates maize, 0 otherwise	Dummy
OWNL	1, If farmer owns land, 0 otherwise	Dummy
FASS	1, if farmer is part of a farmer's association, 0 otherwise	Dummy
Cobb-Douglas Production Function		
Dependent variable		
MAIZE	Quantity of maize harvested	Kilograms
Independent variables		
ACCTS	1, if farmer has access to tractor service, 0 Otherwise	Dummy
HHS	Household size	Number
FERT	Fertilizer used	Kilograms
LAND	Land	Hectares
IRR	1, if farmer irrigates maize, 0 otherwise	Dummy
SEEDS	Quantity of seeds used	kilograms
WEEDCD	Quantity of weedicides used	Litres
LANDFRG	Number of plots that one owns	Number

3.4.3 Cobb-Douglas regression model

Technical efficiency is the ability of a farmer to produce maximum output from a given amount of inputs. According to Kibirige (2008), a farmer is said to be technically efficient if he or she produces at the production frontier level. It is calculated as follows:-

Technical Efficiency (TE) = $\frac{OBSERVED\ OUTPUT\ (Y)}{FRONTIER\ OUTPUT\ (Y^*)}$

Observed output is the actual output that the farmer produces while frontier output is the expected output based on the amount of input used. It is measured using a scale between 0 and 1; if the ratio is closer to 0 then the farmer is regarded as being technically inefficient, and if the value is closer or equal to 1, the farmer is technically efficient. This method was used to calculate technical efficiency and mean efficiency levels for all districts in chapter four of the results.

The Cobb-Douglas model has also been employed to measure the effects of access to tractor service on technical efficiency of small-scale maize farmers. The model was established in 1927 by Charles Cobb and Paul Douglas (hence; Cobb-Douglas), with the objective of understanding the relationship between output level and quantities of inputs used in production (Biddle, 2010). In its general form for production of one commodity with two factors, the function is expressed as follows, $Q = AL^{\beta}K^{\alpha}$ where:

Q= Total production (the real value of all goods produced in a year)

L= Labour input (the total number of person-hours in a year)

K= capital input (the real value of all machinery, equipment, and buildings)

A= Total factor productivity

α and β are output elasticities of both capital and labour, respectively (Alistakius, 2016). The elasticity of scale is estimated as the sum of partial elasticity of output with respect to each input. A value of scale efficiency equal to one which is $\alpha+\beta=1$ implies that the firm is efficient and indicates constant returns to scale, $\alpha+\beta<1$ implies inefficiency and decreasing returns to scale, while $\alpha+\beta>1$ indicates increasing returns to scale (Alemdar and Oren, 2006). In mathematical form the returns to scale are expressed as follows (Alistakius, 2016):

$$\alpha = \frac{\partial Q/Q}{\partial L/L}$$

$$\beta = \frac{\partial Q/Q}{\partial K/K}$$

The Cobb-Douglas model was chosen due to its ability to allow the use of Ordinary Least Squares (OLS) through linearisation in its logarithmic form, giving the model specification below. It can also handle multiple inputs in its generalized form, and ease of interpretations of returns to scale.

Unlike the Stochastic production frontier, where the output of the firm is a function of a set of estimation of a stochastic production frontier, set of inputs, inefficiency and random error (Naqvi and Ashfaq, 2014), the Cobb-Douglas model is criticized. It cannot represent the three stages of the neoclassical production function simultaneously, the elasticity of production is also constant irrespective of the amounts of each input used (Mokgalabane, 2015). It assumes a fixed return to scale and a linear relationship between output and inputs used in the production process (Lwiza, 2013). However; it was still selected to represent technical efficiency due to its attractive mathematical characteristics such as the ability to show diminishing marginal returns.

3.4.3.1 The operational Cobb-Douglas model for this study:

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} \text{.........} X_6^{\beta_6}$$

Where β_0 is the total factor productivity, β_1,….,β_6 are the output elasticities (coefficients) that measure the responsiveness of output to changes in the levels of input $X_{1,\ldots,}X_6$.

3.4.3.2 Model specification (Cobb-Douglas model linearised using logarithms):

$$Ln(MAIZE) = \beta_0 + \beta_1 \ln TRACTS + \beta_2 \ln HHS + \beta_3 \ln FERT + \beta_4 \ln LAND + \beta_5 lnSEEDS + \beta_6 LANDFRG$$

3.4.3.3 Description of Variables in the Cobb-Douglas model:

Output (Maize) - is the total amount of maize produced in that season and is measured in kilograms.

Access to tractor service – 1 if the farmer has access to tractor service and 0 otherwise, the variable is treated as a dummy.

Household size – most if not all of the farmers make use of family labour. The variable is treated as a continuous variable.

Fertilizer – Most of the small-scale farmers in Mpumalanga use planting or basal fertilizer than top dressing. The variable was measured in kilograms.

Land – is the area of ground noted as farm used for the production of maize and it is measured in hectares.

Seeds – This is the use of certified seeds and is measured in kilograms.

Land fragmentation – the number of plots or farms that a small-scale farmer owns was used as a proxy to measure Land fragmentation (Msuya *et al.*, 2008).

3.5 Data Validity and Reliability

Validity and reliability are concepts used to assess the quality of a particular research study (Kothari, 2006) cited by Alistakius (2016). Care should be given that the measuring test is measuring what is supposed to measure (validity), and that results are consistent (reliability) (Alistakius, 2016). All research hypotheses proposed in Chapter two of the study were therefore tested by the theoretical analysis of the previous evidence on technical efficiency of maize production.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents and discusses the results as the methodology outlined in chapter three. Section one discusses and outlines the descriptive statistics, with section two presenting the Logistic regression model and lastly section four which outlines the results from the Cobb-Douglas model.

4.2 Results

4.2.1 Descriptive Statistics

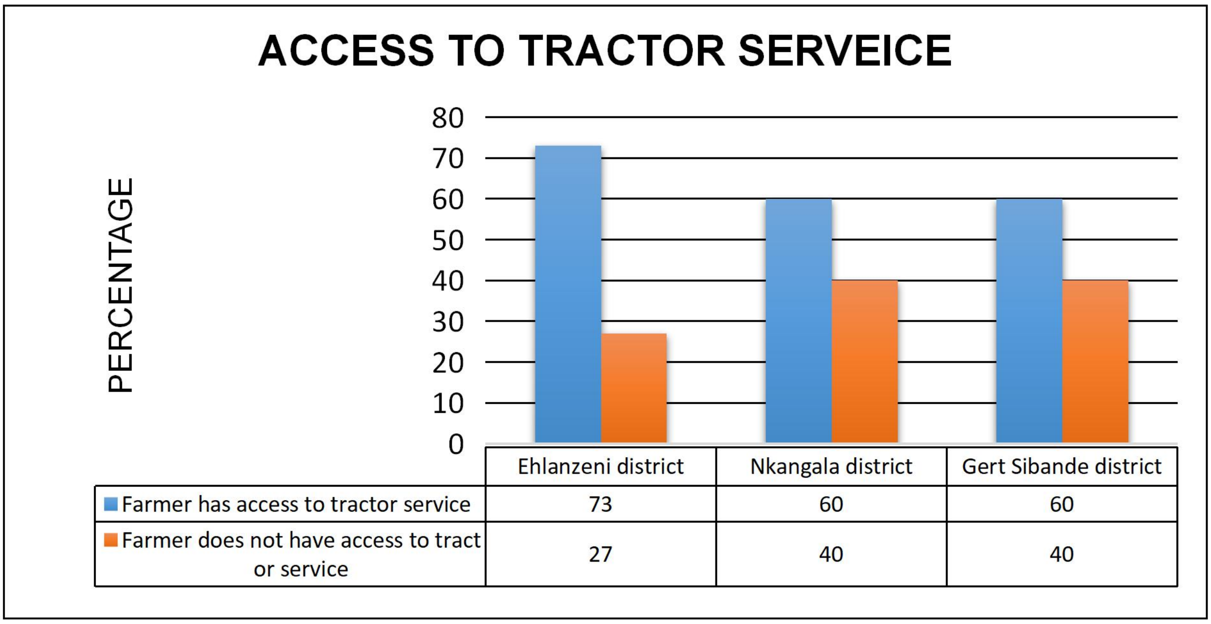

Figure 4.1: Pie chart indicating Farmer's Access to Tractor Service

Source: Field survey (2019)

Figure 4.1 shows that there is a huge gap between the number of farmers who have access to tractor service and those without access, especially in the Ehlanzeni district showing values of approximately 73 and 27 %, respectively. About 60% of small-scale maize farmers in both the Nkangala and Gert Sibande district have access to tractor service, with 40% without access.

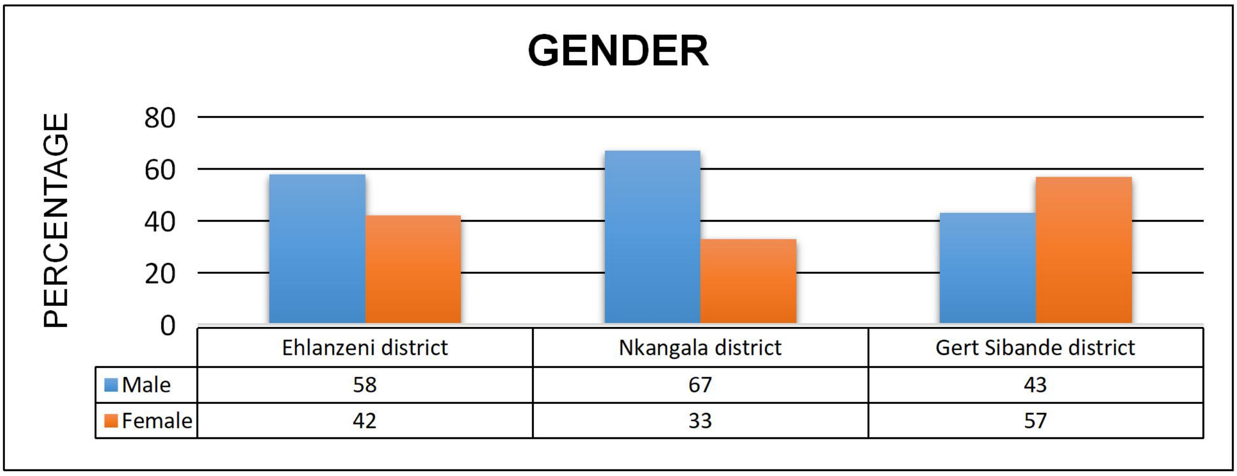

Figure 4.2: Bar Graph indicating Famer's Gender

Source: Field survey (2019)

Figure 4.2 indicates that there are more males participating in maize production than females. Out of the 41 sampled small-scale maize farmers, 58% in the Ehlanzeni district are male while 42% are female, and out of the 30 sampled farmers in Nkangala, 67% are female while 33% are male. Gender issues concerning woman empowerment in land ownership is still an on-going problem within the two districts. On the other hand, Gert Sibande had relatively more females participating in maize production than males, with values of about 57 and 43 %, respectively.

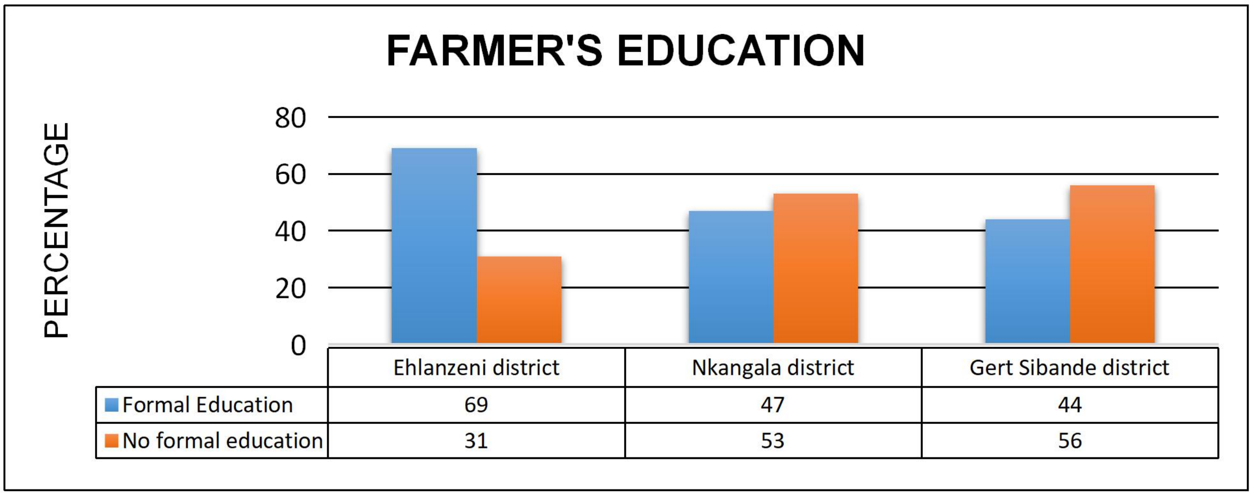

Figure 4.3: Pie Chart indicating Famer's Education

Source: Field survey (2019)

Results on Figure 4.3 show that 69% of the small-scale maize farmers in the Ehlanzeni district have formal education, with only 31% of them having an informal education. Thus; most of the farmers in the district are educated as opposed to the Nkangala and Gert Sibande district, both showing a relatively higher percentage of farmers who have informal education with values of 53 and 56%, respectively. Among the small-scale maize farmers falling within the formal education category in Ehlanzeni; 27% of them have primary education, 37% have secondary education, with only 5% that went further to tertiary level as depicted on the graph below. Moreover; approximately 4% of farmers in the Nkangala district went to primary, 33% have secondary level and only 10% went to tertiary level. While in the Gert Sibande district, only 20% of the farmers have primary education, 17% went to secondary level and only 7% went further to tertiary level.

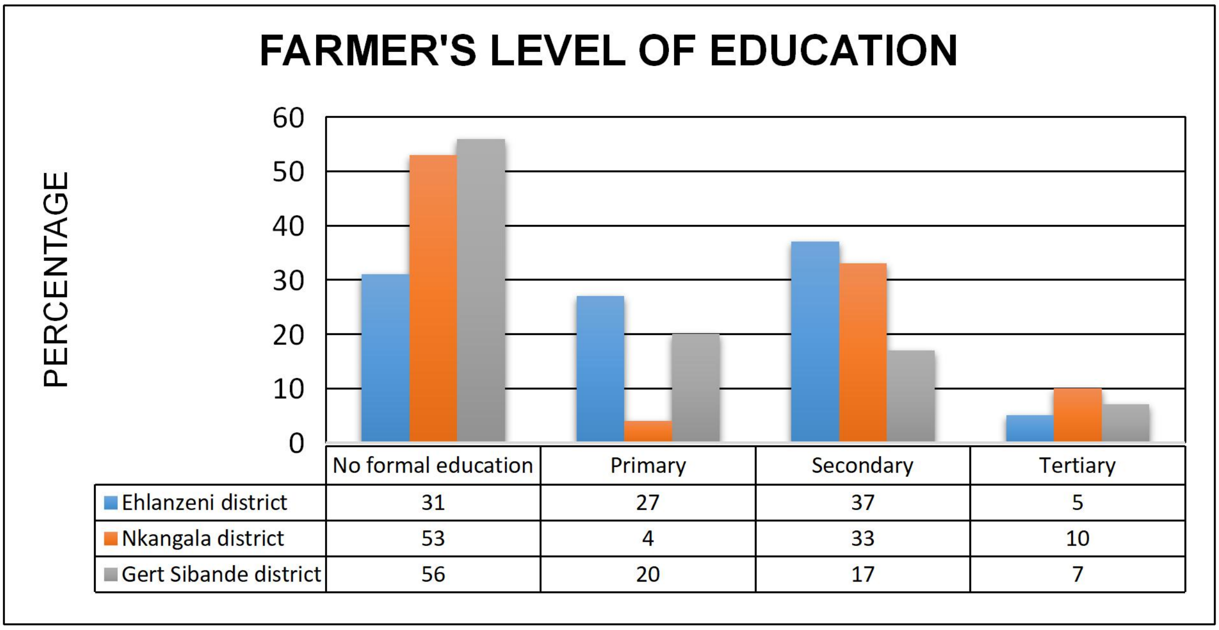

Figure 4.4: Bar Graph indicating Famer's Level of Education

Source: Field survey (2019)

Figure 4.5 below shows the descriptive statistic of extension visits received by small-scale maize farmers in the Mpumalanga province. Approximately 59% of farmers in Ehlanzeni, 57% in Nkangala and 63% in Gert Sibande receive extension visits, with about 41%, 43% and 37% that do not receive any; respectively. This is due to the fact that most farmers live in remote areas, making it difficult for them to access extension agents. Those part of a farmer's association are mostly at an advantage of receiving extension visits.

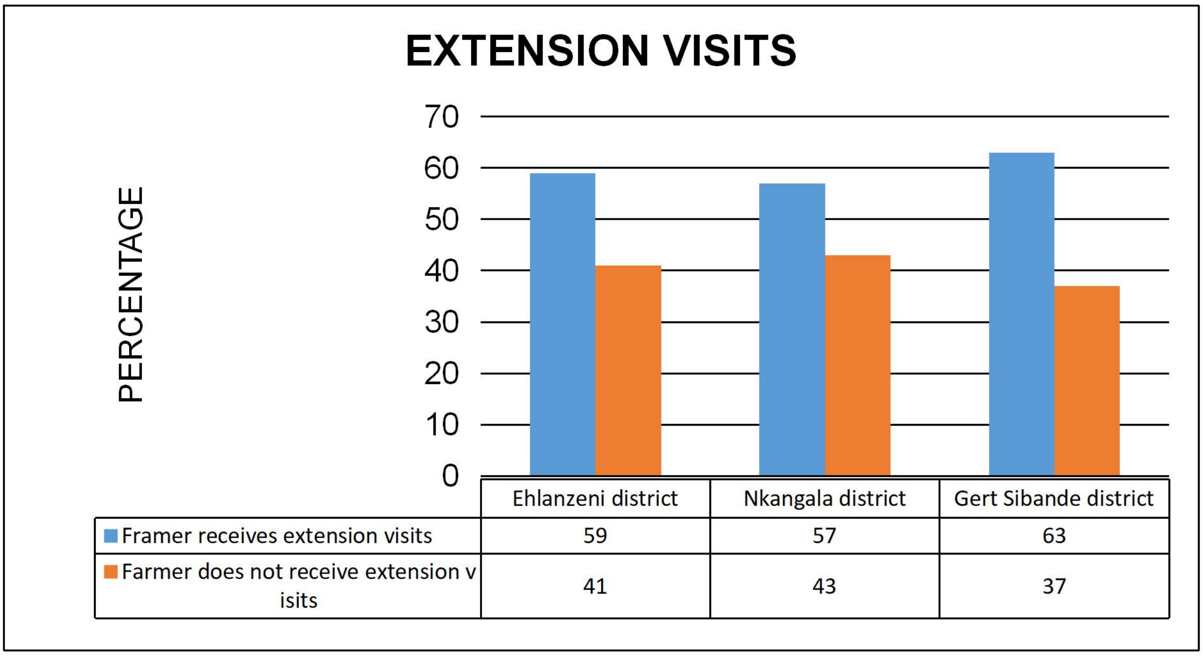

Figure 4.5: Bar Graph indicating Extension Visits

Source: Field survey (2019)

Results from Figure 4.6 depict that 54%, 67% and 50% of the small-scale maize farmers in the Ehlanzeni, Nkangala and Gert Sibande district of the Mpumalanga province irrigate maize; respectively. While those who do not irrigate rely solely on natural rainfall. Those that irrigate use the conventional furrow irrigation method drained from a borehole, and organised by the government. Farmers that are grouped together in a cooperative are at an advantage of accessing irrigation to ensure efficient use of water.

Figure 4.7 shows that out of the 41 sampled small-scale maize farmers in the Ehlanzeni district, 54% of the farmers do not own land, while 46% own it, and out of the 30 sampled farmers in the Nkangala and Gert Sibande district, 63 and 60% of them do not own land; respectively. Most of the farmers without full ownership access land through government leases, and those with full ownership obtain it either through inheritance or purchase.

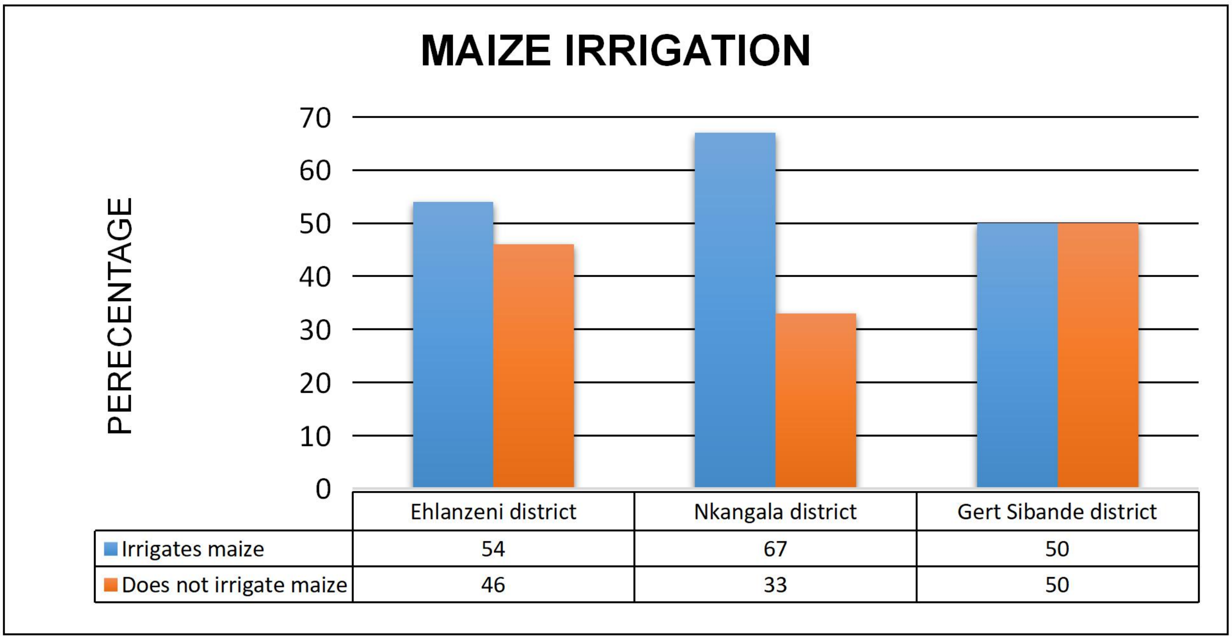

Figure 4.6: Bar Graph indicating Maize Irrigation

Source: Field survey (2019)

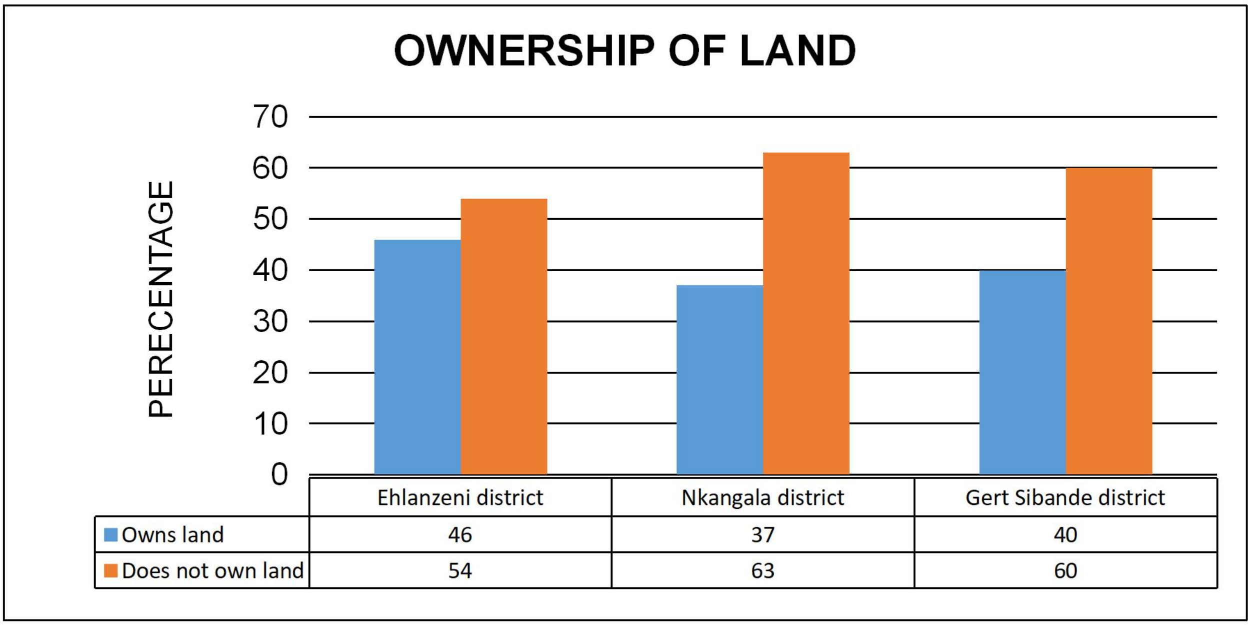

Figure 4.7: Bar Graph indicating Farmer's Ownership of Land

Source: Field survey (2016)

Figure 4.8 reveals that 54% of the small-scale farmers in the Ehlanzeni district are part of a farmer's association, while about 53% of farmers in both the Nkangala and Gert Sibande district are part of an association. This is attributed to the fact that farmers that obtained land through government leases are expected to utilize it productively, and thus; inducing them to participate in cooperatives for maximum production. Moreover; those that are grouped together make it easier for government to render inputs such as irrigation and extension agents, among other things, than farmers that are fragmented.

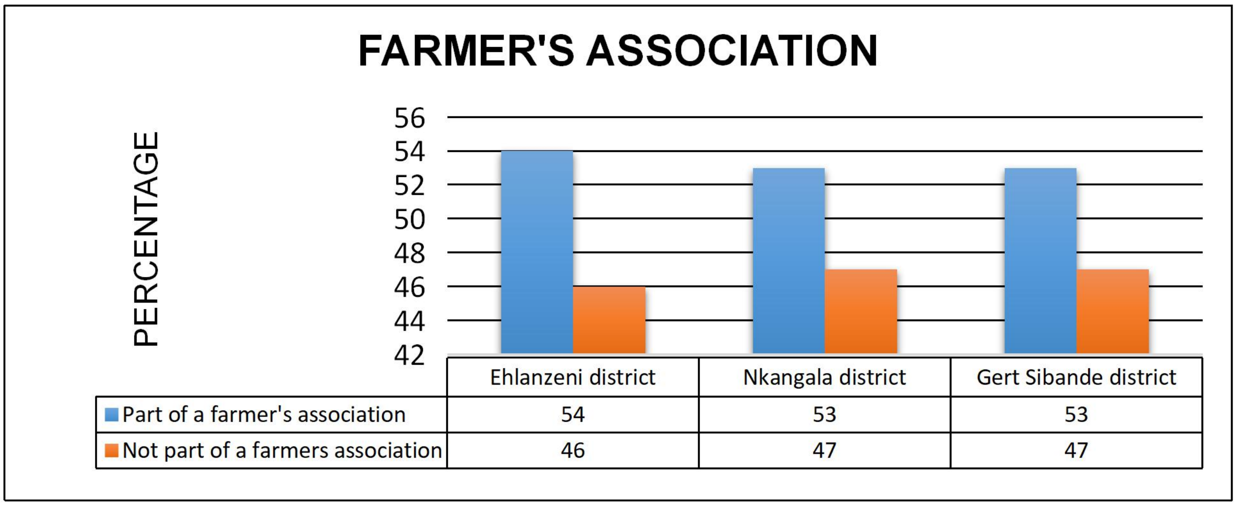

Figure 4.8: Bar Graph indicating Farmer Association

Source: Field survey (2019)

Figure 4.9-11 shows the farm size owned by farmers in the Ehlanzeni, Nkangala and Gert Sibande district. Results on Figure 4.9 illustrate that the majority of farmers (46%) in Ehlanzeni owned a farm or farms which were 1 hectare or below. Meanwhile, 37 percent of the respondents owned 2 hectares of farms, with the remainder owning between 3-4 hectares.

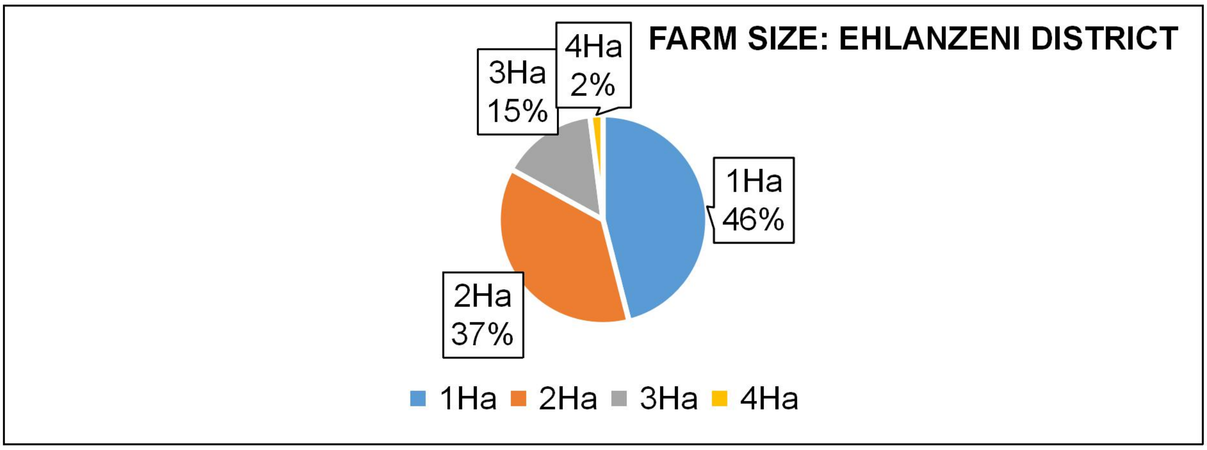

Figure 4.9: Pie chart indicating Farm Size

Source: Field survey (2019)

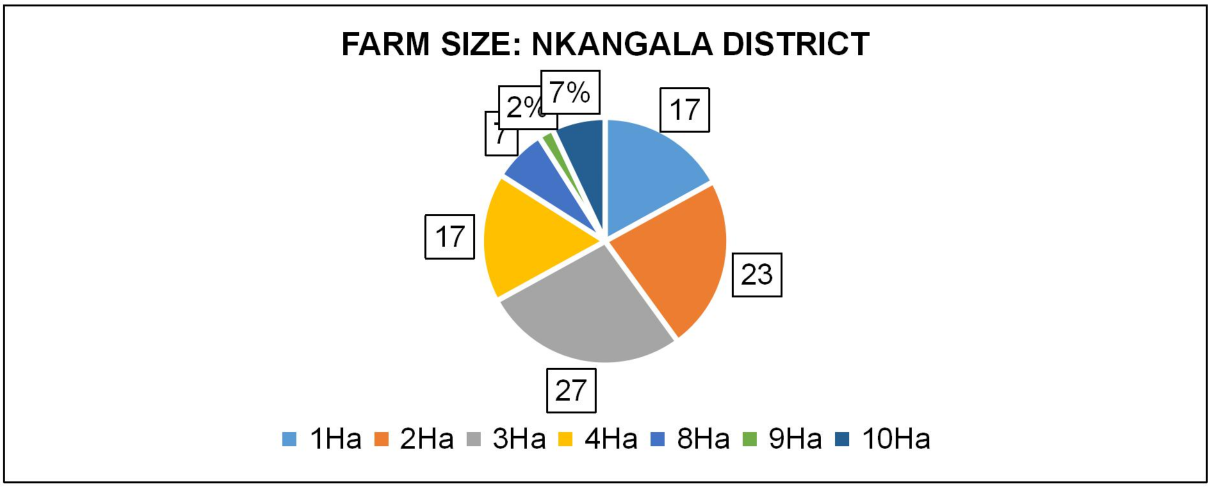

Figure 4.10: Pie chart indicating Farm Size

Source: Field survey (2019)

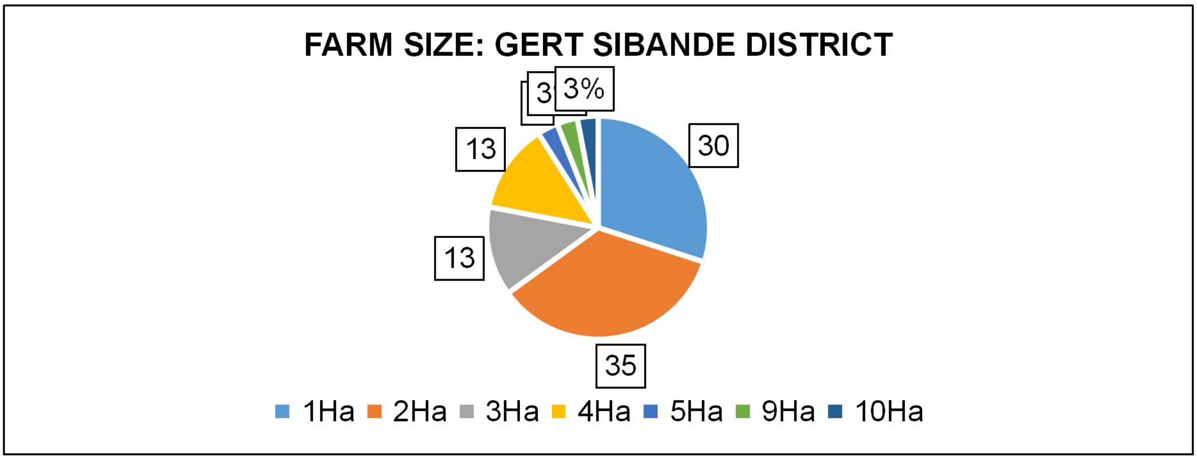

Figure 4.11: Pie chart indicating Farm Size

Source: Field survey (2019)

Table 4.1: Mean descriptive of variables

Source: Field survey (2019)

District	variables	Mean	Standard deviation
Ehlanzeni	Age (Years)	52.34	13.942
	HHS (Number)	5.68	2.392
Nkangala	Age (Years)	56.67	15.09
	HHS (Number)	7.23	3.55
Gert Sibande	Age (Years)	52.60	13.56
	HHS (Number)	6.93	2.75

The results on table 4.1 show that the average age of small-scale maize farmers in the Ehlanzeni, Nkangala and Gert Sibande district is 52.34, 56.67, 52.60; respectively. This implies that majority of farmers within the districts are older. Household size plays an important role in maize production through the provision of labour. The average household size in all districts is 5.68, 7.23 and 6.93; respectively, which reflects 6-7 members per household.

4.2.2 Logistic regression Analysis: EHLANZENI DISTRICT

Table 4.2: Logistic Regression Analysis

Variables	Coefficient	Standard error	Walt Statistics	Significance
GENDF	2.9868*	1.785	2.800	0.094
AGEF	0.024	0.068	0.127	0.722
FEDU	1.153	.878	1.724	0.189
FARMS	-0.669	1.170	.327	0.567
HHS	-0.924*	.501	3.396	0.065
EXTV	3.480	2.257	2.378	0.123
IRR	4.107*	2.165	3.597	0.058
OWNL	-4.191*	2.213	3.586	0.058
FASS	0.975	1.659	.345	0.557
Constant	1.486	3.911	.144	0.704
-2 log Likelihood			21.08	
Chi-Square			26.61	
Pseudo R square			0.69	
Error term			0.31	

*Sig at 10%, **Sig at 5%, ***Sig 1% Source: Author's analysis (2019)

Pseudo R-square value measures how close the data is to the fitted regression line. As can be seen from Table 4.2 the value for the Pseudo R-square is 0.69 and this implies that the model explains 69 percent variability of the response data around its mean.

Significant variables

The probability of farmers' access to tractor service is directly influenced by farmers' gender (GENDF), irrigation (IRR), farmers' ownership of land (OWNL) and household size (HSIZE).

4.2.2.1 Irrigation

The coefficient of IRR=4.107 was found to be positively significant at 10% level, implying that farmers who irrigate maize are more likely to have access to tractor service than those without access. The results concur with (Mabuza *et al*., 2012), who found irrigation to be statistically significant in Swaziland, suggesting that households who produce maize under irrigation are more likely to use improved cultivation methods.

4.2.2.2 Gender

The coefficient of GENDF=2.9868, was found to be positively significant at 10% level, entailing that a unit increase in the number of males participating in maize production is likely to increase farmers' access to tractor service. This also implies that the access to tractor in the Ehlanzeni district of the Mpumalanga province depends on gender, making the use of the input unequally beneficial to both men and women (Mabuza *et al.*, 2012).

4.2.2.3 Ownership of land

On the contrary, the coefficient of OWNL= 4.191, was found to be negatively significant at 10% level, implying that farmers who own land are less likely to have access to tractor service. Ownership of land is one of the criteria used by government to render tractor service; those that obtain land through government leases are likely to have access to various inputs as opposed to farmers that have full ownership of land either through inheritance or purchase.

4.2.2.4 Household size

The coefficient of HSIZE=0.924 was also found to be negatively significant at 10% level, suggesting that households with more members are less likely to have access to tractor service. This is attributed to land fragmentation, an increase in household size oblige farmers to divide their land to balance agriculture and settlement to an extent that the agricultural land becomes too small to use mechanization (Kiprop *et al.*, 2015).

4.2.2.5 Areas of Improvement with regard to Farmer's Access to Tractor service

The results in Table 4.2 demarcate the variables age, farmer's level of education, extension visits and farmer association to be positively insignificant towards access to tractor service in Ehlanzeni district, with farm size being negatively insignificant. This implies that the above mentioned variables do not affect small-scale maize farmer's access, and that there is a need to ensure the provision of education, extension visits as well as encourage farmer associations for maximum access to tractor service.

4.2.3 Cobb-Douglas production function Analysis: EHLANZENI DISTRICT

Table 4.3: Summary Statistics of Technical Efficiency

Variable	***N***	**Mean =** $[\frac{sum\ of\ technical\ efficiency\ ratios}{total\ sample\ size}]$
Technical Efficiency	41	$\frac{0.68+0.27}{2} = 0.48$
Access to tractor service	30	$\frac{27,92}{41} = 0.68$
No Access to tractor service	11	$\frac{10.97}{41} = 0.27$

It is observed that on average, small-scale maize farmers with access to tractor service have significantly higher technical efficiency level (0.68) compared to those without access (0.27) as depicted on table 4.3 above. Average technical efficiency across variables is 0.48. This implies that access to tractor service has implications for fluctuations in maize output in the district of Ehlanzeni. However; the results are not sufficient to make an accurate conclusion of the effect of access to tractor service on technical efficiency of small-scale maize farmers. Efficiency gains may be due to other observable factors.

Table 4.4: Empirical results from Cobb-Douglas production function model

Variables	Coefficient of elasticity	Standard error	t-ratio
Constant		1.349	4.390
ACCTS (dummy)	-0.102	0.079	1.437
HHS (Number)	0.004	0.078	0.054
FERT (kg)	0.033	0.191	0.406
LAND (Ha)	0.846***	0.201	4.639
SEEDS (kg)	0.125	0.109	0.728
LANDFRG (Number)	-0.152*	0.196	1.861
Sum of b's	0.754		
Adjusted R^2	0.82		

*Sig at 10%, **Sig at 5%, ***Sig 1% Source: Author's analysis (2019)

4.2.3.1 Elasticity of production

Empirical results from the Cobb-Douglas production function on Table 4.4 depict an adjusted R^2 of 0.82, entailing that the explanatory variables in the model explain approximately 82% of the variation in maize production in the Ehlanzeni district of the Mpumalanga province. It is fair to state that the variables included in the model highly influence the dependent variable, as only 18 percent is unexplainable.

The production frontier model indicates that maize production is significantly associated with land fragmentation and land:-

4.2.3.1.1 Land fragmentation

The elasticity of land fragmentation is negatively significant towards maize output (as expected) at 10% significance level. The coefficient on the variable (0.152) means that when land fragmentation increases by 1 percent, holding all other inputs constant, maize output would also decrease by about 0.152%. These results concur with Kiprop's *et al.* (2015) findings, who also found land fragmentation to be negatively significant. Due to the absence of land; farmers are obliged to use some of the agricultural land when socio-economic problems such as population size arise, making it uneconomical to increase output.

4.2.3.1.2 Land

This variable was positively significant at 1% significance level and had the highest partial elasticity of 0.846. Implying that a 1 percent increase in land or farm size would increase maize output by 0.846%, holding all other variables constant. Land has always been an important factor in agricultural production, evident by findings from various scholars who also found land to be positively significant, that is, Abdallah and Abdul-Rahman (2017), Alistakius (2016), Baloyi (2011), and Sapkota *et al.* (2017).

4.2.3.1.3 Access to tractor service

The aim of the study was to analyse the effect of access to tractor service on technical efficiency. The results demarcate that access to tractor service has a negative effect on technical efficiency of small-scale maize farmers in the Ehlanzeni district. The elasticity of access to tractor service is unexpectedly negative but insignificant with a coefficient value of 0.102, which is relatively low. An increase in the variable by 1 percent, would decrease maize output by only 0.102%, ceteris paribus. Evident that the input (tractor service) is vital for agricultural production. The probable reason for the negative and insignificant effect of access to tractor service rendered by Masibuyele Emasimini on technical efficiency of maize production may be due to land-use intensification. Martey *et al.* (2015) stated that the relatively high partial elasticity value on land reflects the high land-use intensity. Land was found positively significant with a highest elasticity value of 0.846 as demarcated on table 4.4 above. Land intensification occurs when output is increased with an increase in production inputs, that is, labour, seeds, fertilizers or the use of modern technology such as tractor without increasing farm size (Martin *et al*., 2018). The overuse of tractor or machinery on a specific plot leads to soil compaction (Kanianska, 2016), wherein soil particles are packed closely together reducing the volume of air, making it difficult for the soil to absorb rainfall and eventually leading to a decline in the quantity of maize produced due to land pressure. Hence, the negative and insignificant effect between access to tractor service and technical efficiency of maize production.

4.2.3.1.4 Household size, fertiliser and seeds

Household size, fertiliser and seeds are all positively insignificant, with partial production elasticities of 0.004, 0.033, and 0.125, respectively. Meaning that a percent increase in these variables, would increase maize output by 0.004%, 0.033%, and 0.125%, respectively, holding all other variables constant.

4.2.3.2 Returns to scale

As outlined in chapter three of the study, returns to scale is estimated as the sum of partial elasticity of output with respect to each input. A value of scale efficiency equal to one $\alpha+\beta=1$ implies that the firm is efficient and indicates constant returns to scale, $\alpha+\beta<1$ implies inefficiency and decreasing returns to scale, while $\alpha+\beta>1$ indicates increasing returns to scale (Alemdar and Oren, 2006). Table 4.4 above indicates a returns to scale of 0.754, which represents a decreasing returns to scale for maize production.

The descriptive statistics above, indicated that more farmers have access to tractor service with a value of 73% as opposed to those without access. This implies that even with higher access to tractor service within the Ehlanzeni district, small-scale farmers are still operating in stage three of the production function. An increase in the use of variable inputs over a fixed bundle of resources leads to a less than proportionate increase in output. The cost per unit of tractor used in the production process is more than the return on maize output. Farmers are over-utilising inputs which makes them technically inefficient in the production of maize, and thus; need to cut costs by using less inputs.

4.2.4 Logistic regression Analysis: NKANGALA DISTRICT

Table 4.5: Logistic Regression Analysis

Variables	Coefficient	Standard error	Walt Statistics	Significance
GENDF	2.323	2.514	0.854	0.356
AGEF	0.010	0.062	0.027	0.870
FEDU	1.764*	1.016	3.017	0.082
FARMS	0.073	0.463	0.025	0.874
HHS	-0.430**	0.216	3.951	0.047
EXTV	2.928	1.838	2.538	0.111
IRR	0.182	1.700	0.011	0.415
OWNL	-3.634*	2.105	2.982	0.084
FASS	0.488	1.390	0.123	0.726
Constant	-1.625	6.245	0.068	0.795
-2 log Likelihood			20.045	
Chi-Square			20.335	
Pseudo R square			0.67	
Error term			33	

*Sig at 10%, **Sig at 5%, ***Sig 1% Source: Author's analysis (2019)

Pseudo R-square value measures how close the data is to the fitted regression line. As can be seen from Table 4.5 above the value for the Pseudo R-square is 0.67 and this implies that the model explains 67 percent variability of the response data around its mean.

Significant variables

The probability of farmers' access to tractor service is influenced by farmers' level of education (FEDU), farmers' ownership of land (OWNL) and household size (HSIZE).

4.2.4.1 Farmer's level of education

The coefficient of FEDU=1.764 was found to be positively significant at 10% significance level, entailing that farmers who are educated are more likely to have access to tractor service in the Nkangala district. Education enhances the ability of farmer's to communicate with suppliers and service providers such as tractor operators, concerning tilling and ploughing activities. Moreover; educated farmers are also able to write motivational letters to government outlining the need for tractor service.

4.2.4.2 Ownership of land

On the contrary, the coefficient of OWNL= 3.636, was found to be negatively significant at 10% level, implying that farmers who own land in the Nkangala district are less likely to have access to tractor service. These results concur with those found in Ehlanzeni district, which also revealed a negatively significant variable (ownership of land) at 10% level.

4.2.4.3 Household size

The coefficient of HSIZE=0.430 was also found to be negatively significant at 5% significance level, suggesting that households with more members are less likely to have access to tractor service. Household size is also an important source of labour, thus; households with a large number of household members are likely to use human power by the use of hoes (Savadogo *et al.*, 1998) Mabuza *et al.* (2012), as opposed to those with less members.

4.2.4.4 Areas of Improvement with regard to Farmer's Access to Tractor service

The results in Table 4.5 demarcate the variables gender, age, farm size, extension visits, farmer association and irrigation to be positively insignificant towards access to tractor service in the Nkangala district. This implies that the above mentioned variables do not affect small-scale maize farmer's access, and that there is a need to ensure their provision for maximum access to tractor service.

4.2.5 Cobb-Douglas production function Analysis: NKANGALA DISTRICT

Table 4.6: Summary Statistics of Technical Efficiency

Variable	***N***	**Mean =** $[\frac{sum\ of\ technical\ efficiency\ ratios}{total\ sample\ size}]$
Technical Efficiency	30	0.49
Access to tractor service	18	$\frac{18.09}{30} =$ 0.60
No Access to tractor service	12	$\frac{11.09}{30} =$ 0.37

The average technical efficiency for small-scale maize farmers with access to tractor service in the Nkangala district is 0.60, about 23% higher than farmers without access to tractor service as depicted on table 4.6 above, while average technical efficiency is approximately 0.49. This implies that access to tractor service has implications for fluctuations in maize output in the district of Nkangala. The results are however not sufficient to make an accurate conclusion of the effect of access to tractor service on technical efficiency of small-scale maize farmers. Efficiency gains may be due to other observable factors.

Table 4.7: Empirical results from Cobb-Douglas production function model

Variables	Coefficient of elasticity	Standard error	t-ratio
Constant		1.115	0.452
ACCTS (dummy)	-0.046	0.232	0.340
HHS (Number)	-0.017	0.229	0.125
FERT (kg)	0.307*	0.219	2.047
LAND (Ha)	0.736***	0.176	5.205
SEEDS (kg)	-0.095	0,203	0.579
LANDFRG (Number)	-0.037	0.404	0.281
Sum of b's	0.848		
Adjusted R^2	0.594		

*Sig at 10%, **Sig at 5%, ***Sig 1% Source: Author's analysis (2019)

4.2.5.1 Elasticity of production

Empirical results from the Cobb-Douglas production function on Table 4.7 depict an adjusted R^2 of 0.59, entailing that the explanatory variables in the model explain approximately 59 percent of the variation in maize production in the Gert Sibande district of Mpumalanga province. The variables included in the model fairly influence the dependent variable, as 41 percent is the error term.

4.2.5.1.1 Land

The elasticity of land is positively significant at 1% significance level and has the highest partial elasticity of 0.736, similarly to the Ehlanzeni districts' results that also revealed a positively significant land elasticity of (0.846). This implies that a 1 percent increase in farm size (in the Nkangala district), would increase maize output by 0.736%, holding all other variables constant. It is clear that land is an indispensable resource in Mpumalanga's agricultural-maize production.

4.2.5.1.2 Fertilizer

The elasticity coefficient of fertilizer was found to be positive and significant at 10% level, with a coefficient value of 0.307. This indicates that small-scale maize farmers in the Nkangala district are under-utilising the input, hence; a 1 percent increase in fertilizer would increase maize output by 0.307%, ceteris paribus.

4.2.5.1.3 Access to tractor service

Similarly to the Ehlanzeni district; access to tractor service also revealed an unexpected negative and insignificant elasticity of production with a coefficient value of 0.046 in Nkangala. An increase in output by 1 percent, would decrease maize output by 0.046%, relatively lower than that of the Ehlanzeni, which decreased maize output by 0.102%. Evident that tractor is also an important input for maize production in Nkangala district as output decreases only by a small percentage.

Access to tractor service in the district is positively influenced by farmer's education, therefore; to increase efficiency levels government officials should implement educational programs for the elderly where they are taught how to read and write, which will further enable them to manage their farms.

4.2.5.1.4 Household size, Land fragmentation and seeds

Household size, land fragmentation and seeds are all negatively insignificant, with partial production elasticities of 0.017, 0.037 and 0.095, respectively. Land fragmentation occurs when people operate a number of non-contiguous plots at the same time. It depends mainly on factors such as market factors, external policy, agro-ecological conditions and socio-economic characteristics. Socio-economic characteristics such as household size oblige farmers to divide their land to balance agriculture and settlement, to an extent that the agricultural land becomes too small to sustain agricultural practices and therefore leading to a decline in agricultural productivity (Kiprop *et al.*, 2015). So an increase in household size, leads to land fragmentation making it difficult and uneconomical to use mechanical inputs such as tractor, thus leading to inefficient maize production. The negative relationship between seeds and maize production may be due to delays in weeding the maize field.

4.2.5.2 Returns to scale

Table 4.7 above indicates a returns to scale of 0.848, which represents a decreasing returns to scale. This implies that small-scale maize farmers in Nkangala district are operating in stage three of the production function, that is, an increase in the use of variable inputs over a fixed bundle of resources leads to a less than proportionate increase in output.

The descriptive statistics above, indicated that more farmers have access to tractor service with a value of 60% as opposed to those without access. Therefore; this implies that even with higher access to tractor service within the district, small-scale farmers are still operating in stage three of the production function. The cost per unit of tractor used in the production process is more than the return on maize output. Farmers are over-utilising inputs on small plots of land which makes them technically inefficient in the production of maize, and thus; need to cut costs using less inputs.

4.2.6 Logistic regression Analysis: GERT SIBANDE DISTRICT

Pseudo R-square value measures how close the data is to the fitted regression line. Table 4.8 below indicates a Pseudo R-square value of 0.73; implying that the model explains 73 percent variability of the response data around its mean.

Significant variables

The probability of farmers' access to tractor service in the Gert Sibande district of the Mpumalanga province is directly influenced by farmers' education level (FEDU), irrigation (IRR), and farmer's association (FASS).

4.2.6.1 Irrigation

The coefficient of IRR=5.723 was found to be positively significant at 10% level, implying that farmers who irrigate maize are more likely to have access to tractor service. The results concur with (Mabuza *et al.*, 2012), who found irrigation to be statistically significant, suggesting that households who produce maize under irrigation are more likely to use improved cultivation methods.

Table 4.8: Logistic Regression Analysis

Variables	Coefficient	Standard error	Walt Statistics	Significance
GENDF	-0.201	2.573	0.006	0.938
AGEF	0.261	0.189	1.893	0.169
FEDU	5.580*	3.255	2.938	0.087
FARMS	0.639	0.565	1.278	0.258
HHS	0.007	0.349	0.000	0.985
EXTV	2.603	2.169	1.439	0.230
IRR	5.723*	3.333	2.047	0.086
OWNL	-3.938	2.699	2.130	0.144
FASS	7.650**	3.729	4.210	0.040
Constant	-30.199	19.396	2.424	0.199
-2 log Likelihood			17.089	
Chi-Square			23.29	
Pseudo R square			0.73	
Error term			27	

*Sig at 10%, **Sig at 5%, ***Sig 1% Source: Author's analysis (2019)

4.2.6.2 Farmer's Level Education

Similarly, the coefficient of FEDU=5.580 was also found to be positively significant at 10% significance level, entailing that farmers who are educated are more likely to have access to tractor service in the Gert Sibande district. Education enhances the ability of farmer's to communicate with suppliers and service providers such as tractor operators, concerning tilling and ploughing activities.

4.2.6.3 Farmer's Association

Farmer's association also had an expected positive sign with a coefficient of 7.650 and significant at 5% significance level. Implying that farmers who are part of a farmer's association are more likely to have access to tractor service in the Gert Sibande district. Farmer's that are grouped together make it easy for the government to access them, and are also able to use inputs efficiently than fragmented farmers.

4.2.6.4 Areas of Improvement with regard to Farmer's Access to Tractor service

The results in Table 4.8 demarcate the variables age, farmer size, household size and extension visits to be positively insignificant towards access to tractor service in Gert Sibande district, with gender and ownership of land being negatively insignificant. This implies that the above mentioned variables do not affect small-scale maize farmer's access, and that there is a need to ensure the provision of land and extension visits for maximum access to tractor service. Land should also be made available to women than men, to enhance access of government inputs in the Gert Sibande district.

4.2.7 Cobb-Douglas production function Analysis: GERT SIBANDE DISTRICT

Table 4.9: Summary Statistics of Technical Efficiency

Variable	***N***	**Mean =** $[\frac{sum\ of\ technical\ efficiency\ ratios}{total\ sample\ size}]$
Technical Efficiency	30	0.5
Access to tractor service	18	$\frac{17.96}{30} =$ 0.60
No Access to tractor service	12	$\frac{12.14}{30} =$ 0.40

Table 4.9 above shows the average technical efficiency for small-scale maize farmers who have access to tractor service in the Gert Sibande district; which is 0.60. About 20% higher than farmers without access to tractor service, while average technical efficiency is approximately 0.5. The results however; are not sufficient to make an accurate conclusion of the effect of access to tractor service on technical efficiency of small-scale maize farmers. Efficiency gains may be due to other observable factors as depicted on table 4.10 below.

Table 4.10: Empirical results from Cobb-Douglas production function model

Variables	Coefficient of elasticity	Standard error	t-ratio
Constant		1.660	5.285
ACCTS (dummy)	0.076	0.339	0.690
HHS (Number)	-0.178	0.406	1.624
FERT (kg)	-0.289**	0.264	2.169
LAND (Ha)	0.949***	0.349	6.331
SEEDS (kg)	0.086	0.160	0.671
LANDFRG (Number)	-0.046	0.642	0.415
Sum of b's	0.598		
Adjusted R^2	0.67		

*Sig at 10%, **Sig at 5%, ***Sig 1% Source: Author's analysis (2019)

4.2.7.1 Elasticity of production

Empirical results from the Cobb-Douglas production function on Table 4.14 depict an adjusted R^2 of 0.67, entailing that the explanatory variables in the model explain approximately 67 percent of the variation in maize production in the Gert Sibande district of the Mpumalanga province. The variables included in the model fairly influence the dependent variable, as 33 percent is unexplainable.

4.2.7.1.1 Land

The elasticity of land is positively significant at 1% significance level and has the highest partial elasticity of 0.949, similarly to the Ehlanzeni and Nkangala districts' results that both revealed a positively significant land elasticity of 0.846 and 0.736, respectively. This implies that a 1 percent increase in farm size in the Gert Sibande district, would increase maize output by 0.949%, holding all other variables constant.

4.2.7.1.2 Fertilizer

The elasticity coefficient of fertilizer was found to be negative and significant at 5% significance level, with a value of 0.289. This indicates that small-scale maize farmers are over-utilising the input, and thus; a 1 percent increase in fertilizer would decrease maize output by 0.289%, ceteris paribus.

4.2.7.1.3 Access to tractor service

The variable access to tractor service revealed an expected positive but insignificant elasticity of production with a coefficient value of 0.076. An increase in the variable by 1 percent, would increase maize output by only 0.076%, ceteris paribus. Although maize output increases by a small percentage with an increase in the use of the variable; access to tractor service has a positive effect on technical efficiency of small-scale maize farmers in the Gert Sibande district. Therefore; to increase efficiency more tractors need to be rendered and made available by encouraging participation in farmer's associations, provision of modern irrigation methods and enhancing education as outlined by Logistic regression results in Table 4.12 above.

4.2.7.1.4 Household size, Land fragmentation and seeds

Household size and land fragmentation are both negatively insignificant, with partial production elasticities of 0.178 and 0.046, respectively, while seeds were found influencing maize output positively, although insignificant.

4.2.7.2 Returns to scale

Table 4.14 above indicates a returns to scale of 0.598, which represents a decreasing returns to scale. This implies that small-scale maize farmers in the Gert Sibande district are operating in stage three of the production function, that is, an increase in the use of variable inputs over a fixed bundle of resources leads to a less than proportionate increase in output.

The descriptive statistics above, indicated that more farmers have access to tractor service with a value of 60% as opposed to those without access. The variable also positively influences maize production (although insignificant) with a coefficient value of 0.076. However; even with higher access small-scale farmers are still operating in stage three of the production function. Entailing that an increase in the use of variable inputs over a fixed bundle of resources leads to a less than proportionate increase in output. The cost per unit of input used in the production process is more than the return on maize output. This could imply that farmers are over-utilising tractor, among other variables, on small hectares of land which makes them technically inefficient in the production of maize, and thus; need to cut costs by using less inputs.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter provides a summary of the findings derived in chapter four, as well as the extent to which objectives and hypotheses outlined at the beginning of the study have been addressed and finally provides recommendations based on the results.

5.2 Summary

The aim of the study was to analyse the effect of access to tractor service on technical efficiency of small-scale maize farmers in the Mpumalanga province: A case study of Masibuyele Emasimini, with the following objectives: (i) to assess the socio-economic characteristics of small-scale maize farmers among the three districts, (ii) analyse socio-economic factors influencing small-scale maize farmers' access to tractor service in the Mpumalanga Province, and (iii) to measure technical efficiency of farmers who have access to tractor service. A set of analytical techniques were used, namely, the Descriptive statistics, Logistic regression and Cobb-Douglas production function model, wherein significant variables were identified for each district (Ehlanzeni, Nkangala and Gert Sibande district).

The descriptive statistics demarcated that some of the small-scale maize farmers in the Mpumalanga province have access to tractor service, while some do not, with the Ehlanzeni district having a larger gap between the number of farmers who have access and those without. Most of them obtain land from the Traditional authority and government through leases and have large household sizes, with approximately 7 members per household. Majority of the farmers in the province own 1 to 3 hectares of land, and are mostly male.

The Logistic regression model was employed to analyse socio-economic factors influencing small-scale maize farmers' access to tractor service. Results indicate that there are socio-economic factors influencing small-scale maize farmers' access to tractor service per district. These are; Ehlanzeni: Irrigation, Gender, Ownership of land and Household size. Nkangala: Farmer's level of Education, Household size and Ownership of land. Gert Sibande: Irrigation, Farmer's association and Education. These factors were found to be significant, although some showed a negative relationship towards access to tractor service.

The Cobb-Douglas production function model was used to measure technical efficiency of farmers who have access to tractor service. The model revealed land to be a significant and indispensable input towards maize output with a high partial elasticity for all three districts. Land fragmentation and fertilizer were also significant, however, depicting different signs for each district. Access to tractor service had a negative and insignificant effect on technical efficiency of small-maize farmers in both the Ehlanzeni and Nkangala district, and had a positive effect (although insignificant) in Gert Sibande.

Table 5.1: Summary of returns to scale estimates across the three districts of the Mpumalanga province.

Source: Author's Analysis (2019)

District	**Sum of b's**	**Returns to scale**
Ehlanzeni	0.754	Decreasing
Nkangala	0.848	Decreasing
Gert Sibande	0.598	Decreasing

Table 5.1 above clearly indicates that small-scale maize farmers in the Mpumalanga province are experiencing decreasing returns to scale and operating at stage three of the production function. Production inputs are over-utilised and are adding less and less to total output.

5.3 Conclusion

Hypothesis 1: Socio-economic characteristics of small-scale maize farmers do not differ among the three districts. The hypothesis is rejected as descriptive results in chapter four above demonstrated differences in socio-economic characteristics among farmers per district. with access and without access to tractor services. For example, the bar graph in Figure 4.3 of the descriptive results showed that farmers in the Ehlanzeni district were more educated as opposed to those in the Nkangala and Gert Sibande district, both showing a relatively higher percentage of farmers who have informal education with values of 53 and 56%, respectively.

Hypothesis 2: Socio-economic factors of maize small-scale farmers do not influence access to tractor services in the Mpumalanga province. The hypothesis is rejected as the empirical results show a positive influence of socio-economic factors towards access to tractor service. Variables that were found significant are: Irrigation, ownership of land, gender, household size, farmer's association and level of education.

Hypothesis 3: Access to tractor service does not have an effect on the technical efficiency of small-scale maize farmers. The hypothesis is also rejected as empirical results revealed that those with access to tractor service were technically inefficient in both the Ehlanzeni and Nkangala district, and efficient in the Gert Sibande district. Moreover; average technical efficiency levels for small-scale maize farmers with access to tractor service was higher than those without access in all districts. The average technical efficiency for farmers with access to tractor service in Ehlanzeni district was 0.68 and 0.60 for both the Nkangala and Gert Sibande district, compared to 0.27, 0.37, and 0.40 without access, respectively.

In general, the study concludes that access to tractor service rendered by the programme has a negative effect on technical efficiency, and that farmers' access can be determined through the influence of certain socio-economic factors.

5.4 Recommendations

The findings obtained in this study (chapter four) could be useful to policy makers and the recommendations discussed below are based on those findings. The recommendations are discussed per district as not all districts require the same inputs or factors for efficient maize production.

Ehlanzeni District

The study's findings revealed that there is a negative relationship between household size and access to tractor service. Based on the results, it is clear that larger-sized households would prefer using man-power or conventional methods such as hoes and animal draught than small-sized households. The negative relationship between the two variables is also attributed to land fragmentation. According to Kiprop *et al.* (2015); an increase in the number of household members obliges the farmer to divide the land in order to balance both agriculture and human settlement to an extent that the agricultural land because too small and uneconomical to use tractor. All these limit the access to tractor service, which in turn leads to inefficient maize production of small-scale farmers in the Ehlanzeni district.

Local municipalities within the district should implement a program wherein health specialists visit communities/villages on a monthly basis to give advice on family planning. This will control birth rates, and ultimately reduce household size. Households who practice land fragmentation are mostly those who received agricultural land through inheritance rather than government leases.

Land size had a positive and significant effect on maize production in all districts of the province. Thus; government should start distributing land of at-least 2 hectares to ensure efficient use of machinery and prevent the overuse of production inputs on small plots of land. Land that was once used for production, and then inherited by a family member due to death of the owner should be surrendered to government if it is left purposeless or undeveloped after the deceased, and further distributed to potential farmers through leases. Tractor services should also not only be rendered to those that obtained land from the government, but also to farmers who purchased and inherited land to influence maximum and efficient maize production.

The study observed a positive relation between gender and access to tractor service, with male farmers having more access than females, yet; the variable (access to tractor service) was found to have a negative effect on maize production. Clearly, implying that the input (tractor) is unbeneficial to women and that policies towards women empowerment be implemented. Gender practitioners, government and non-government organisations (NGO's) should also play a role in advocacy, raising awareness and lobbying against gender inequality as well as the wrong perceptions that society has on women (Abdulai *et al*., 2013).

Irrigation was also found to be positively significant implying that farmers who irrigate maize are more likely to have access to tractor service. The results concur with (Mabuza *et al*., 2012), who found irrigation to be statistically significant, suggesting that households who produce maize under irrigation are more likely to use improved cultivation methods. Most farmers in the district irrigate their maize through the furrow irrigation method (if not rain), which requires lower initial investment of equipment and pumping costs per acre-inch of water pumped. However; it includes greater labour costs and lower application efficiency compared to the more modern irrigation systems such as the sprinkler and drip irrigation. The Masibuyele Emasimini programme should therefore; include the provision of modern irrigation systems (preferably, sprinkler) as part of its input list to contribute towards efficient maize production. These sprinklers will be placed on land owned by the government and monitored by extension officers.

Nkangala District

Results demarcated that farmer’s level of education enhances the access to tractor service by small-scale maize farmers in the Nkangala district. About half of the farmers in the district have formal education, with most of them falling within the secondary level category. Education enhances the ability of farmer’s to communicate with suppliers and service providers such as tractor operators, concerning tilling and ploughing activities. Moreover; educated farmers are also able to write motivational letters to government outlining the need for tractor service. They are able to receive, analyse, interpret and show quick response to new information (Sapkota *et al*., 2017), which eventually increases their access to tractor service and therefore; positively influencing the technical efficiency of maize production. Most of the uneducated farmers are older, making it difficult for them to go back to school. However; the government as well as NGO’s can implement educational programs for the elderly where they are taught how to read and write, which will further enable them to manage their farms. Programs such as the Setlakalane Molepo Adult Education Centre are significant in addressing national goals- inequality, unemployment and poverty.

Gert Sibande District

Farmer’s association also had an expected positive sign with access to tractor service, implying that farmers who are part of a farmer’s association are more likely to have access to tractor service in the Gert Sibande district. Farmer’s that are grouped together make it easy for the government to access them, and are also able to use inputs efficiently than fragmented farmers. Farmer’s should therefore; be encouraged to form farmer associations, perhaps by strictly rendering tractor service to only those that are grouped together. Some of the educated farmers within the association will instil their knowledge to others on the use of inputs such as fertilizer and irrigation facilities, and therefore enhance the efficient use of resources.

In brief, to ensure a positive effect of access to tractor service on technical efficiency of small-scale maize production; government should focus on significant factors influencing the access of this machinery, namely: irrigation, gender, ownership of land, farmer’s level of education, farmer’s association, household and land size per district.

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APPENDIX 1: RESEARCH QUESTIONNAIRE

Questionnaire No….

ANALYSING THE EFFECTS OF ACCESS TO TRACTOR SERVICE ON TECHNICAL EFFICIENCY OF SMALL-SCALE MAIZE FARMERS IN THE MPUMALANGA PROVINCE: A CASE STUDY OF THE MASIBUYELE EMASIMINI PROGRAMME

The aim of the study is to analyse the effects of access to tractor service on technical efficiency of small-scale maize farmers following the implementation of the Masibuyele Emasimini programme in the Mpumalanga Province.

The study will abide by the guidelines and regulations of the University of Limpopo ethical research. It will allow farmers to participate voluntarily without force and won't be harmful to them nor plants. Information acquired from the farmers will also be kept confidential.

Name of enumerator …………………….

Date of data collection …………………….

Name of district …………………….

Name of respondent …………………….

Contact details …………………….

A. DEMOGRAPHIC DETAILS

A.1 Gender	
M	F
1.	2.

A.2 How old is the farmer? ………. (Years)

A.3 How many are you in the household? .... (Number)

A.4 Farmers' Highest Education Level

No Formal Education	Primary School	Secondary School	Tertiary Level	Other (specify)
1.	2.	3.	4.	5.

A.5 Amongst the following, what is your main objective for farming?

Own consumption	Marketing	Own consumption & marketing
1.	2.	3.

B) LAND AND FARMING

B.1 What is the farm size in use?

Ha

B.2 How did you acquire the land?

Bought	Renting/share cropping	Inherited	Tenancy of government will	Other (specify)
1.	2.	3.	4.	5.

B.3 How do you cultivate land?

	Own	Borrowed	Hired
Tractor	1.	2.	3.
Government mechanisation		2.	3.
Animal traction	1.	2.	3.
Labour (hand)	1.		3.
Other (specify)			

B.4 How many farms do you own? ....

B.4.1 If more than 1, how far apart are the farms in minutes? ....

B.5 Are you part of any farmer association?

Yes	No
1.	2.

B.6 Do you irrigate maize?

Yes	No
1.	2.

B.7 If yes, what method of irrigation are you using?

Traditional method (basin, furrow, draught animal etc.)	Modern method (Sprinkler, drip and centre pivot)	Other (specify)
1.	2.	3.

B.8 Do you experience any destruction of land boundary (trees, stones) during cultivation?

Yes	No
1.	2.

B.9 How far is the farm from an all-season road by walking? …….. (Minutes)

B.10 How far is the farm from an all-season road if you are using a car?.... (Minutes)

B.11 Are the roads paved?

Yes	No
1.	2.

B.11.1 If yes, what is the condition of the paved road?

Excellent	Good	Fair	Poor
1.	2.	3.	4.

B.11.2 If No, what is the condition of the unpaved (Gravel) road?

Excellent	Good	Poor
1.	2.	3.

C) EXTENSION SERVICES

C.1 How often does an extension officer visit you?

Never	Once a week	Once a month	Twice a month	Other (specify)
1.	2.	3.	4.	5.

C.2 In your opinion, how do you view the quality of the extension worker who visits you?

Poor	Satisfactory	Good	Very good	Excellent
1.	2.	3.	4.	5.

D) PRODUCTION

D.1 Quantity of maize produced in Kilograms? ....

D.2 Amount of planting fertilizer applied in kilograms per hectare? ....

D.4 Amount of top dressing fertilizer applied on kilograms per hectare? ....

D.4 Amount of seeds used in kilograms per hectare? ....

D.5 Amount of weedicides used per hectare in litres? ....

THANK YOU FOR YOUR COOPERATION!

SISWATI TRANSLATION

RESEARCH QUESTIONNAIRE

Questionnaire No….

ANALYSING THE EFFECTS OF ACCESS TO TRACTOR SERVICE ON TECHNICAL EFFICIENCY AMONG SMALL-SCALE MAIZE FARMERS IN THE MPUMALANGA PROVINCE: A CASE STUDY OF THE MASIBUYELE EMASIMINI PROGRAMME

The aim of the study is to analyse the effects of access to tractor service on technical efficiency among small-scale maize farmers following the implementation of the Masibuyele Emasimini programme in the Mpumalanga Province.

Kuhlanganyela kulelihlolo kukunikela kwakho unemagunya ekuphuma kulenkulumiswano yemibuto mpendvulwano nawuva ngatsi ngeke usakhona kuchubeka ufike emaphetselweni. Lwati lotasiniketa lona sitalivikela libe yimfihlo.

Ligama lalowenta lelihlolo ……………………

Lusuku lokukoleka ……………………

Ligama ledistrict ……………………

Ligama lalophendulako ……………………

Tinombolo tekuchumana ……………………

A. LWATI NGEBULILI

A.1 Bulili	
Silisa	Sifazane
1.	2.

A.2 Mingaki minyaka yemlimi? ………. (mnyaka)

A.3 Nihlala nibangaki ekhaya? .... (inombolo)

A.4 TICU LETINGENHLA TEMLIMI LATIPHOTFULILE.

Tigaba temfundvo lehloliwe	Tifundvo temabanga laphansi	Tifundvo temabanga laphakeme	Timfundvo tasekholishi	Lokunye lokucuketfwe (kusho)
1.	2.	3.	4.	5.

A.5 Kuloku lokulandzelako, ngikuphi lofisa/ lojule kulimela kona?

Kutidlela	Kutsengisa	Kudla uphindze utsengise
1.	2.	3.

B) UMHLABA NEKULIMA

B.1 Linani lemhlaba losetjentiswako?

Ha

B.2 Uwuthole kanjani lomhlaba?

Uwutsengile	Uwubolekile/ nigiyelana sivuno	Lifa loshiyelwe lona	Ubolekwe nguhulumende	Lokunye (kusho)
1.	2.	3.	4.	5.

B.3 Usebentisa yiphi indlela yokulima?

	yakho	uyaboleka	Uboleka ngemali
Sigulumba	1.	2.	3.
Sigulumba sahulumende	1.	2.	3..
Tinkhabi/ timbongolo	1.	2.	3.
Tisebenti (tandla)	1.	2.	3.
Lokunye (kusho)			

B.4 Ungulomunye wemalunga etinhlangano tekulima?

Yebo	Cha
1.	2.

B.5 Uyawunisela umbhila?

Yebo	Cha
1.	2.

B.6 Nawunisela, usebentisa yiphi indle yokunisela?

Ngendlela yasemakhaya/yakadzeni(basin, furrow, draught animal etc.)	Ngendlela yesimanje (Sprinkler, drip and centre pivot)	Lokunye (kusho)
1.	2.	3.

B.7 Uyahlangabetana netinkinga tekutsikameteka kwemhlaba nekuvimbeka kungaba (tihlahla, matje,) nawulima?

Yebo	Cha
1.	2.

B.8 Likhashane ngakanani liplazi kunemgwaco wetimotolo?

≤20 yemaminitsi	21-29 yemaminitsi	30-49 yemaminitsi	≥50 yemaminitsi
1.	2.	3.	4.

B.9 Ingabe lomgwaco unesikontili?

Yebo	Cha
1.	2.

B.10 Uma utsi yebo, usesimeni lesinjani lomgeaco lonesikontili?

Muhle ngalokwecile	Muhle	Ukahle	Mubi
1.	2.	3.	4.

B.11 Uma utsi cha, usesimeni lesinjani limgwaco lote tikontili?

Muhle ngalokwecile	Muhle	Mubi
1.	2.	3.

C) LOKUPHATSELENE NEMLIMISI

C.1 Ingabe umlimisi univakashela kangaki?

Akamange afike	Kanye ngemphelasondvo	Kanye enyangeni	Kabili enyangeni	lokunye (kusho)
1.	2.	3.	4.	5.

C.2 Ngewakho umbono, uwubona kanjani nobe usitakala kanjani ngemsebenti walomlimisi lonivakahlelako?

Kubi	Kuyanelisa	Kuhle	Kuhle kahkulu	Kuhle ngalokwecile
1.	2.	3.	4.	5.

D) SIVUNO

D.1 Linani lembila lokhicitiwe ngeka khilo (kg)? ....

D.2 Linani lamanyolo lofakiwe ngemakhili (kg)? ....

D.3 Linani letinhlavu tembila letifakiwe ngemakhilo (kg)? ....

SIYABONGA NGEKUHLANGANYELA KWAKHO!