# Comparison of technical efficiency between cooperative member and non-member farmers: A case of small-scale sugarcane farmers in the Nkomazi Local Municipality, Mpumalanga province, South Africa

By

Lonhlanhla Samantha Mkhabela

Thesis presented in partial fulfilment of the requirements for the degree of Master of Science (Agricultural Economics) in the Faculty of AgriSciences at Stellenbosch University

Supervisor: Dr Cecilia Punt

March 2023

## Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Date: March 2023

## Abstract

The aim of the study was to determine whether cooperative membership improved technical efficiency for small-scale sugarcane farmers in the Nkomazi Local Municipality, in order to test the relevance of the motivation surrounding cooperative formation. The study analysed technical efficiency of small-scale sugarcane farming in order to identify the potential increase in sugarcane output using the available inputs and to determine if cooperative membership reduces technical inefficiency, in order to improve farming activities.

100 small-scale sugarcane farmers in the Nkomazi Local Municipality were selected and telephonically interviewed with regard to the 2018/19 sugarcane production season. The Stochastic Frontier Approach (SFA) was employed for data analysis. Results indicated that technical efficiency of cooperative member farmers ranged from 19.81 % to 93.10% with the mean technical efficiency of 70.77%. For non-member farmers' technical efficiency ranged from 14.08% to 95.76% with a mean of 69.57%. From the empirical results it was concluded that there is no statistically significant difference in mean technical efficiency between cooperative member farmers and non-member farmers in the Nkomazi Local Municipality.

The results from the Cobb-Douglas stochastic frontier production model confirmed that an increased use of inputs increases sugarcane output, because the coefficients of all the explanatory variables (farm size, permanent labour and fertiliser) were positive. Only farm size and permanent labour were found to be statistically significant.

The results of the inefficiency sub-model showed that only farmers' experience had a statistically significant (at 10%) contribution in increasing technical efficiency. Results further indicated that being a member of a producer cooperative reduces technical inefficiency in sugarcane production, but the estimated coefficient was not statistically significant. Hence, one can conclude that being a member of an agricultural cooperative in the study area does not serve as a beneficial factor to increase technical efficiency. This finding is in line with the work of Ortmann and King (2007a) who argue that agricultural cooperatives serving small-scale famers in South Africa did not contribute to improving agricultural development and the economic well-being of its members. However, it contrasts with work of Jaime and Salazar (2011) who stated

that participating in cooperatives improves technical efficiency. This suggests that cooperatives' quality and ability to respond to market failures should also be taken into account.

Given that the experience of small-scale sugarcane farmers was found to increase technical efficiency, the study recommends that new entrants should learn from the older farmers before the latter exit, in order for them to gain practical farming knowledge. The study further recommends that those farmers that achieved high sugarcane output as well as high technical efficiencies, can be used to demonstrate the benefit of good agricultural practices in reducing the gap between actual and potential sugarcane output. The results show that there is an opportunity to increase sugarcane output with current input use and technology. Given the result that cooperative member farmers were not found to be significantly more technically efficient compared to non-members, cooperatives in the Nkomazi Local Municipality should carefully consider how they can improve their service to their members.

**Opsomming**

Die doel van die studie was om vas te stel of koöperatiewe lidmaatskap tegniese doeltreffendheid vir kleinskaalse suikerrietboere in die Nkomazi Plaaslike Munisipaliteit verbeter het, ten einde te toets of die motivering rondom koöperasievorming relevant is. Die studie het tegniese doeltreffendheid van kleinskaalse suikerrietboerdery ontleed ten einde die potensiële toename in suikerrietuitset met behulp van die beskikbare insette te identifiseer en om te bepaal of koöperatiewe lidmaatskap tegniese ondoeltreffendheid verminder, ten einde boerderyaktiwiteite te verbeter.

100 kleinskaalse suikerrietboere in die Nkomazi Plaaslike Munisipaliteit is gekies en telefonies ondervra met betrekking tot die 2018/19 suikerriet produksieseisoen. Die Stogastiese Grensbenadering (SFA) is vir data analise aangewend. Resultate het aangedui dat tegniese doeltreffendheid van koöperatiewe lidboere gewissel het van 19.81% tot 93.10% met die gemiddelde tegniese doeltreffendheid van 70.77%. Vir nie-lid boere het tegniese doeltreffendheid gewissel van 14.08% tot 95.76% met 'n gemiddeld van 69.57%. Uit die empiriese resultate is tot die gevolgtrekking gekom dat daar geen statisties betekenisvolle verskil in gemiddelde tegniese doeltreffendheid tussen koöperatiewe lid boere en nie-lid boere in die Nkomazi Plaaslike Munisipaliteit is nie.

Die resultate van die Cobb-Douglas stogastiese grensproduksiemodel het bevestig dat 'n verhoogde gebruik van insette suikerrietuitset verhoog, omdat die koëffisiënte van al die verklarende veranderlikes (plaasgrootte, permanente arbeid en kunsmis) positief was. Slegs plaasgrootte en permanente arbeid was statisties betekenisvol.

Die resultate van die ondoeltreffendheid-submodel het getoon dat slegs boere se ervaring 'n statisties betekenisvolle (teen 10%) bydrae in die verhoging van tegniese doeltreffendheid gehad het. Resultate het verder aangedui dat om 'n lid van 'n produsentekoöperasie te wees verminder tegniese ondoeltreffendheid in suikerrietproduksie, maar die beraamde koëffisiënt was nie statisties betekenisvol nie. Daarom kan 'n mens tot die gevolgtrekking kom dat lidmaatskap van 'n landboukoöperasie in die studiegebied nie as 'n voordelige faktor dien om tegniese doeltreffendheid te verhoog nie. Hierdie bevinding is in ooreenstemming met die werk

van Ortmann en King (2007a) wat aanvoer dat landboukoöperasies wat kleinskaalse boere in Suid-Afrika bedien nie bygedra het tot die verbetering van landbou-ontwikkeling en die ekonomiese welstand van sy lede nie. Dit kontrasteer egter met werk van Jaime en Salazar (2011) wat gesê het dat deelname aan koöperasies tegniese doeltreffendheid verbeter. Dit dui daarop dat koöperasies se kwaliteit en vermoë om op markmislukkings te reageer ook in ag geneem moet word.

Aangesien gevind is dat die ondervinding van kleinskaalse suikerrietboere tegniese doeltreffendheid verhoog, beveel die studie aan dat nuwe toetreders by die ouer boere moet leer voor laasgenoemde uittree, sodat hulle praktiese boerderykennis kan opdoen. Die studie beveel verder aan dat daardie boere wat hoë suikerrietuitset sowel as hoë tegniese doeltreffendheid behaal het, ingespan kan word om die voordeel van goeie landboupraktyke te demonstreer om die gaping tussen werklike en potensiële suikerrietuitset te verklein. Die resultate toon dat daar 'n geleentheid is om suikerrietuitset te verhoog met huidige insetgebruik en tegnologie. Gegewe die gevolg dat daar nie gevind is dat koöperatiewe lede boere aansienlik meer tegnies doeltreffend is in vergelyking met nie-lede nie, moet koöperasies in die Nkomazi Plaaslike Munisipaliteit deeglik oorweeg hoe hulle hul diens aan hul lede kan verbeter.

**Acknowledgement**

I would like to appreciate the Messiah for giving me strength during my research. Special thanks and gratitude go to my Supervisor, Dr C Punt for her meaningful suggestions, contributions and inspiration during this study. Sincere appreciation is extended to Prof E Mungatana who so willingly provided much assistance in this study.

A special acknowledgement goes to AgriSeta for the bursary which was granted to me without which I could not have reached this far. I am grateful to Nkomazi Local Municipality producers, particularly small-scale sugarcane producers for their collaboration and as well as to Mr E. Mashego who works with the SA Cane Growers Association as an advisor for providing necessary information regarding the small-scale sugarcane farmers.

Gratitude to my parents, friends and student mates for their motivation. My last appreciation goes to everyone who supported me that are not mentioned here during my study.

## Table of contents

## Table of tables



## Table of figures

## List of abbreviations and acronyms

| | |
|---|---|
| AP | Average Product |
| DAFF | Department of Agriculture, Forestry and Fisheries |
| DEA | Data Envelopment Analysis |
| ICA | International Cooperative Alliance |
| IDP | Integrated Development Plan |
| LR | Likelihood Ratio |
| MLE | Maximum Likelihood Estimates |
| MP | Marginal Product |
| RSA | Republic of South Africa |
| SASA | South African Sugar Association |
| SFA | Stochastic Frontier Analysis |
| Stats SA | Statistics South Africa |
| TE | Technical Efficiency |

# 1. INTRODUCTION

## 1.1 Background of the study

Agricultural activities have become an essential means of improving family income in rural areas especially in developing countries since many people depend on agriculture for their livelihood (Christiansen *et al.*, 2011).

The agricultural sector of South Africa contributed 2.4% to the overall GDP in 2021. The sector itself contributed 0.3 percentage points to GDP growth in the final quarter of 2021 (Stats SA, 2021). This evidently concurs with Vink and Van Rooyen (2009) in stating that a decline in the share of GDP does not imply that the agricultural sector is diminishing, merely that the services industry is growing faster. Although agriculture's relative contribution to the GDP has been declining, it is still relevant in food security and employment, especially in rural areas.

South Africa's agriculture has a dual nature, with a well-developed commercial sector encompassing just over 30 000 large commercial farmers that produce nearly 95% of agricultural output and many small-scale farmers which are characterised by poor on-farm infrastructure and uncoordinated production systems (Mkhabela *et al*., 2018).

According to Kirsten and Van Zyl (1998) small-scale farming in South Africa is often equated with backward, unproductive, non-commercial, subsistence agriculture that is found in rural areas. However, there is no standard definition for smallholders, but the term is usually used for black producers in a South African context and for producers that are different from the dominant (and white-dominated) large commercial sector (Chisasa & Makina, 2012). Zantsi *et al*. (2019) stated that to qualify as a smallholder, one must be black and located in a former homeland or on a land reform farm.

In the Nkomazi Local Municipality, Mpumalanga Province; sugarcane production is produced by different business models. They are cooperatives, individual growers and joint-venture agreements, such as Transvaal Suiker Beperk (TSB) who made an agreement with communities under restitution awards. The reason is that TSB realised that 62% of sugarcane production land was transferred to black communities. According to James and Woodhouse (2017) "Joint-venture production involves the creation of farming services companies based on 50/50 partnership between an organisation representing the applying community (trusts or community property associations) and the TSB Shubombo Agricultural Services''. The trusts get payment from the joint-venture companies for leasing the land. It has been stipulated that joint-venture farms operate effectively and efficiently in producing sugarcane output in the industry and from this viewpoint, it can be said that land restitution in the sugar industry of Mpumalanga has been a success.

Ma *et al*. (2018) argues that agricultural cooperatives play an important role in small-scale agricultural systems of many developing countries. It is believed that agricultural cooperatives are a useful tool for overcoming barriers of access to services, information, markets for high-value items such as sugarcane crops and assets (Holloway *et al*., 2000). They further state that producer cooperatives offer an assured supply of a good to processors or marketers.

According to Torgerson (1977) and Valentinov and Iliopoulos (2013) cooperatives of farmers exist due to services that are not available to farmers in their rural communities, or it might happen that the services are not available at affordable prices. Cooperatives are there to improve the competitiveness of the capitalistic economic order, the community and the individual's position and this structural activity is governed by democratic principles. In addition, Mhembwe and Dube (2017) argue that cooperatives play an important role in the form of job creation, poverty alleviation, food security, women empowerment, human capital development, creation of rural markets and benefiting members for the betterment of rural communities' livelihood in numerous countries.

It is known that cooperatives are capable of serving farmers' needs such as marketing of products and providing credit for farm supplies because of their large-scale efficient operations. Cooperatives are orientated to the users' needs not the investors' needs and they have two types of goals. The first one is an economic goal of improving the well-being of members and the second is the social goal of enriching the position of members upward through a bootstrap organisational process (Torgerson, 1977).

According to Valentinov and Iliopoulos (2013) cooperatives are regarded as business organisations driven by values, not just profit. This kind of organisation exists if the operation of the market is not satisfactory to some stakeholders. According to the

International Cooperative Alliance (ICA, 2005) a cooperative can be defined as “an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise” and “Co-operatives are founded on values of self-help, self-responsibility, democracy, equality, equity and solidarity”. Cooperatives have seven principles that are recognised worldwide which are: provision of information, training and education; autonomy and independence; cooperation among cooperatives and concern for the community; voluntary and open membership; member economic participation and democratic member control (ICA, 2005).

A sole proprietorship (non-member farmer) can be defined as a business owned and operated by an individual, whose decision-making and risk-taking functions are undertaken by the owner. Producer cooperatives are closed organisations and voluntary, in which decision-making control and risk-taking are in the hands of members, and decision-making management is being carried out by the agent, who acts on behalf of the principal’s interest (Porter & Scully, 1987).

In South Africa cooperatives are being perceived as an organisation that may perhaps aid in improving the development of small-scale farmers and other communities within the country (RSA, 2005). The South African government has committed to providing a supportive legal environment, for cooperatives to develop and flourish. In 2014 there were 1 778 agricultural cooperatives (DAFF, 2014).

Sexton and Iskow (1993) noted that there are possibilities of inefficient organisational form that may emerge through the government support of cooperatives. According to Porter and Scully (1987) “cooperatives are explicitly efficient if the equity between membership patronage (dividends) and investment (shares) is time invariant, if the level of sponsorship or funding correspond exactly to the level of net investment, if there is homothetic preference functions with respect to leisure-income choices and risk among the members, if the production function is homogeneous of degree one (no economies of scale from horizontal or vertical integration), if the principals can costless negotiate, monitor and enforce a contract with the manager (agency) that structures the decision manager's incentive to precisely adhere to the principals' objective function, and if the returns from cooperative activity equal the risk-adjusted returns from other productive activities. Violation of one or more of these conditions introduces inefficiencies into the cooperative form and violates the relevant marginal conditions for profit maximization''.

From the above discussion, one can conclude that the agricultural sector is one of those sectors that plays a significant role in improving the livelihoods of rural people because it reduces unemployment and it serve as the main source of income. For this reason, the South African government has established agricultural cooperatives for small-scale farmers, which serves as a tool of poverty reduction. The South African government continues to support the agricultural sector because the agricultural activities plays a role in economic growth through the forward and backward linkages with the industrial sector in the economy. Therefore, the present study gives attention to one of the agricultural sectors namely the sugarcane industry. The focus is only on the production of sugarcane by small-scale farmers who are cooperative member and non-member farmers, not on sugarcane processing.

## 1.2 Problem statement

The sugar industry is one of the agricultural sectors in South Africa which includes sugarcane growing (classified as an agricultural activity) and sugar manufacturing (classified as an industrial activity), therefore it implies that the agricultural activity plays a role in economic growth through the forward and backward linkages with the industrial sector in the economy. Sugar is a basic foodstuff that is consumed worldwide, but it cannot be considered as a dietary staple. It is produced for both export and domestic consumption and can be used in the production of various commodities (McDonald *et al*., 2004).

In 2016, the South African sugar industry contributed 0.84% of the national gross domestic product (SASA, 2016). Sugarcane comprises nearly 50% of field crop gross farming income across Mpumalanga and KwaZulu-Natal. It also contributes 0.3% of the national salaries and wages (SASA, 2019b).

According to SASA (2019a) approximately 1 million people (2% of the population of South Africa) depend on cane growing and milling activities of the industry for a living. The industry generated 18 643 million tons of sugar during the 2018 / 2019 production season. The area under sugarcane production was approximately 395 000 ha (DAFF, 2019). About 60% of sugar is sold in the Southern African Customs Union (SACU).

The rest is exported to other parts of Asia, Africa and the Middle East market (SASA, 2019a).

Small-scale sugarcane farmers are an important sector of sugarcane production in South Africa. Since the 2000s, the number of small-scale sugarcane farmers has declined sharply (Zulu *et al*., 2019). In 2018, there were approximately 21 581 small-scale growers, however during 2018/2019 sugarcane season only 12 019 small-scale sugarcane farmers delivered cane, producing 9.33% of the total crop. Likewise in 2018, there were approximately 1 368 large-scale growers – including 345 black[1] emerging farmers – producing 81.17% of total sugarcane. The milling factories with its own sugarcane plantation produced 9.17% of the harvest (SASA, 2019b).

According to Stats SA (2020) Mpumalanga province has shown a decline in the area under sugarcane production and in sugarcane output. In 2007 the total area for sugarcane was 28 258 ha whereas in 2017 the total area planted to sugarcane decreased to 23 932 ha. Additionally, James and Woodhouse (2017) argue that there has been a decline of sugarcane output from the small-scale growers whereby in 2012, only 888 farmers delivered sugarcane on 6 238 ha of land, leaving approximately 39% of the land in small-scale projects unproductive that season. Small-scale sugarcane farmers still face challenges in improving production levels (Metiso & Tsvakirai, 2019; Farmer's Weekly, 2015)

It can be argued that the decline of sugarcane output in the Nkomazi Local Municipality, Mpumalanga, might be due to the inefficient use of resources occurring within business models operating in the Nkomazi Local Municipality but not limited to it. Inefficient use of resources can be factors of production (land, labour and capital); intermediate inputs (pesticides, fertilisers, herbicides and seed); human capital (gender, experience, education, family size, extension, age) and structural factors (off-farm income, farm size, access to credit, etc.).

[1] According to Rother *et al*. (2008) emerging farmers aim to become commercialised and can be defined as "black farmers operating under disadvantaged conditions compared to their white counterparts, regardless of whether they intend to pursue large-scale commercial production."

Technical efficiency is associated with the method of application of the chosen inputs and the interaction among the inputs, as well as the environmental conditions of the production process that are not under the control of the firm. These associations determine the differences in performance among firms (Obwona, 1994; Siddaraju & Indira, 2014).

As mentioned earlier that the South Africa's agriculture has a dual nature, with a well-developed commercial sector and many small-scale farmers who are characterised by poor on-farm infrastructure and uncoordinated production systems. Due to the poor conditions of the small-scale farmers, the South African government has embarked over the past 15 years on promoting agricultural cooperative organizations, with the believe that cooperatives may be of help for farmers to improve their farming activities and that cooperatives can play a major role in the economic and social development of the country, especially through job creation, income enhancement, enabling large-scale black economy empowerment (RSA, 2005). This Cooperatives Act 2005 (No. 14, 2005), based on the principles of international cooperation, was enacted by the South African government in August 2005.

Ortmann and King (2007a) argues that agricultural cooperatives serving small-scale famers in South Africa did not contribute to improving agricultural development and the economic well-being of its members. In contrast, recent studies have shown that agricultural cooperatives play a vital role in the development of an area, as it decreases unemployment and that agricultural cooperatives are technically efficient (Ngwamba, 2017; Xaba et al., 2018).

Economic production theory suggests that the producer's rationale should be based on allocating available resources in a wise way, for output maximisation, therefore, the ability to quantify efficiency provides the decision-maker with a control mechanism with which to monitor the performance of the production system to improve productivity. It is therefore compelling to determine if there is a statistically significant difference in technical efficiency between cooperative member and non-member sugarcane farmers in the Nkomazi Local Municipality, to further test the relevance of the motivation surrounding cooperative formation in sugarcane farming.

### 1.3 Objectives of the study

i. To determine and compare the level of technical efficiency of cooperative member and non-member small-scale sugarcane farmers in the Nkomazi Local Municipality.

ii. To determine if cooperative membership reduces technical inefficiency.

iii. To identify sources that reduce technical inefficiency.

### 1.4 Research hypothesis

Small-scale sugarcane farmers who are part of a cooperative are more technically efficient, compared to non-member farmers.

### 1.5 The significance of the study

The study on estimating technical efficiency of small-scale sugarcane farmers in the Nkomazi Local Municipality might reveal whether farmers are more technically efficient when they are members of a cooperative or not. Improved technical efficiency is expected to alleviate poverty and aid food security, hence the reason to estimate technical efficiency for farmers in order to see which group is operating more efficiently and whether there is a statistically significant difference between the groups.

For instance, if the findings of the study show that farmers are more efficient when operating in cooperatives, these might encourage individual farmers to be part of cooperatives, rather than suffering losses by themselves. Cooperatives have been perceived as a way forward for poverty reduction in rural areas. Participation in this organisation might bring a good change in the Nkomazi Local Municipality, but theoretic evidence is not clear in this regard.

Moreover, the study aimed to identify some factors that influence technical efficiency of small-scale sugarcane farmers The information that is provided may be useful to decision makers, extension services, researchers and specialists in improving productivity and the competitiveness of the agricultural sector. As a result, Nkomazi small-scale sugarcane farmers might benefit from this research because extension officers might advise them based on the findings of this study.

Sugarcane is one of those crops in the country which require attention from different stakeholders in order to minimise production challenges and maximise output. The contribution of small-scale farmers to the overall supply in the market also matters hence, the relevance of this study. Mpumalanga's economy may benefit from increased production if small-scale sugarcane farmers can improve their efficiency based on the findings.

Small-scale sugarcane farmers are important for the development of the local economy and the national economy. Providing recommendations on how to adjust or treat factors causing technical inefficiencies on sugarcane output, may assist small-scale farmers in using resources in an efficient way, this might help in improving sugarcane farming and preventing small-scale sugarcane farmers from leaving the sector, as it has been perceived through the decline of small-scale sugarcane farmers over the years.

Thabethe (2014) conducted a study on measuring productive efficiency (technical, allocative and economic efficiencies) of small-scale sugarcane farmers in Mpumalanga and the results showed that small-scale sugarcane farmers are operating with inefficiencies (technical, allocative and economic). However, her study did not pay attention to different business models under production of sugarcane in the area. Therefore, this study contributes to the literature by addressing aspects of sugarcane production business models in the Nkomazi Local Municipality, whereby small-scale sugarcane farmers are categorised according to whether farmers are operating as a cooperative or working as individuals. The expectation is that the efficiency of farmers who operate together as cooperatives, compared to those who operate as individuals, would be different.

### 1.6 Delimitation of the study

This study focuses only on small-scale farmers who are producing sugarcane in the Nkomazi Local Municipality. Hence there is no focus on the processing of sugarcane that takes place at the sugarcane milling.

## 1.7 Study outline

The study is organised into six chapters. Chapter one gives the introduction, problem statement, objectives, research hypotheses, significance and delimitation of the study. Chapter two presents an overview of empirical and theoretical topics regarding technical efficiency, the measurement of technical efficiency, production economics, the history of South African agricultural cooperatives and the sources of inefficiency in cooperatives. This chapter further gives a review of empirical studies on technical efficiency in the agricultural sector. The literature review helps with guidance as to which approach (parametric approach or non-parametric approach) will be suitable for the analysis. Chapter three includes the information on the Nkomazi Local Municipality (study area). Chapter four outlines the sampling techniques adopted for data collection, socioeconomic characteristics of sampled small-scale sugarcane farmers and the analytical techniques used. Chapter five presents and discusses descriptive statistics and the maximum likelihood estimate results. Lastly chapter six provides the summary, conclusions and recommendations from the study.

# 2. LITERATURE REVIEW

## 2.1 Introduction

This chapter outlines the theoretical measurement of technical efficiency specifically looking at parametric and non-parametric approaches with its advantages and limitations. Further it suggests the most relevant approach among the two. This is followed by a theoretic review on production economics theory. This chapter not only focuses on some main themes in agricultural cooperatives; it also reviews previous studies regarding technical efficiency, both in South Africa and other countries.

## 2.2 Productive efficiency

According to Dejene (2013) productive efficiency is one of the most important issues in the production process especially in a case where there is limited or scarce resources. Further scarcity of resources makes efficiency to be an important goal of every producer because improved efficiency brings growth in businesses. Efficiency helps in measuring the production performance of a farm or firm. Efficiency is the condition in which people get as many services or goods as possible from scarce resources (Farrell, 1957). Productive efficiency implies reaching production goals without wasting (Ajibefun & Daramola, 2003).

In micro economic theory, productive efficiency of a firm or farm can be measured from its technical and allocative aspects. Technical efficiency is the ability of the firm to produce maximum output from an existing set of inputs and a given technology (Farrell, 1957). Meanwhile allocative efficiency is the firm's ability to use inputs in optimal proportions, at existing prices (Coelli, 2002). Economic efficiency is the product of allocative efficiency and technical efficiency (Farrell, 1957). According to Ouattara (2010) economic efficiency is measured by the firm's ability to make its operations profitable; it allows for the identification of potential gains within the firm.

For this study, the focus is on technical efficiency in order to help to identify those factors that are associated with inefficiencies that might exist. The identification of inefficiency factors might improve sugarcane production over time.

According to Dejene (2013) “Technical efficiency implies that two firms may produce different levels of output while using the same levels of input and technology’’. In short, there will always be different levels of technical efficiencies on two or more farms producing homogeneous goods or commodities, using the same resources. That is why measurement of technical efficiency is important in improving each farm’s production.

The importance of technical efficiency in production performance analyses was initiated by Farrell (1957) who introduced the concept of the production frontier representing production technology with hundred percent technical efficiency. A production function can be used to measure technical efficiency. The production function defines a frontier, as a result the deviations away from the frontier can be interpreted as inefficiency (Cornwell & Schmidt, 2008). The production function can be defined as an economic process of producing output from the input in relation with technology. Technology is then defined as the ability of the firm or producer to generate more output with a given set of resources, such as factors of production (labour and capital), natural resources (land) and human capital (education, experience, training) (Arnold, 2018). All the mentioned resources influence productivity. Therefore, technical efficiency is one of the efficiency concepts that could be related to the efficiency of cooperatives and individuals.

Farrell (1957) was the first to display the importance of technical efficiency in analysing production performances. The estimate of technical efficiency indicates how much output can be obtained by effectively using a given input and technology. Hence a production frontier is about the maximum set of outputs which are obtainable from a given set of inputs and technology. Frontier refers to a bounding function (see figure 2.1).

Figure 2.1 represent Farrell’s (1957) depiction of allocative (price) efficiency, technical efficiency and economic efficiency. The y and x axes represent two factors of production such as labour and capital used in the production of a single product under the assumption of constant returns to scale. The point P represents the combination of the two factors per unit of output, that a non-efficient firm is expected to use. The unit-output isoquant is represented by the SS' curve. Point Q shows an efficient firm utilising the two resources in the same ratio as at P. As a result, it generates the same output as at P using only a fraction OQ/OP of each factor. The index of technical efficiency, TE, is defined as the ratio between the distance from the origin of the unit-output isoquant at Q and the distance from the origin of the given firm's normalised input combination at P. Thus for technical efficiency: TE = OQ/OP.

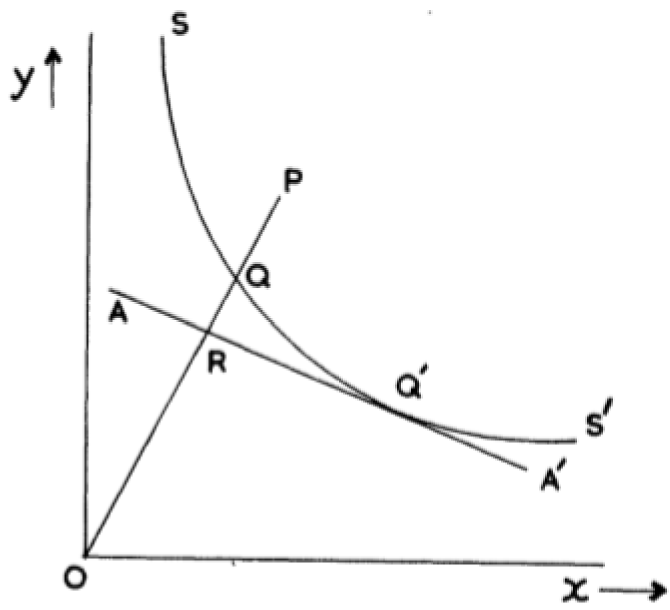


**Figure 2.1: Farrell's technical and allocative efficiency measures**

Source: Farrell (1957)

Figure 2.1 represents allocative efficiency by the unit-output isocost line shown by line AA'. Point R signifies an input-output combination on the same line of AA' that is efficient from an allocative viewpoint but not from a technical one. Point Q' represents the cost of production. The index of allocative efficiency, AE, is demarcated as OR/OQ at point Q. Thus for allocative efficiency: AE = OR/OQ.

However, if the observed firm was perfectly efficient, both technically and regardless of prices, its costs would be the fraction OR/OP, that is the overall economic efficiency (EE) of the firm, and it is equal to the product of the technical and allocative efficiencies. Thus for economic efficiency: EE = OR/OP.

Several studies have highlighted that technical efficiency can either be estimated using the parametric or non-parametric frontier. These methods are discussed in more detail in the next section.

## 2.3 Measurement of technical efficiency

The production frontier models developed on the basis of Farrell's work can be classified into two basic categories, namely parametric and non-parametric approaches. These approaches can be adopted to measure a firm's technical efficiency. The parametric approach comprises the stochastic frontier analysis (SFA) and the non-parametric approach comprises of data envelopment analysis (DEA) (Thiam *et al*., 2001; Coelli *et al*., 2002; Olarinde, 2011; Wheat *et al*., 2014; Nguyen *et al*., 2016).

The distinctions between these approaches is based on assumptions made about the functional form, such as whether random errors have been included in the function, and the probability distribution assumed for the inefficiency. The non-parametric approach (DEA) does not consider a functional form for the data whereas the parametric approach (SFA) relies on a parametric specification of the production function, cost function or profit function (Chavas & Aliber, 1993).

### 2.3.1 The parametric approach

Stochastic frontier analysis is a parametric approach based on the estimation of the frontier production function. Aigner *et al*. (1977) suggested the approach to be utilised in estimating frontier production functions. Their approach involved the specification of the error term being made up of two components. This approach helped in overcoming some of the previous shortcomings on previous work in the area (Aigner & Chu, 1968; Afriat, 1972; Richmond, 1974; and Schmidt, 1976).

According to Aigner *et al*. (1977) the specification of the error term shows that from an economic point of view, the production process is subject to two economically distinguishable random disturbances with different characteristics. They believe that this distinction makes it easier to evaluate and interpret the boundaries. They further highlighted that the non-positive disturbance term reflects the fact that each firm's output must lie on or below its frontier. Any such deviation is the result of factors under the firm's control, such as technical and allocative inefficiency. However, the frontier may vary randomly between firms, or it may change over time (Schmidt, 1976). There is also a statistical noise term, which accounts for the combined effects of unobserved inputs on production as well as factors such as weather, measurement error in the dependent variable etc. (Coelli and Battese, 1996).

The parametric approach econometrically estimates the production function, allowing statistical inference on the estimated frontier (Jaime & Salazar, 2011). This kind of approach depends mainly on the specification of a functional form, which can be divided into stochastic and deterministic components.

According to Thiam *et al*. (2001) the deterministic model assumes that any deviation from the frontier is the result of inefficiency, it does not consider the statistical noise term. Whereas the stochastic model considers both terms (statistical noise and technical inefficiency term). They further argue that the problem with a deterministic frontier is that any measurement error is based on the one-sided component. This kind of approach is overly sensitive to outliers.

*2.3.1.1 Advantages of the parametric approach*

The essential idea about the stochastic frontier production model as mentioned earlier is that it incorporates a composed error term which is made of two parts (noise term and inefficiency term). Stochastic frontier analysis measures the uncertainty of efficiency estimates recognising distinctive factor parts influencing output and providing information on the production technique. It hypothesizes the existence of technical inefficiencies of production of firms involved in producing a precise output (Battese & Coelli, 1995; Mkhabela, 2005; Cornwell & Schmidt, 2008; Addai-Asante & Sekyi, 2016; Hlali, 2018). Stochastic frontier models are unique in such a way that it can distinguish between observed factors (regressors), inefficiency and statistical noise (Wheat *et al*., 2014). In short, the model allows technical inefficiency to be measured separately from statistical noise (Erkoc, 2012; Piesse *et al*., 2018; Hlali, 2018). The stochastic frontier indicates maximum output, which results from a set of inputs as a distribution rather than a point. It is also important to note that the stochastic frontier model focuses only on one dependent variable unlike DEA with multiple outputs. It allows for great flexibility in the specification of the functional form (production technology).

#### *2.3.1.2 Limitations of the parametric approach*

The limitation of stochastic models is the choice of the functional form of the production frontier to be used in analysing farm efficiency (Thiam *et al*., 2001). Further, Idiong (2007) stated that functional forms (Cobb-Douglas and translog) have a limited effect on empirical efficiency measurement. Kopp and Smith (1980) also concluded that functional form has a discernible but rather small impact on estimated efficiency. Another limitation is that the assumptions concerning the distribution of the inefficiency term must be imposed to decompose the error (Hlali, 2018).

### 2.3.2 The non-parametric approach

The DEA method is a non-parametric technique based on mathematical programming techniques introduced by Charnes *et al*. (1978) to measure efficiency based on a constant return to scale assumption. Later Banker, Gadh and Gorr (1993) extended the model by including variable returns to scale.

#### *2.3.2.1 Advantages of the non-parametric approach*

The major advantage of the approach is that it does not require any functional form for the production function and distributional form for inefficiency terms. Moreover, the approach has the ability for the estimation of frontiers with multiple outputs and multiple inputs (Bravo-Ureta & Pinheiro, 1993; Obwona, 1994; Mkhabela, 2005; Ruggiero, 2007; Erkoc, 2012; Ueasin *et al*., 2015; Conradie *et al*., 2019).

#### *2.3.2.2 Limitations of the non-parametric approach*

The limitation of the non-parametric approach is that it does not consider or allow for the statistical noise or two-sided symmetric term, as a result no statistical hypothesis on the estimates can be carried out. For instance, this kind of approach does not differentiate between technical inefficiency and a statistical noise effect (for example random factors such as natural disasters and climate, which might influence the position and shape of the estimated frontier). The results are greatly influenced by the arbitrary choice of explanatory variables (Obwona, 1994; Murillo-Zamorano, 2004; Mkhabela, 2005; Jaime & Salazar, 2011; Erkoc, 2012).

### 2.3.3 The preferred approach for the current study

Murillo-Zamorano (2004) conducted a study on economic efficiency and frontier techniques, distinguishing between parametric and non-parametric methods. Murillo-Zamorano (2004) argues that neither approach is rigorously preferable to the other since both approaches have got their own advantages and drawbacks. According to Ueasin, *et al*. (2015) "DEA is defined as a non-parametric method that is exclusively applied to measure the firm's efficiency scores. In contrast, SFA is a parametric method that requires a specific function to compute the efficiency scores''.

Ueasin *et al*. (2015) used cross-sectional samples of biomass power plants in Thailand, to compare Stochastic Frontier Analysis and Data Envelopment Analysis to estimate technical efficiency. They discovered that SFA provided the best results because SFA determined the relationship between the dependent and independent variables in their research. Although SFA results were slightly greater than DEA, one possible reason could be that DEA attributes any deviation from the frontier to inefficiency, it does not consider the statistical noise term. Ruggiero (2007) investigated a study based on a comparison of SFA and DEA using panel data and his finding was that both models yielded similar results. In Vietnam, Nguyen *et al*. (2016) did a study on cost efficiency of banks, testing for the robustness of efficiency analysis through the application of both DEA and SFA. Their results showed that the cost efficiency scores obtained by SFA and DEA were comparable. Madau (2015) conducted a study on Italian citrus farms focusing on scale and technical efficiency using panel data (3 years), and his findings were that the estimated technical efficiencies from the SFA model and DEA model were comparable.

For the purpose of this study, SFA was used instead of DEA because of a number of reasons. First, it considers both factors that are beyond the farmers' control and the technical inefficiency. Second, the DEA attributes any deviation from the frontier to inefficiency, it does not consider the statistical noise term into the frontier. Third, it allows statistical tests on the estimates whereas DEA does not allow for that. Several studies have used SFA (Mkhabela, 2005; Hossain *et al*., 2008; Dlamini *et al*., 2010; Maietta & Sena, 2010; Jaime & Salazar, 2011; Olarinde, 2011; Tchereni *et al*., 2012; Daniel *et al*., 2013; Dejene, 2013; Belotti *et al*., 2013; Wheat *et al*., 2014; Abate *et al*., 2014; Ueasin, *et al*., 2015; Dong *et al*., 2016; Amsler *et al*., 2016; Abdul-Rahaman, 2016; Murali & Prathap, 2017; Seymour, 2017; Fatima *et al*., 2017; Ma *et al*., 2018; Hlali, 2018). The stochastic frontier analysis has therefore been used as a fundamental tool to analyse the existence of technical production inefficiencies of firms engaged in the production of output.

Sexton and Iskow (1993) highlighted that one problem that most studies encounter in comparing and evaluating cooperatives' efficiency is that they do not use the formal concept that emerge from the theory of economic efficiency. They further argue that a well-known statistical approach in measuring technical efficiency is the stochastic production frontier approach suggested by Aigner, Lovell and Schmidt (1977). It is against this background, together with the aim of the study, that stochastic frontier analysis was employed.

### 2.4 Review of production economics

According to Debertin (2012), agricultural production economics is primarily concerned with economic theory as it relates to agricultural commodities that are produced by producers. There are major concerns in agricultural production economics, which includes the following:

- Goals and objectives of the farm manager: it is often assumed that the goal of any farmer is profit maximisation. However, individual farmers have unique goals.
- Choice of output to be produced: here the farmer is not only concerned about the quantity of each commodity to be produced, but also the allocation of available resources among the alternative commodities.
- Assumption of risk and uncertainty: models in production economics frequently assume that the manager knows with certainty the applicable production function (for example, the yield that would result for a crop if a particular amount of fertiliser were applied), however, in agriculture the assumption of knowledge with respect to the production function is almost never met. Weather is, of course, a key variable, but nature presents other challenges.

Jordaan *et al*. (2017) stated that in farm business, success is not achieved through luck, however a growing, profitable farm is the results of thorough and meaningful planning. Planning involves decision-making, that is, choosing the most sustainable and profitable alternative from all possible actions. Hence economics is about making the right decisions and choices, bearing in mind that resources are limited or scarce. There are three production economics principles or concepts that need to be considered by any producer in order to be productive in their agricultural activities, which are: marginality, the production function, and the law of diminishing marginal returns. These concepts will be explained in more details below. These concepts help producers or farmers in making wise decision regarding farming activities.

### 2.4.1 The marginality principle (marginalism)

Marginality is one of the central concepts in production economics. Marginalism refers to the influence or effect that a change in the input will have on the output. When a farmer makes incremental decisions, marginality is applied, such as: by how much will cost or yield increase if another input is added to the production process? (Jordaan *et al*., 2017).

### 2.4.2 Law of diminishing marginal returns

This law states that as additional units of a variable input are applied in combination with one or more fixed inputs, the marginal returns will eventually start to decline, that is, initial additional units will lead to an increase in output at an increasing rate, then an increase in output at a decreasing rate and eventually a decrease in output. This principle plays an important role in determining the optimum input allocation (Jordaan *et al*., 2017). This law is largely responsible for the typical production function that occurs in agriculture.

### 2.4.3 The production function

This principle essentially shows how output will change as a result of a change in an input or factor of production. There are four main factors of production: natural resources (land), labour, capital and entrepreneurship (Mohr & Seymore, 2012). These factors of production or inputs are transformed into output during the production processes. A Production function describes the relationship of this transformation, which is converting inputs into outputs (Kumbhakar *et al*., 2015).

A production function thus represents the relationship that exists between inputs and outputs. For each level of input use, the function assigns a unique output level. When a zero level of input is used, output might be zero, or, in some instances, output might be produced without the input (Debertin, 2012). This concept has two related production concepts namely average product and marginal product, used in decision making (Jordaan *et al*., 2017). According to Mohr and Seymore (2012), average product (AP) of the variable input is the average number of units of output produced per unit of the variable input. Marginal product (MP) is the extra output for one-unit increase in input, that is the addition to the total product as a result of the addition of an extra unit of input.

Consider the typical production function for an agricultural product in Figure 2.2, which shows the important relationships between total product (TP), average product (AP) and marginal (MP). It is then assumed to have three stages representing the three different relationships that exists between a single input and a single output.

At the first stage the yield or total product increases at an increasing rate until it reaches a particular point (inflection point) after which it increases at a decreasing rate. The average yield per unit, however, continues to increase up to point d', where the highest average product is achieved. Up to point d' the marginal product is higher than the average product and the two intersect at point d. This stage represents an irrational production area because the average product continues to increase, which indicates that each additional unit of input leads to a bigger increase in output than that caused by a previous unit of input.

At the second stage the output/yield/total product continues to increase but at a decreasing rate. Stage 2 lies in the area between the maximum average product (which is point d') and the maximum total product (which is point e'). Stage 2 is known as the rational stage because the most profitable production level occurs in this stage, that is, additional units of the variable input still affect the production process positively but at a diminishing rate. A rational producer will not apply less input than that represented by point d (stage 1). Neither will the farmer use more factor inputs than represented by stage 2 (point e), because beyond this stage each unit of input used would cause a decrease in total product.

Stage 3: This stage extends from the maximum total product (point e'), where the total product curve starts to decline causing the marginal product curve to be negative at point e, due to that this stage is also known as irrational stage like stage 1.

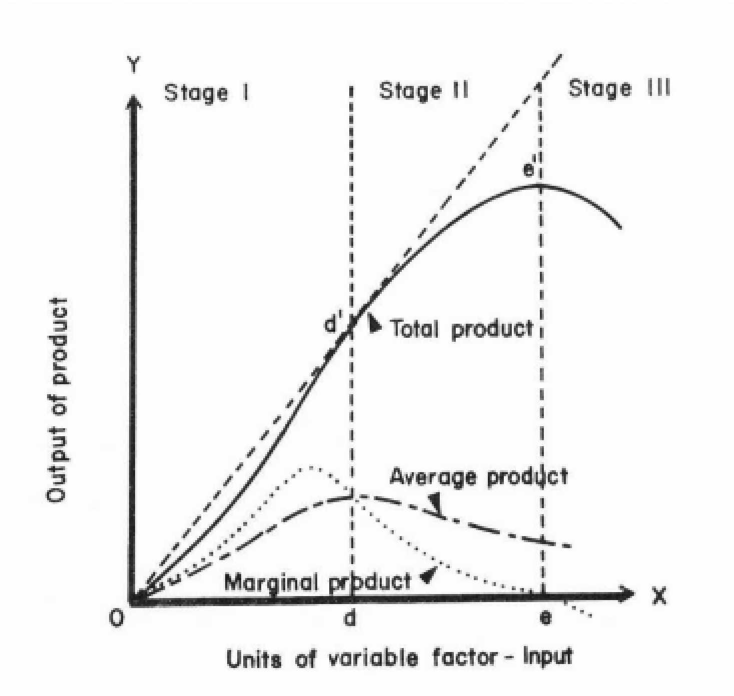


**Figure 2.2: The typical production function in agriculture**

Source: Jordaan *et al*. (2017)

From the discussion above, it should be clear that stages 1 and 3 do not qualify for consideration when trying to find out the most productive level of production. This leaves stage 2 as the rational production phase.

### 2.4.4 The Cobb Douglas function

According to Kumbhakar *et al*. (2015) the Cobb-Douglas production function, the translog and the transcendental are commonly used production functions in terms of their parametric form. Ray *et al*. (2022) stated that the Cobb-Douglas production function has served as the gold standard in neoclassical production economic theory for decades. It has retained much of its popular appeal despite the advent of more flexible functional forms and it has remained a classic example of empirical evidence inspiring a theoretical formulation of a production function.

The Cobb-Douglas function formula used in farm production function analysis, may be generalised as: $y = A{x_1}^{\beta 1} x_2^{\beta 2}$

According to Debertin (2012) the first generalisation of the Cobb Douglas production function allows the parameters on the inputs to sum to a number other than 1, and this allows for returns to scale of something other than 1. The production function represents production processes at the individual farm level. The assumption of Cobb and Douglas was that output could be produced with only labour and capital under the supervision of the farm manager. Further, the second generalisation was the expansion of the function in terms of the number of inputs after which it is transformed into logs. As the number of inputs expand, the sum of the parameters on the input variables should increase, with the assumption that each input variable has a positive marginal product. Thus, the Cobb Douglas type of function is used where the sum of the individual production elasticities is equal to 1 (the Cobb-Douglas function assumes a constant production elasticity) and where the elasticities of production sum to a number other than 1.

The Cobb Douglas function is homogeneous of degree equal to the sum of the parameters ($\Sigma\beta_i$). The returns to scale parameter is equal to the sum of the parameter values of the individual inputs ($\beta$), with the assumption that all inputs are treated as variable. According to Mohr and Seymore (2012) “the term returns to scale refers to the long-run relationship between inputs and output’’.

The parameter values ($\beta$) represent the elasticity of production with respect to the corresponding input and are constants. Also, the parameters for each input variable are the partial elasticities of production. For example, the partial elasticity of production for input $x_i$ is the ratio of marginal product (MP) to average product (AP) for that input (Debertin, 2012).

Additionally, the marginal product and average product for each input never intersect, but stay at the fixed ratio relative to each other as determined by the partial elasticity of production. For output to be produced all inputs must be used. Moreover, the Cobb-Douglas production function increases up the expansion path at a rate that corresponds to the value of the function coefficient or the returns to scale parameter. If the parameter ($\beta$) equals 1, the function coefficient increases at a constant rate up the expansion path, if the parameter ($\beta$) is less than 1, decreasing return to scale exists and if the parameter ($\beta$) is greater than 1, the function increases at an increasing rate. (Debertin, 2012; Mohr & Seymore, 2012). The estimated agricultural production functions of the Cobb-Douglas type usually have a function coefficient of less than 1 (Debertin, 2012).

### 2.4.5 The important of production economics and technical efficiency on small-scale sugarcane farmers

It has been noted that small-scale sugarcane farmers in the Nkomazi Local Municipality are experiencing a decline in sugarcane output and a decline in the number of small-scale sugarcane farmers (James and Woodhouse (2017; Metiso & Tsvakirai, 2019). From this statement, one can conclude that small-scale sugarcane farmers have challenges in improving production levels. Therefore, an understanding of the production function and technical efficiency of the small-scale sugarcane farmers might help in understanding the reason of why the number of farmers and output are decreasing.

The information on the production function of sugarcane output will reveal if there are returns to scale in sugarcane production. The information obtained can be used by small-scale sugarcane farmers or extension officers in determining the appropriate application of inputs, resulting in sugarcane output maximisation. Further, knowing the information from the production function is not enough, farmers need information on efficiency. Small-scale sugarcane farmers in the Nkomazi Local Municipality, can only improve their productivity through the efficient use of input resources, bearing in mind that the resources of producing sugarcane output are very limited. Technical efficiency helps in measuring the production performance of small-scale sugarcane farmers.

Therefore, it is worth finding out if small-scale sugarcane farmers are technically efficient, this will help small-scale sugarcane farmers to know that they still have an opportunity to increase sugarcane output without wasting, through the usage of the same sugarcane inputs, regardless of the unfavourable prevailing circumstances. In conclusion production economics helps farmers to make wise decision regarding farming activities, that is, the small-scale sugarcane farmers' ability to take decision regarding input utilisation will lead to high sugarcane output and high level of technical efficiency. This will improve their living standards, because sugarcane planting is regarded as their main source of income.

## 2.5 Agricultural cooperatives

### 2.5.1 History of agricultural cooperatives in South Africa

Several researchers have written on the history of South African agricultural cooperatives (Piesse *et al*., 2005; Ortmann & King, 2007a; Ortmann & King, 2007b; Ngwamba, 2016; Rena, 2017). According to Ortmann and King (2007a) before the cooperative Societies Act of 1922 (Act No. 28 of 1922) was passed agricultural cooperatives were registered under the Companies Act of early 1908. Time passed and the new act was implemented by the South African Parliament. The Cooperative Societies Act of 1939 (Act No. 29 of 1939) continues with the same goal of the first act, which was concerned with agricultural activities. During the apartheid era agricultural cooperatives facilitated great development for commercial agriculture because the government was supporting commercial farmers. Meanwhile nothing much was done for small-scale farmers. The agricultural cooperatives served as a tool to supply farm inputs to the commercial farmers (Ortmann & King, 2007b; Rena, 2017).

According to Piesse *et al*. (2005) there were policies that came with the Land Act of 1913 that were supportive to white commercial farmers but disregarded black farmers, such as the mentioned Cooperative Acts of 1922 and 1939 based on the output market services and supply of inputs; the Marketing Act of 1937 under which the tightening of controls over produce marketing was taking place, and the initiation of the Land and Agricultural Development Bank in 1912. Consequently, black farmers had no access to credit markets, output markets, public sector investment, farmers' unions and marketing organisations.

After the 1994 election of a democratic government, there was limited support given to commercial farmers from the present South African government and the existing agricultural cooperatives had to be converted to investor-oriented firms (Ortmann & King, 2007b). During the 2000 era the government implemented a new Cooperative Act (No. 14 of 2005) in accordance with the principles of international cooperatives and it was approved on 14 August 2005 (RSA, 2005). The South African government believed that this law would enhance the development of communities as well as small-scale farmers within the country, since the agricultural cooperatives could generate income, create employment, eradicate poverty and facilitate black economic empowerment.

### 2.5.2 Operational structure of agricultural cooperatives

The general operational structure of agricultural cooperatives found in Mpumalanga may include cooperative members, other interest group and employees. The top-down approach can be used to describe the hierarchical structure of agricultural cooperatives (Ngwamba, 2016). Figure 2.3 below is an illustration of the structure of the functioning agricultural cooperatives, not limited to any particular commodity.


**Figure 2.3: Agricultural cooperative operational structure**

Source: Ngwamba (2016)

### 2.5.3 Motives for cooperative formation

According to Valentinov and Iliopoulos (2013), cooperatives are being formed due to market failure. Market failure is defined as an imperfection in the pricing system that prevents an efficient allocation of resources (Samuelson and Nordhaus, 1992). Market power avoidance is an aspect of market failure that results from adverse selection. Adverse selection is due to asymmetric information that arises when a seller (contractual partner) has more knowledge about the qualities (characteristics) or price of the good that is traded in the markets than the buyer (farmer) (Mankiw, 2008). In cases like this, farmers are at jeopardy for facing price discrimination. Cooperatives protects farmers in situations like these.

Agricultural cooperatives are being perceived as tools to minimise risk in production through the establishment of a resource pool. Cooperatives act as agents for providing missing services such as providing farmers with markets for their produce, supplying them with farm inputs, as well as training (Valentinov & Iliopoulos, 2013). Cooperatives are helpful in terms of bargaining power. A study conducted by Msimango and Oladele (2013) stated that some farmers are part of cooperatives for food security reasons, while others seek higher returns on income. Agricultural cooperatives are perceived as a tool to acquire knowledge regarding agricultural production.

Another motivation to form or join agricultural cooperatives is that farmers are trying to redistribute rights in their favour. This kind of motivation works best when farmers have strong common interest and are single commodity organisations and producer cooperative may help farmers take political action as a collective (Staatz,1987). Deininger (1995) argues that individual farmers are often more efficient than large agricultural cooperatives. On the other hand, cooperative can be viewed as inefficient because of overproduction, since cooperatives do not have the rule of how much an individual member farmer should produce. However, it has been noted that cooperatives tend to maximise profit at the expense of firms, which are also based on profit maximisation (Albæk & Schultz, 1998).

In a nutshell, cooperatives are expected to protect member farmers from market failure, to provide market information regarding the goods that are produced within the organization, to supply its members with farm inputs and to provide farm training for its members. (This training can be done through proper extension services as well as the farmer-field school; these programs improve farmers' decision skills in terms of adapting improved farming technologies). For this reason, the benefits that are derived by cooperative member farmers from the services that are rendered by the cooperative organisations are expected to be favourable for improving technical efficiency of small-scale farmers. Additionally, Xaba *et al*. (2018) stated that they found agricultural cooperatives to be technically efficient.

### 2.5.4 Types of agricultural cooperatives

Agricultural cooperatives are formed by farmers who take collective action in pooling their resources in a specific area of activities, with the aim of facilitating optimal production through the efficient utilisation of the resources (RSA, 2005; Msimango & Oladele, 2013).

Agricultural cooperatives play an important role in the development of the rural sector and for the improvement of food security within a country. For example, Israel's agricultural cooperatives account for about 80% of the agricultural production as well as the agricultural services (Rosenthal & Eiges, 2014).

According to Ortmann and King (2007a) different types of cooperatives (such as producer, consumer, worker and service) have been established globally for the purpose of serving the interest of its members. They further elaborated on the provision made by these cooperatives such as equipment and farm supplies, financial services, agricultural product market, consumer commodities, housing, utilities (e.g. telephone, electricity) and insurance. Moreover, Staatz (1987) argues that cooperative bargaining associations might result in increased efficiency, through the transformation of market relationship between farmers and their trading partners, which would be governed by the bilateral monopoly approach.

Furthermore, according to Ortmann and King (2007a) in general agricultural cooperatives can be divided into three types according to their goals, i.e. farm supply cooperatives (which may purchase inputs in volume, manufacture, process or formulate, and distribute farm supplies and inputs such as seed, fertilizer, feed, chemicals, petroleum products, farm equipment, hardware, and building supplies), marketing cooperatives (which may bargain for better prices, handle, process or manufacture, and sell farm product) and service cooperatives (which provide services such as trucking, storage, ginning, grinding, drying, artificial insemination, irrigation, credit, utilities, and insurance) (Ortmann & King, 2007a).

Hence, from the above discussion on different types of agricultural cooperative, one can conclude that small-scale sugarcane farmers in the Nkomazi Local Municipality are part of a farm supply cooperative (producer cooperative), reason being small-scale sugarcane farmers highlighted during the survey that there were several benefits derived from the organisation, such as the sharing of input cost (fertiliser, seed, water-pump, electricity) which results from the bargaining power, receiving free training in order to improve sugarcane production and as cooperative members they are able to hire local transport at a reasonable price. They concluded by saying, the reduction in input cost and transportation costs, increases their farming income (making it easier for the farmers to provide for their families and sending their children to universities).

### 2.5.5 Source of inefficiency in cooperatives

The horizon problem is the manifestation of inequality amongst membership patronage (dividends) and investment (shares), and this causes cooperatives to be less likely than their proprietary counterparts to take on long-term investments that yield best-practice. The difference in dividends and shares amongst members makes it unlikely that the principal may impose restrictions on effective conduct of the agent. A horizon problem arises when an owner or decision maker's residual claim on the returns generated by an asset is shorter compared to the production life of that asset. In short, the decision maker is experiencing underinvestment on his or her asset because the net income generated by the decision maker is lower than the return generated by the asset (Porter & Scully, 1987).

According to Cook (1995), when property rights are non-transferable, unassigned or insecure, free-riding problems arise. Free riders exist where members or non-members utilises resources for their individual benefits meanwhile property rights are not clearly defined and enforced to ensure that those individuals bear the full costs of the behaviour or gain from the benefits they created. This event materialises in open membership cooperatives. For example, one finds a non-member producer who produces the same good as cooperative benefiting from terms of trade, which was negotiated by the cooperative organisation.

Portfolio problems occur when the shares of a conventional cooperative are generally not freely traded, so members cannot diversify their individual portfolios based on personal wealth and risky investment preferences. Therefore, the manager and director of the cooperative cannot invest for the benefit of all members (Ortmann & King, 2007b).

The control problem arises from the principal-agent issue, which occurs due to the divergence of interests between the membership and their representative board of directors (principal) and management (agent) in a cooperative. The principal agent problem is severe in cooperatives because of the absence of an exchange market for equity shares. This problem is likely to exist in any organisation where ownership and control are separated. The lack of an equity market implies that members are unable to monitor cooperative's value as well as to evaluate the performance of management. Cooperative members may be at a disadvantage in attracting and maintaining good managers because they have nothing with which to compensate or motivate the management, since cooperatives cannot use equity ownership or purchase options (Cook, 1995; Royer, 1999).

"Influence costs are those costs associated with activities in which members or groups within an organisation engage in an attempt to influence the decisions that affect the distribution of wealth or other benefits within an organisation" (Royer, 1999). Cook (1995) argues that for a cooperative that engage in a wide range of activities, diverse objectives among its members are inevitable and this can result in costly influence activities. The influence costs include both the direct costs of influence activities and the costs of poor decisions in terms of misallocation of resources due to the successful exercise of influence. Milgrom and Roberts (1990) stated that influence costs depend on the existence of a central authority who can affect the distribution of costs and benefits among individuals. It also depends on the kinds of procedures that govern decision making as well as the degree of homogeneity or conflict in the interest of the individual in a cooperative. Cooperatives are likely to experience more cost influence as compared to other organisations because "the interests of cooperative members, which are linked to individual farm production activities, are more diverse than the interests of corporate stockholders, who share a common objective of maximising wealth" (Royer,1999).

## 2.6 Agricultural cooperatives and technical efficiency

According to Zamani *et al*. (2019) technical efficiency is important due to the increasing population worldwide, food security and climate change. A goal for policymakers is to increase efficiency in agricultural and non-agricultural markets.

The study by Kolleh (2016) investigated determinants of farmers' participation in agricultural production cooperatives and the impact of cooperative membership on farm income in Liberia. They argued that cooperatives help members in attaining higher standard of living through higher profits. This is one of the reasons for farmers to be part of agricultural production cooperatives. Cooperatives in Liberia were found to having a positive impact on the farm income of members.

In India, Singh *et al*. (2001) investigated the performance of dairy plants in the cooperative and private sectors using stochastic frontier analysis (SFA) and found that cooperative plants are more cost efficient compared to private operators.

Jaime and Salazar (2011) conducted a study on technical efficiency and the participation in organisations of small wheat farmers in Chile using stochastic frontier analysis. Their results indicated that participating in cooperatives improves technical efficiency and the age of producers was found to be the variable causing technical inefficiency. According to Xaba *et al*. (2018) cooperatives' technical efficiency is likely to be affected by the size of the land or farm on which it operates.

Nowak *et al*. (2016) conducted a study on cooperative movements in rural areas of Poland and they found that cooperative members were operating on larger farms compared to non-member members. Cooperative members were trusting one another, and their trust tended to strengthen their organisation. Also, members argue that cooperatives are an important tool for agricultural and rural development. The study also highlighted that cooperative members were not knowledgeable enough about the history, functioning and principles of cooperatives. However, they were much better informed compared to non-member members. Such results were not surprising, given that cooperatives are founded on primary principles such as training, education and distribution of information among cooperative members.

Abdul-Rahaman and Abdulai (2018) compared technical efficiency between farm groups and non-farm groups of rice farmers in northern Ghana, applying stochastic frontier analysis. They argued that farmers who are part of a farming group operate closer to their production frontier than those farmers who produce individually and they identified land size, fertilisers and chemicals as those variables influencing technical efficiency. Several studies have included variables such as tractor hours, seed rate, labour days, irrigation numbers, chemicals, fertiliser, farmyard manure and herbicide for estimating the production function, while age, experience and education of sugarcane growers were taken as factors influencing technical inefficiency (Msuya & Ashimogo, 2005; Padilla-Fernandez and Nuthall, 2009; Dlamini, 2010; Tchereni *et al*., 2012; Ali *et al*., 2013; Murali and Prathap, 2017).

In Ethiopia, Abate *et al*. (2014) carried out a study on the impact of agricultural cooperatives on the technical efficiency of smallholder farmers, applying SFA. The results highlighted that agricultural cooperative member farmers are technical efficient, due to the support services provided by cooperative organisations.

According to the study investigated by Mavimbela *et al.* (2010) in Swaziland, cooperative member farmers were found to be producing more output per hectare compared to individual farmers. Higher yields obtained by cooperative member farmers were the result of using improved production inputs such as fertiliser, seeds and pesticides.

In KwaZulu-Natal, Chibanda *et al*. (2009) investigated institutional and governance factors influencing the performance of agricultural cooperatives for smallholders. The results showed that the performance was being affected by governance problems (such as low levels of education, low returns to members as patrons or investors, weak marketing arrangements and lack of management training skills and production) and institutional problems (such as decline of membership, lower investment, low levels of debt capital and equity and government dependency for funding).

Msimango and Oladele (2013) stated that North West farmers who were part of cooperatives used hired labour to produce goods and experienced inadequate capital for production.

### 2.7 Summary

Chapter 2 presents a literature review focused on technical efficiency, as well as the production economics theory. The reason being that technical efficiency helps in measuring the performance of farm's activities such as the production activity. It has been perceived that efficient use of inputs can help farmers to achieve higher production from a given number of resources. Growth in an enterprise results from improved efficiency. Further, techniques to estimate technical efficiency were reviewed, which included the non-parametric (DEA) and parametric (SFA) approaches. SFA was chosen for the study because it considers the inefficiency term and noise term separately, which is in accordance with the objectives of the study. The researcher then reviewed the history of agricultural cooperatives in South Africa. The contribution of agricultural cooperatives to the country's development was without question during the apartheid era, hence the reason the current government implemented a cooperative act, which is aimed at enhancing the development of small-scale farmers. The formation of agricultural cooperatives was then assessed and the results showed that they potentially minimise production risk through resource pool establishment, as well as preventing market failure.

Several studies in other countries showed that agricultural cooperatives are mostly technically efficient compared to private operators. The reason might be that in agricultural cooperatives there is a pool of knowledge regarding agricultural production and support services received from the government. There were some factors that were identified that influence the technical efficiency of cooperative member and non-member farmers, such as size of a land, cooperative membership, age of producer, fertiliser use, chemical use, gender of the farmer, etc. The researcher studied the sources of inefficiency in cooperatives, which included horizon, free rider, portfolio, control and influence cost problem. The mentioned problems found in cooperative organisations, clearly show that in some instances agricultural cooperative members might be less technically efficient compared to non-member farmers, so our focus should be on how to improve technical efficiencies of farmers who are part of a cooperative, as well as farmers who are not cooperative members, for the betterment of our country's economy.

# 3. DESCRIPTION OF THE STUDY AREA

## 3.1 Introduction

This chapter describes the Nkomazi Local Municipality where the study was conducted. Several topics have been discussed such as the geographic information, which includes the location, ethnic groups settling within the Nkomazi Local Municipality, and the climate of the study area. Further, the exact location of the study is supported with the aid of a map. The evolution of small-scale sugarcane farmers and the production of sugarcane by small-scale farmers in the Nkomazi Local Municipality was also discussed.

## 3.2 Location of the study area

The study was conducted in the Nkomazi Local Municipality and this municipality is one of the five municipalities found in Ehlanzeni District of Mpumalanga province. The Nkomazi Local Municipality is a Category B municipality located in the eastern part of the Ehlanzeni District in the Mpumalanga Province. The Nkomazi Local Municipality is divided into 33 municipal wards. The municipality is located between Swaziland and Mozambique, bordered by the Kruger National Park to the north and Mbombela city to the west. It is the smallest of the five municipalities in the district, accounting for 17% of the geographic area. This municipality is driven largely by agriculture, mining and tourism activities (IDP, 2016).

The Nkomazi Local Municipality has a license for supplying water in all areas within its jurisdiction and is a Water Service Authority. There are eight Traditional Authorities found in the Nkomazi Local Municipality and these are situated in the southern section of the municipality. The Nkomazi Local Municipality is also facing land ownership predicaments because most of the land is either under the tribal authority or is dominated by farmers. Another problem is delays in land claim finalisation, which negatively impact the development of entire municipality. There is a low crime rate in the municipality (IDP, 2015).

## 3.3 Ethnic groups

The population of this area is made up of different groups (blacks, whites, Indians, coloureds). The dominating group is black people making up of 98.79% and least are Indians at 0.09%. The area occupied by Nkomazi Local Municipality is 4 787km² (IDP, 2016).

## 3.4 Climate of the study area

Nkomazi Local Municipality is a subtropical area with hot summers, mild winters and summer rainfall from October to March and is a warm region. There is approximately 750 to 860mm variation in the annual average mean rainfall within the municipality. In the eastern areas the average variation is roughly 450 to 550mm whereas in higher western areas it is around 1500mm. The Nkomazi Local Municipality has no high potential soil for agricultural activities, whereas 75.3% is regarded as medium potential soil for agricultural activities. Most of the activities under agriculture, such as grazing and irrigation, are carried out on the medium potential land. Low potential soil for agricultural activities in this area comprises 15.3% (IDP, 2015). Figure 3 below shows a map of five local municipalities within the Ehlanzeni District Municipality.

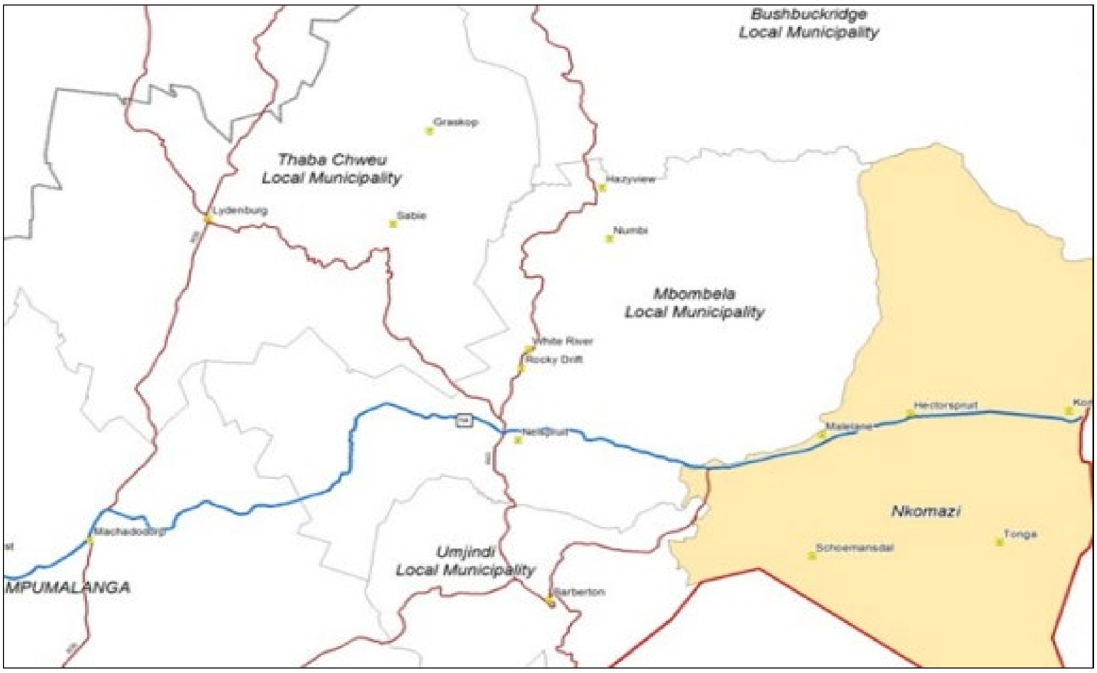


**Figure 3.1: Map showing Ehlanzeni District Local Municipalities**

Source: IDP (2017)

## 3.5 The evolution of small-scale sugarcane farmers in the Nkomazi Local Municipality

According to James and Woodhouse (2015) the emergence of small-scale farmers involved in sugarcane farming in the Nkomazi Local Municipality was a consequence of apartheid. During this era people experienced forced removal, displacement, as well as resettlement. These processes led to the evolution of tribal authorities (Matsamo, Mawewe, Mhlaba, Siboshwa, Lugedlane, Hoyi, Mhlambo and Lomshiyo) which control how people obtain sugarcane fields and land rights.

The Nkomazi Local Municipality is an area that used to be an arena of settlement and struggle linked to the formation and expansion of the Swazi state during the 19th century. During the period from 1840s until 1870s the Swazi sovereignty covered much ground on this area. Migration and immigration were taking place in the area because the Swazi and neighbouring African powers (Zulu, Pedi and Gaza-Shangaan) and the Boer republic centred on Lydenburg were fighting to take control over the area (Myburgh, 1949).

Following the 1913 Land Act, a Native Land Commission was established to identify areas for African settlement. When the National Party gained power in 1948, after two years of reign African people were removed from the northern parts of the district (Tenbosch) to the 'trust land' reserved for black settlement in the south. During that period two forms of displacement were experienced: some groups such as the Ngomane, the Mhlaba, some of the Matsamo and the Mawewe were displaced to make a way for white settlement, and the other displacement took place involved groups (Matsamo, Mawewe and Mahlalela) to give room for those relocating from the north. All blacks in the area were under the separate administration of the homeland government of KaNgwane from 1982 to 1995 (James and Woodhouse, 2015).

According to Mathews (2010) there are a variety of crops planted in the Nkomazi Location Municipality by small-scale farmers such as cassava, maize, groundnuts, bambara groundnuts, sugarcane, etc. Nkomazi small-scale farmers have irrigation facilities.

### 3.6 Production of sugarcane by small-scale farmers

The Nkomazi Local Municipality is the major sugarcane producing unit in Mpumalanga. Sugarcane growers are represented by the South African Cane Growers Association and the South African Farmers Development Association in the Nkomazi Local Municipality. Sugarcane production takes place in the areas between the Mananga border, the Komatipoort border and the areas towards Nelspruit, particularly the Lowveld region of Mpumalanga. Sugarcane in this region is produced under irrigation.

The small-scale sugarcane production area in the Nkomazi Local Municipality is equivalent to 10 292 ha of irrigated land (James & Woodhouse, 2015). During the survey of the study in 2020, it has been observed that there were approximately 1304 small-scale sugarcane farmers in the Nkomazi Local Municipality and in season 2018-19 on average, cooperative farmers produced 1996.8 tons and non-member produced 616.2 tons. The higher the sugarcane output, the higher the income, which improve the standard of living for small-scale farmers.

There is only one market for farmers that produce sugarcane in Mpumalanga, where all sugarcane producers (cooperative member farmers and non-member farmers) deliver their sugarcane output for further processing, namely RCL Foods Sugar and Milling (Pty) Ltd, with two mills, one in Komati and one in Malalane. According to the RCL Corporate Brochure (2019) RCL Foods has been established on four separate businesses which includes TSB Sugar, Rainbow Chicken, Foodcorp and Vector Logistics. RCL Foods has two divisions, that is the food division (baking, chicken, groceries, sugar, spreads) and the logistics division (sales solution, supply chain intelligence, warehousing, distribution, imports / exports, credit management) supported by common group functions (finance, information technology, human resource, CEO's office).

The small-scale sugarcane farmers have sugarcane delivery agreement with the company, but they do not have shares in the RCL foods sugar and milling (Pty) Ltd. The only relationship that the small-scale sugarcane farmers have with the RCL foods sugar and milling (Pty) Ltd is the marketing relationship.

In the Nkomazi Local Municipality, there are about 15 farm supply cooperative (producer cooperative) organisations, each consisting of a number of between 5 and 50 small-scale sugarcane farmers. Farm supply cooperatives (producer cooperatives) in the Nkomazi Local Municipality seem to improve the welfare of its members. However, it should be noted that majority of these farmers produce individually within the cooperatives and some produce collectively within the cooperatives.

The committee representatives of the farm supply cooperative organisations consist of seven members (chairperson, vice chairperson, secretary, vice secretary, treasures and two additional members). The operational structure of farm supply cooperatives for small-scale sugarcane farmers in the Nkomazi Local Municipality is more likely the same as the general operational structure found in chapter 2 (figure 2.3). For financial officers, there is Akwandze Agricultural Finance officers, which serve as the funding company and as a farm advisor (since they manage funds for sugarcane farmers). For the administration officers, there are clerks within the cooperative that deals with administration work. Further the Mpumalanga cane growers Association usually hires interns with the aim of assisting farm supply cooperatives with the administration work. As for the operation officers, the farmer is a manager and is working with the extension officers from the private sector (TSGRO Farming Services (pty) Ltd; South African Cane Growers Association; South African Farmers Development) and from the government sector (Lima Rural Development Foundation) in the production of sugarcane. Permanent and seasonal workers are employed for the production and harvesting of the sugarcane crop.

For marketing officers, small-scale sugarcane farmers in farm supply cooperatives usually hires Buhle Betfu Cargo transport to carry the harvested cane from the field to RCL foods sugar and milling (pty) Ltd.

# 4. RESEARCH METHOD

## 4.1 Introduction

The general goal of every farmer is to improve their productivity through the efficient and effective use of input resources. While one may identify farmers as either efficient or inefficient, it is not beneficial without understanding the factors causing the state of efficiency. The identification of such factors could enable an attempt to rectify the situation through focused policy advice. It is therefore relevant to measure technical efficiency for cooperative member and non-member sugarcane farmers since farming contributes to their welfare through the income generated, recognising that solutions might differ between the groups. This section explains the theoretical part of the stochastic frontier model and the analytical framework applied to this study.

## 4.2 Data collection and sampling

Sampling is an applied way of collecting data when the population is infinite or large, and good sampling satisfies the different criteria for a quantitative or qualitative approach. Quantitative methods rely heavily on numbers and statistics in the analysis and interpretation of results that are generalised from sample to population. On the other hand, qualitative methods are often used when the problem has not been studied before (Bless *et al*., 2013).

According to Merriam (2002) quantitative methods focus on statistical data, while qualitative research uses descriptive narratives (such as transcriptions, audio or video recordings, and other written records) to obtain high-quality information that gives meaning to social phenomena (Makwakwa, 2017). For this study a quantitative approach was used.

Quantitative methods use tools such as scales, tests, questionnaires and computers in data collection, while qualitative methods make researchers the main tool for data collection (Moriarty, 2011). In quantitative methods, researchers use methods such as interviews, observations, and analysis of existing documents on the subject (Makwakwa, 2017).

According to Wagner *et al*. (2012) an interview is a two-way conversation with the intention of acquiring some information on ideas, experiences, beliefs, views, opinions and behaviour from the interviewee or participant on an issue. Thus, the study used the structured interview where all questions are predetermined and posed to participants in the same order.

The sample was generated from a list of sugarcane growers supplied by the South African Cane Growers' Association found in Mpumalanga; with offices within the RCL foods sugar and milling (Pty) Ltd premises. Their list contains 1304 small-scale sugarcane growers of which some are part of cooperatives (approximately 300 farmers) and others are not. There are approximately 15 cooperatives operating under sugarcane in the Nkomazi Local Municipality.

The study used convenience or availability sampling technique. Only small-scale farmers who produce sugarcane in the Nkomazi Local Municipality were selected, given the main purpose of the study which was to determine if there is a statistically significant difference in technical efficiency between producers who are members of a cooperative and those who are not. Convenience sampling was used given the fact that the researcher was taking all cases on hand until the sample reached the desired size (see 4.2.1 below). Using a 90% confidence level and an 8% margin of error for a population of 1300, the sample size required based on an online sample size calculator is 100 respondents (see website: http://www.raosoft.com/samplesize.html).

#### 4.2.1 Procedure for data collection from small-scale sugarcane producers

In February 2020 the researcher contacted Mr Tibane who works at RCL foods sugar and milling (Pty) Ltd, enquiring about the number of small-scale farmers producing sugarcane in the Nkomazi Local Municipality to ensure that there are indeed small-scale sugarcane farmers in the Nkomazi Local Municipality. Mr Tibane sent the list of small-scale sugarcane farmers to the researcher.

On 16 November 2020 the researcher received the ethics approval letter from the Research Ethics Committee. On the same day the researcher wrote an email to Mr Mashego who works at the South African Cane Growers' Association as the Senior Agricultural Business Advisor, explaining every detail about the study that had to be conducted, therefore requesting the contact lists of small-scale sugarcane farmers, since the survey had to be done telephonically due to the pandemic of covid-19.

Mr Mashego responded by inviting the researcher to their 2020 annual general meeting (AGM) during the following week. There the researcher was given an opportunity to explain the survey or the study to over 300 small-scale sugarcane growers. Farmers were then told that the survey will be done telephonically due to the pandemic covid-19. The researcher read the questionnaire to the small-scale farmers, to familiarise the farmers with the questions that would be asked during the telephonic interview. Clerks were requested to forward the list of contacts of farmers from their projects to the researcher. Farmers who were also in the meeting presented their telephone numbers to the researcher.

After the AGM the researcher began to contact the small-scale sugarcane growers. During the phone calls, the researcher captured the responses on the questionnaire. Data capturing in Excel started middle January 2021. The phone calls between the researcher and respondents took on average 30 minutes depending on the information that each farmer shared. The researcher called at least three or four farmers per day. As a result, the journey of data collection was not that challenging because the majority of famers were willing to participate and were expecting the phone call. During the phone calls some of those farmers who were not present at the AGM would contact Mr Mashego or their project clerks just to confirm that the researcher was truly conducting research. After the confirmation the farmers participated. Very few farmers (less than 10) did not participate.

A simple random sampling was adopted in selecting 50 non-members farmers in 8 villages (Driekoppies (6); Langeloop1 (6); Masibekela (12); Mangeni (8); Kahoyi (8); Madadeni (4); Sibange (5) and Sikwahlane (1)). Further, 50 cooperative member farmers in different cooperative organisations were selected (Khanyangwane (11); Ngogolo (24); Group Four Farmers (1); Mbongozi (7); Vlakbult (1); Sikwahlane (3); Siboshwa (1); Wald (1); Langeloop2 (1)). These farmers were interviewed telephonically using the prepared questionnaires (see appendix) that focused on collection of data on inputs of sugarcane production during the 2018/2019 production season.

### 4.3 Analytical methods

To analyse the data and to fit the objectives of the study, two types of data analyses were used, namely descriptive analysis and econometric analysis. The two methods were used for analysing the primary data collected from small-scale sugarcane farmers in the Nkomazi Local Municipality. After the completion of data collection, information was compiled for data processing.

#### 4.3.1 Descriptive statistics

Descriptive statistics were used to summarise the data by describing the basic features of the data from the Nkomazi Local Municipality, and to provide a clear summary of the variables with their units of measurement. Results are presented in chapter 5.

#### 4.3.2 Econometric analysis

As discussed earlier, the stochastic frontier production model was introduced by Aigner *et al*. (1977) and Meeusen and Van den Broeck (1977) based on the context of production function estimation. The model has two error terms of which one accounts for the random error and the other for technical inefficiency in production.

Following Dey *et al*. (2001) and Abdul-Rahaman (2016), the stochastic frontier production function can be written as:

$$Y_i = f(X_i\,;\,\beta)\exp(V_i - U_i) \tag{1}$$

Where:

$Y_i$ is sugarcane output of $i^{th}$ farmer; $X_i$ is a (1 X k) vector of farm inputs used in sugarcane production; β is a (1 X k) vector of parameters to be estimated; $V_i$ is a random error (variation in sugarcane output) associated with random factors not under the control of the farmer whereas $U_i$ is a non-negative random variable associated with the technical inefficiency of the $i^{th}$ farm.

Following Battese and Coelli (1995), $U_i$ is assumed to be independently distributed and obtained by truncating the normal distribution, with mean $\mu_i = 0$, and variance, $\sigma^2_U = 0$.

Where:

$$U_i = Z_i\delta + W_i \quad (2)$$

$Z_i$ is a vector of explanatory variables associated with farm-level technical inefficiencies, δ is the vector of parameters to be evaluated and $W_i$ refers to the error term. The model's total variance estimates the variance parameters of the likelihood function, which is defined as $\sigma_T^2 = \sigma_V^2 + \sigma_U^2$. The information is then used to calculate the parameter $\gamma = \frac{\sigma_U^2}{\sigma_T^2}$ which is the proportional total variance explained by the variance of inefficiencies and its value lies between 0 and 1, with value equal to 1 indicating that all the deviations from the frontier are due entirely to technical inefficiency (Coelli *et al.,* 1998).

Technical inefficiency determinants are specified as (Coelli *et al.,* 1998; Mango et al., 2015):

$$\ln (U_i) = \delta_0 + \delta_1 (Z_i) + W_i \quad (3)$$

where $U_i$ is technical inefficiency; $\delta_0, \ldots \delta_1$ are the parameters to be estimated; $Z_i$ is a vector of farmer and household socio-economic characteristics; Wi is a random error.

The stochastic production frontier, defined by equation (1), and the technical inefficiency model, defined by equation (3), were simultaneously estimated by the maximum likelihood method. A half-normal distribution of the inefficiency variance was used in the estimation (Kumbhakar *et al*., 2015; Mango *et al*., 2015)[2].

*4.3.2.1 The likelihood ratio test*

According to Coelli (1995), the technical inefficiency model can be estimated only if the inefficiency effects are stochastic and the model have a particular distributional specification. Hence there is interest to test the null hypothesis that the inefficiency

[2] It is recognised that the truncated normal distribution is frequently used in this type of analysis, but the model does not converge under the truncated normal distribution for any desired combination of variables.

effects are absent from the model. The generalised likelihood-ratio statistic is used to test this hypothesis and other null hypotheses of interest.

$LR = -2 [\log(L_0) - \log(L_1)]$

Where $\log(L_0)$ is the log-likelihood value under the null hypothesis and $\log(L_1)$ is the log likelihood value assuming the null is false.

The null hypothesis ($H_0$) which specifies that the inefficiency effects are absent from the model is presented as follows for the present study:

$H_0: \gamma = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 = 0$

The null hypothesis ($H_0$) will be strongly rejected if the estimated likelihood ratio (LR) test statistic is greater than the critical chi-square value given by Kodde and Palm (1986). Then the alternative hypothesis which states that inefficiency effects are present in the model and that they are stochastic, will be accepted. This implies that the inefficiency stochastic frontier production function is a significant improvement over the corresponding stochastic frontier (traditional mean response model) which does not involve a model for the technical inefficiency effects.

The LR test statistic is assumed to be asymptotically distributed as a chi-square random variable with degrees of freedom equal to the number of restrictions involved (in this instance one). However, in the case of the test of the null hypothesis that gamma ($\gamma$) =0, then the likelihood ratio statistic will have asymptotic distribution equal to a mixture of chi-square distribution. Due to the fact that the value of $\gamma$ cannot be less than zero because this would imply that the variance, $\sigma^2_U$ is negative (Coelli,1995).

*4.3.2.2 Technical efficiency*

Each farm's technical efficiency is defined as the ratio of the actual observed output to the corresponding frontier output, conditional on the inputs level used (Piesse *et al*., 2018). Therefore, following Dey *et al*. (2001) and Piesse *et al*. (2018), the stochastic production frontier representing maximum possible output ($Y_i^*$) of the $i^{th}$ farm is expressed as:

$$Y_i^* = f(X_i; \beta) \exp(V_i) \quad (3)$$

Equation (1) may be rewritten using equation (3) as:

$$Y_i = Y_i^* \exp(-U_i) \tag{4}$$

Therefore, technical efficiency of the $i^{th}$ farm in the context of the stochastic production frontier, denoted by $TE_i$, is given as:

$$TE_i = Y_i / Y_i^* = \exp(-U_i) \tag{5}$$

$TE_i$ is measured on a scale of 0 to 1. A value of 1 indicates that a farm is fully technical efficient, in contrast, a value less than 1 indicates the presence of technical inefficiency on the farm. The variation between Y and Y* is embedded in $U_i$. For instance, if $U_i$ = 0, then Y is equal to Y* and it reflects that production is on the stochastic frontier as well as maximum possible output is obtained by the farm given the level of inputs and hence the farm is technically efficient. If $U_i > 0$, production lies below the frontier and the farm is technically inefficient (Dey *et al*., 2000).

### 4.4 Model specification for the study

The stochastic frontier production function was initiated by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977). According to Battese and Coelli (1995) the stochastic frontier production function postulates the existence of technical inefficiencies of production of firms involved in producing a particular output.

Battese and Coelli (1995) proposed a model for technical inefficiency effects in a stochastic frontier production function for panel data, under the assumption that the inefficiency effects (Ui) are assumed to be independently distributed as truncations of normal distributions with constant variance, but with means which are a linear function of observable variables. In Zimbabwe Mango *et al.* (2015) did a study on the stochastic frontier analysis of technical efficiency in smallholder maize production, using cross sectional data. A half-normal distribution of the inefficiency variance was used in their estimation.

Therefore, the study follows the work of Mango *et al.* (2015) and Kumbhakar *et al.* (2015) since they deal with cross sectional data, and the assumption that the technical inefficiency effects (Ui) follow a half-normal distribution. The use of the specification of the SFA models are in natural logs to estimate a linear functional form.

In order to determine the significance of factors influencing the sugarcane output, a Cobb-Douglas stochastic frontier production model was used for this study (Coelli & Battese 1996; Amornkitvikai *et al*., 2014; Ehirim *et al*., 2016; Kumbhakar *et al*., 2015):

$$\ln(Y_i) = \beta_0 + \ln\beta_1 X_1 + \ln\beta_2 X_2 + \ln\beta_3 X_3 + \ln\beta_4 X_4 + V_i - U_i \quad (6)$$

Where[3]:

The subscript i represent the $i^{th}$ farmer in the sample of n farmers (i = 1, 2, 3…, n) and In indicates that the natural logarithm of the variable was used;

Output (Y) is the sugarcane output harvested per farm during the 2018/2019 production season (tons);

Farm size ($X_1$) is the area devoted to the production of sugarcane, measured in hectares;

Labour ($X_2$) is the number of permanent labourers used for sugarcane production per year per farm (see 5.2.1.3)

Fertiliser ($X_3$) is the total amount of fertiliser used, measured in kilograms per farm;

Herbicides ($X_4$) is the total amount of herbicides used, measured in litres per farm.

The $V_i$'s are random errors associated with measurement errors in the output of sugarcane reported or the combined effects of input variables not included in the production function.

In order to determine the significance of factors causing technical inefficiency, the inefficiency sub-model based on Battese and Coelli (1995) and Mango *et al*. (2015) is specified as follows:

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + W_i \quad (7)$$

Where[4]:

$Z_1$ = Age of the small-scale sugarcane farmers in terms of categories (1 if the age of the farmer is above 50, 0 if the age of the farmer is below 50)

[3] Only selected variables were retained in the final version of the model.
[4] Only selected variables were retained in the final version of the model.

$Z_2$ = Education (1 if a farmer has formal education, 0 otherwise)

$Z_3$ = Off-farm income (1 if a farmer has off-farm income, 0 otherwise)

$Z_4$ = Experience, the farmer's farming background, measured as the number of years in sugarcane farming

$Z_5$ = Training is the number of interactions with extension officers a farmer has received (both advisory or workshop-based training) on cultivation of sugarcane in 2018 and 2019

$Z_6$= Gender (1 if a farmer is female, 0 otherwise)

$Z_7$ = Cooperative membership (1 if cooperative member, 0 otherwise)

$\delta$ = inefficiency parameters to be estimated

$W_i$ = an error term

# 5. RESULTS AND DISCUSSION

## 5.1 Introduction

This chapter outlines the results of the study. The descriptive statistics was used in order is to describe the basic features of data from the study area. The computer software Stata version 16 was used for the regression output. The results for the stochastic frontier production function and inefficiency effects sub-model are presented by the maximum likelihood estimates (MLE). The maximum likelihood estimates give an indication of efficient use of available technology. Also, frequency distributions of technical efficiency estimates for cooperative member and non-member farmers are shown and discussed.

## 5.2 Descriptive analysis of the sample data

This section presents the results of the descriptive analysis for small-scale sugarcane farmers who are members of cooperatives and those who are not, in the Nkomazi Local Municipality. It describes the sugarcane farming units in the research area that were surveyed. The variables included in the initial production function include farm size, number of permanent labourers, use of fertiliser and use of herbicides; and those variables included in the initial inefficiency sub-model include age, education, off-farm income, experience, training, gender and cooperative membership.

### 5.2.1 Data for continuous variables

Table 5.1 shows the descriptive statistics for continuous variables considered in the model. It includes the minimum and maximum values, the sample mean, and standard deviation of each variable in the two groups. The first set of data (raw data) represents data as it was collected, for example the dependent variable (sugarcane yield) was measured in tons per hectare, whereas in the second set (transformed data) the dependent variable (sugarcane output) is measured in tons because the focus is on the entire farm, i.e. after multiplying with the farm size, no longer per hectare. The reason behind the farm size multiplication was to derive total output to compare to total input per farm. To derive total inputs per farm, herbicide and fertiliser use per hectare were also multiplied by farm size as shown in the bottom part of table 5.1.

The variables for farm size, labour (various), fertiliser and herbicides were considered for the production function, whereas experience and the number of training interventions were considered as determinants of production inefficiency. The variables in bold were included in the final stochastic frontier production function, after considering different combinations of variables.

**Table 5.1: Descriptive statistics of data for the continuous variables**

| Variable | Cooperative member farmers, n=50 | | | | Non-member farmers, n=50 | | | |
|---|---|---|---|---|---|---|---|---|
| | Min | Max | Mean | Std | Min | Max | Mean | Std |
| ***Raw data collected through survey*** | | | | | | | | |
| Sugarcane yield (t/ha) | 17.7 | 117.5 | 75.51 | 20.21 | 15.0 | 133.3 | 75.18 | 24.53 |
| **Farm size (ha)** | 2.0 | 283.0 | 24.46 | 53.94 | 2.0 | 22.0 | 7.89 | 4.27 |
| Family labour (no) | 0 | 7 | 1.5 | 1.64 | 0 | 8 | 2.3 | 1.97 |
| Hired labour (no) | 2 | 122 | 19.06 | 20.57 | 2 | 50 | 11.12 | 10.56 |
| **Permanent labour (no)** | 1.0 | 60.0 | 6.02 | 9.79 | 1.0 | 8.0 | 2.90 | 1.66 |
| Fertiliser (kg/ha) | 228.0 | 1000.0 | 776.52 | 156.60 | 250.0 | 1500.0 | 760.66 | 188.20 |
| Herbicides (litres/ha) | 60.0 | 88.7 | 80.65 | 6.03 | 60.0 | 114.0 | 82.28 | 6.71 |
| **Experience (years)** | 1.0 | 38.0 | 16.70 | 11.18 | 1.0 | 33.0 | 15.02 | 8.04 |
| Training (no) | 0.0 | 49.0 | 11.36 | 12.54 | 0.0 | 51.0 | 10.70 | 15.85 |
| ***Transformed data for model (farm level)*** | | | | | | | | |
| **Sugarcane output (t)** | 90.0 | 28 300 | 1 996.8 | 4 854.9 | 108.0 | 2 799.9 | 616.2 | 486.7 |
| **Fertiliser (kg)** | 1 600.0 | 226 400 | 18 242.2 | 41 874.0 | 1 600.0 | 21 000.0 | 6 042.3 | 4 115.1 |
| Herbicides (litres) | 168.0 | 24 904 | 2 027.5 | 4 629.4 | 160.0 | 2 508.0 | 662.2 | 417.2 |

Source: Field Survey, 2020.

### *5.2.1.1 Sugarcane yield (tons/ha) and sugarcane output (tons)*

Table 5.1 indicate that the tons of sugarcane produced per hectare of land varies between farm units in the Nkomazi Local Municipality. In the 2018/2019 season of sugarcane production, the average sugarcane yield was approximately 75.5 tons per hectare of raw cane, the minimum and maximum of sugarcane yield were found to be 17.65 t/ha and 117.5 t/ha respectively for cooperative member farmers. Additionally, the transformed data shows that on average cooperative member farmers were producing 1 996.8 tons of raw cane. The minimum and maximum sugarcane output were recorded as 90 tons and 28 300 tons.

As for non-member farmers the minimum and maximum of sugarcane yield produced were found to be 15 t/ha and 133.3 t/ha, with a mean of 75.18 t/ha. It implies that on average farmers produced 75.18 tons per hectare. The transformed data shows that on average non-member farmers produced 616.2 tons. The minimum and maximum of sugarcane output were recorded to be 108 tons and 2 779.9 tons.

When comparing the two groups there was not much difference between the average yields of the two groups. However, the mean of total output of cooperative member farmers is notably higher than that of non-member farmers, the reason being that the farm sizes of cooperative member farmers are larger.

*5.2.1.2 Farm size (ha)*

The majority of the small-scale sugarcane farmers practice sugarcane farming on land given to them by the traditional authority and some through the land reform programme. The results from table 5.1 show that cooperatives' farm sizes range from 2 ha to 283 ha. Something to note regarding this ranges of farm size, is that in some cooperatives, farmers produce separately within the organisation and in some cooperatives, they produce as a group hence the higher farm size in cooperatives. Cooperative member farmers use on average 24.46 ha to produce sugarcane. Non-member farmers use on average 7.89 ha to produce sugarcane, with the minimum and maximum of farm size ranging between 2 ha and 22 ha. When comparing the means of the two groups it shows that cooperative members have more land compared to non-members farmers. Of the total area of 1 617 ha covered in the survey, only 24% belong to the non-member farmers (individual farmers).

Farm size has an impact on sugarcane output. Table 5.2 shows that majority of cooperative member farmers own about 7 to 9.9 hectares of land that they use for sugarcane production, which is about 48% of the farmers. Likewise, table 5.2 shows that only 34% of non-member farmers have between 7 and 9.9 hectares of land. Most (42%) of non-members are owning less than 7 hectares of land, meanwhile only 20% of cooperative members own less than 7 hectares. Lastly, the data indicate that only 32% of cooperative members are owning land that is greater than 10 hectares. Whereas only 24% of non-members own between 10 to 25.9 hectares. When comparing the two groups it shows that cooperative member farmers own larger farms compared to non-member farmers, the reason being that some of the cooperatives produce sugarcane jointly, whereas some produce separately within the organisation, hence the relatively larger farm size for cooperative members.

**Table 5.2: Cooperative members and non-members' land / farm size devoted to sugarcane production**

| | Cooperative members (N=50) | | Non-members (N=50) | |
|---|---|---|---|---|
| **Range of farm size** | **Frequency** | **Percentage** | **Frequency** | **Percentage** |
| 1.0 - 3.9 | 1 | 2% | 4 | 8% |
| 4.0 - 6.9 | 9 | 18% | 17 | 34% |
| 7.0 - 9.9 | 24 | 48% | 17 | 34% |
| 10.0 - 12.9 | 5 | 10% | 7 | 14% |
| 13.0 - 15.9 | 1 | 2% | 2 | 4% |
| 16.0 - 18.9 | 1 | 2% | 0 | 0% |
| 19.0 - 21.9 | 1 | 2% | 2 | 4% |
| 22.0 - 25.9 | 2 | 4% | 1 | 2% |
| ≥26 | 6 | 12% | 0 | 0 |
| Total | 50 | 100% | 50 | 100% |
| Farm size (ha) | Min= 2 | Max= 283 | Min= 2 | Max= 22 |

*5.2.1.3 Family and hired labour*

Table 5.1 reveals that on average cooperative member farmers had one to two family members and non-member farmers only two to three family members. For cooperative farmers family labour ranged from 0 to 7 and for non-members it ranged from 0 to 8. Hired labour on average for cooperative member famers is 19 and for non-member farmers it is 11. The minimum and maximum number of hired labour by cooperative member farmers are found to be 2 and 122 respectively, and for non-member farmers it was found to be 2 to 50. When comparing these two groups it shows that cooperative farmers had a higher number of labourers, the reason being that most of the cooperative member farmers were hiring contractors in most of the sugarcane activities, unlike non-member farmers.

*5.2.1.4 Permanent workers or labour (number)*

In question 2.7.1 from the questionnaire (refer to appendix 9) labour was recorded as labour per hectare, however, during the interview, the farmers on that particular question answered per farm size and not per ha. Further, they gave the number of their permanent labours and seasonal workers separately. Additionally, the small-scale sugarcane farmers indicated that only permanent labours work through the whole year unlike seasonal workers or contract workers. It was thus decided to include only permanent labour in the model, because it gave better results than the combined labour numbers. The question on labour man days (question 2.7.3 in appendix 9) was not clearly explained to the farmers and the data captured from this question was not accurately captured, and hence it was omitted.

In the 2018/2019 season of sugarcane production, cooperative member and non-member farmers on average employed 6 and 3 permanent labours per farm respectively. The minimum and maximum number of permanent labourers used during sugarcane production by cooperative member farmers was found to be 1 and 60. Likewise, the number of permanent labourers employed by non-member farmers ranged from 1 to 8.

*5.2.1.5 Fertiliser application (kg/ha and kg per farm)*

Table 5.1 indicates how much fertiliser small-scale sugarcane farmers in the Nkomazi Local Municipality uses on average in sugarcane farming. Cooperative member and non-member farmers applied on average 776.52 kg and 760.66 kg per hectare. The minimum and maximum of fertiliser used by cooperative member farmers was found to be 228 kg/ha and 1000 kg/ha. Likewise, non-member farmers used fertiliser which ranged from 250 kg/ha to 1500 kg/ha. Fertiliser is very important in irrigated sugarcane production; it increases sugarcane yields if it is applied properly as recommended by the agronomist or extension officers of the study area. Under or over application could potentially lead to reduced yields.

Table 5.1 also showed that fertiliser utilisation per farm among the cooperative member sugarcane farmers ranged between 1 600 kg and 226 400 kg with a mean of 18 242 kg. Likewise, non-member sugarcane farmers on average used 6 042.3 kg of fertiliser, along with the minimum and maximum of 1 600 kg and 21 000 kg.

*5.2.1.6 Herbicides application (litres/ha and litres per farm)*

Table 5.1 reveals that cooperative member farmers apply 80.7 litres of herbicides on average per hectare, while non-member farmers apply 82.3 kg on average per hectare. For cooperative member farmers the herbicide application ranged from 60 l/ha to 88.7 l/ha and for non-member farmers it ranged from 60 l/ha to 114 l/ha.

Furthermore, table 5.1 shows that cooperative member farmers on average apply 2 027 litres of herbicides on their entire farm. The minimum and maximum application of herbicides were found to be 168 litres and 24 904 litres. Non-member farmers used herbicides ranging from 160 litres to 2 508 litres, with a mean of 662 litres.

*5.2.1.7 Experience (years)*

The average farming experience is about 17 years for cooperative member farmers and 15 years for non-member farmers. Experience for cooperative members ranged from 1 year to 38 years and for non-member it ranged from 1 year to 33 years. Data shows that most of the sugarcane farmers have been producing sugarcane for more than ten years. Also, it implies a specialisation and expertise in sugarcane production.

*5.2.1.8 Training interventions (number)*

Table 5.1 shows that some of the small-scale sugarcane farmers receive training in the study area. The training involves the number of extension officer's visits to a farm and the number of different workshops the farmer has attended. It does not take into account how long the workshop was in terms of days or weeks, or the quality of the intervention. The small-scale sugarcane farmers received training in the form of workshops provided by extension officers from the government, from the South African Cane Growers Association, and from the South African Farmers Development Association.

Farmers who are trained on sugarcane farming adopt innovations which help in improving the level of production by applying the knowledge and skills acquired through training. On average cooperative member farmers had received training 11.36 times and non-member farmers 10.7 times during the 2018/2019 production season. For cooperative member farmers' training ranged from 0 to 49 times and for non-member farmers it ranged from 0 to 51 times.

### 5.2.2 Binary variables

*5.2.2.1 Age category of small-scale sugarcane farmers*

Figure 5.1 below shows that the majority of farmers, both cooperative members and non-members (74% and 64% respectively) are above the age of 50 years. The results show that most small-scale farmers are older people, which could imply that the older they get the more experience they have about sugarcane farming. The results show that the age of the remaining 26% of cooperative member farmers ranges between 31 to 50 years whereas that of the remaining 36% of non-member farmers ranged between 26 to 50 years. When comparing both groups it implies that most farmers in cooperatives are older farmers compared to non-member farmers. Age was included in the model as follows: age less than 50 was set to 0 and age above 50 was set to 1.

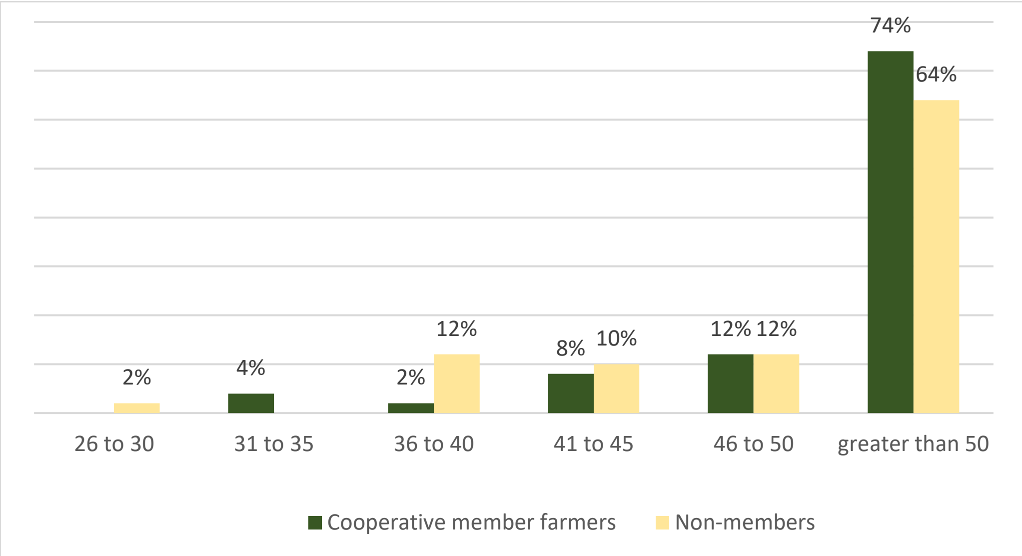


**Figure 5.1: Age of sugarcane farmers (N = 50 for each group)**

*5.2.2.2 Level of education of small-scale sugarcane farmers*

Education is expected to improve farm efficiency since educated farmers can apply better farming practices. They can develop themselves further by reading magazines and newspaper that relate to sugarcane production. Results in figure 5.2 show that 12% of the farmers who are cooperative members have no formal education, thus 88% of these farmers have some form of formal education: primary school (38%), secondary school (30%) and tertiary education (20%). Likewise, 22% of non-member farmers have informal education, and 78% of these farmers have formal education. Relatively more cooperative member farmers therefore have formal education as compared to non-member farmers. Education was included in the model as follows: informal education was set to 0 and formal education was set to 1.

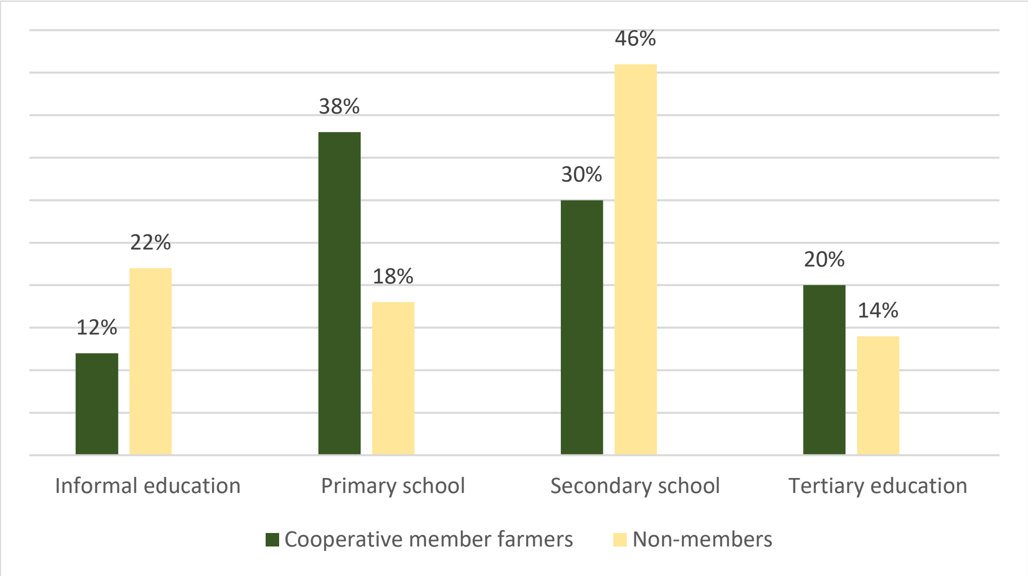


**Figure 5.2: Level of education of sugarcane farmers (N = 50 for each group)**

*5.2.2.3 Off-farm income of small-scale sugarcane farmers*

Figure 5.3 indicates that 74% of non-member farmers have off-farm income and only 26% do not have off-farm income. Similarly, 60% of cooperative member farmers have off-farm income and 40% does not have off-farm income. When comparing the two groups it is noticeable that most non-member farmers have other sources of income compared to cooperative member farmers. The results indicate that those farmers who do not have off-farm income are heavily dependent on sugarcane farming. Their one source of income might affect sugarcane yield in a way, for instance they could be unable to buy all the necessary inputs because they also need to settle their debt from the loan company Akwandze Agricultural Finance, and these affect the effort to increase sugarcane yields and thereby limiting farmers to improve their technical efficiency levels. This information was acquired from the survey. Off-farm income was included in the model as follows: no off-farm income was set to 0 and off-farm income was set to 1.

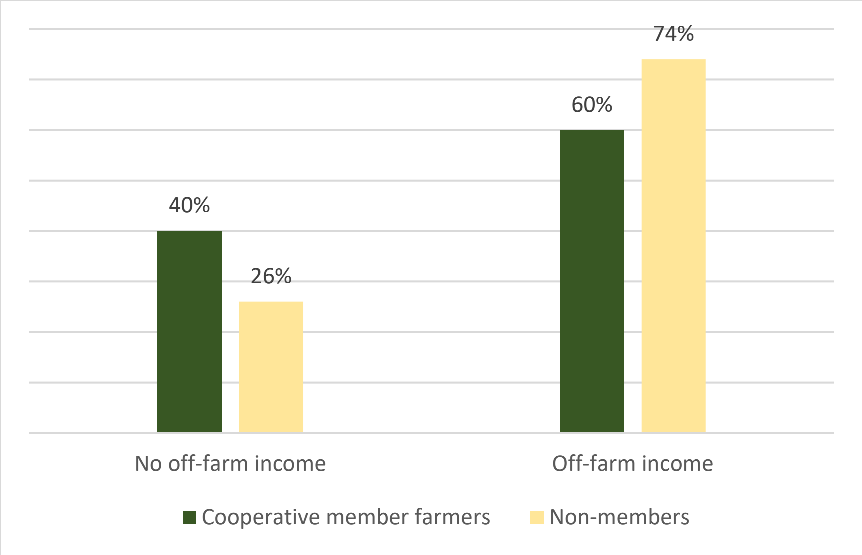


**Figure 5.3: Off-farm income of sugarcane farmers (N = 50 for each group)**

### *5.2.2.4 Gender of small-scale sugarcane farmers*

The results of figure 5.4 indicate that 72% of cooperative member farmers are males and 28% are females. It also shows that 56% of non-member farmers are male relative to 44% of females. The results revealed that there are relatively more men participating in sugarcane farming in the study area. Gender was included in the model as follows: male was set to 0 and female was set to 1.

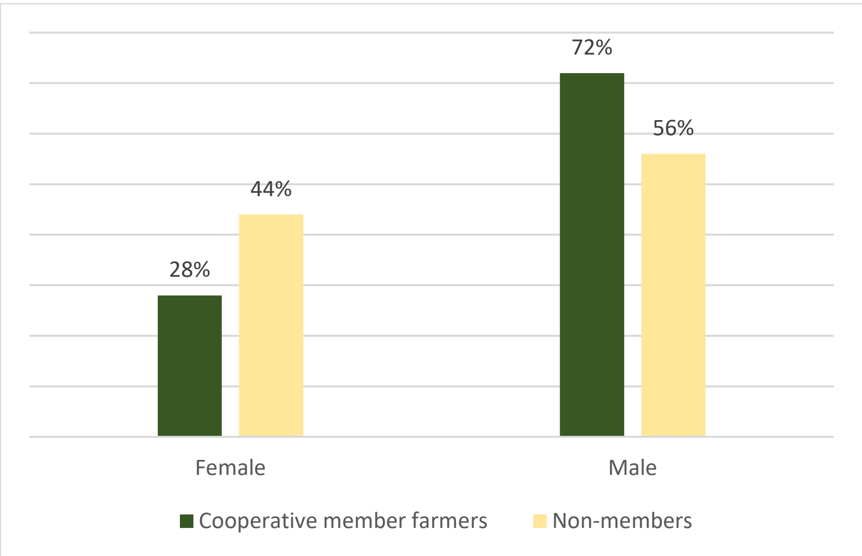


**Figure 5.4: Gender of sugarcane farmers (N = 50 for each group)**

## 5.3 Results of the econometric analysis

The maximum likelihood estimates of the parameters in the Cobb-Douglas stochastic frontier model and those in the inefficiency sub-model are presented in Table 5.7. Five explanatory variables were included in the model, out of which three explanatory variables were for the production frontier model, and two were for the inefficiency sub-model. The results of the estimated sugarcane output for the sugarcane small-scale farmers are presented by the maximum likelihood estimates. The OLS estimates are provided along with the maximum likelihood estimates of the stochastic frontier production. The Cobb-Douglas functional form was used to provide an initial approximation to the production frontier.

### 5.3.1 The Cobb-Douglas production function

Table 5.3 shows the strength of the linear relationship between the variables included in the production function. The correlations between the natural logs of the following variables are reported: farm level variables for output, farm size, permanent labour, fertiliser and herbicides. The results suggest that there is a strong linear relationship between the dependent variable and the independent variables. However, there is a high correlation between herbicides and fertiliser; another correlation is perceived between herbicides and farm size. Fertiliser and herbicides serve as proxy for working capital. According to Jordaan *et al*. (2017) the production function or information represents a physical or biological relationship that contains no economic information. For the present study machinery was only captured as a cost and not in physical terms, so it was not included in the production function.

**Table 5.3: Correlation table (logged variables)**

| | lnoutp~f | lnfarm~f | lnperm~f | lnfert~f | lnherb~f |
|---|---|---|---|---|---|
| lnoutput_f | 1.0000 | | | | |
| lnfarmsize_f | 0.9179 | 1.0000 | | | |
| lnpermanen~f | 0.6829 | 0.6855 | 1.0000 | | |
| lnfertilis~f | 0.8705 | 0.9423 | 0.6528 | 1.0000 | |
| lnherbicid~f | 0.9161 | 0.9950 | 0.6929 | 0.9391 | 1.0000 |

Table 5.4 shows the OLS Cobb-Douglas production function, where herbicides was excluded from the model due to the multicollinearity that occurred between fertiliser and herbicides (refer to results in appendix table 8.2 for the model including herbicides

in the VIF test result). By looking at the coefficients of the explanatory variables, one can conclude that there is a relationship between sugarcane output and the three explanatory variables (farm size, permanent labour and fertiliser). The coefficients for farm size and permanent labour are significant at 1% and 5% respectively, whereas the coefficient for fertiliser is not statistically significant. The fertiliser variable was retained because it serves as a proxy for working capital. The $R^2$ of 0.84 indicates that the model as a whole has good explanatory power. A more detailed discussion on the coefficients will be presented with the final model in table 5.7.

**Table 5.4: OLS Cobb-Douglas production function**

```
Linear regression                               Number of obs     =        100
                                                F(3, 96)          =     356.63
                                                Prob > F          =     0.0000
                                                R-squared         =     0.8482
                                                Root MSE          =     .36089
```

| lnoutput_f | Coef. | Robust Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| lnfarmsize_f | .9300291 | .1775176 | 5.24 | 0.000 | .5776594 | 1.282399 |
| lnpermanentlab_f | .1133802 | .0554918 | 2.04 | 0.044 | .0032298 | .2235306 |
| lnfertiliser_f | .0481101 | .1774414 | 0.27 | 0.787 | -.3041084 | .4003286 |
| _cons | 3.875291 | 1.191198 | 3.25 | 0.002 | 1.510782 | 6.239799 |

## 5.3.2 Testing whether the production model is a production frontier

### 5.3.2.1. A Skewness Test on OLS Residuals

According to Kumbhakar *et al*. (2015) a skewness test on OLS residuals serves as a pre-test of the stochastic frontier specification model before the more complex maximum likelihood estimation is carried out. They further highlighted that if the residuals from the corresponding OLS estimation are skewed to the left (i.e. negative skewness), then it implies that it is a production frontier.

The study results in table 5.5 show that the value of the statistic skewness equals - 1.689. The negative sign indicates that the distribution of the residuals skews to the left which is consistent with a production frontier specification. The p-value for the skewness is 0.0000; thus the null hypothesis of no skewness in the OLS residuals has been rejected at 99% confidence level.

**Table 5.5: Test for skewness on OLS residuals**

Residuals

| | Percentiles | Smallest | | |
|---|---|---|---|---|
| 1% | -1.446848 | -1.603161 | | |
| 5% | -.6710148 | -1.290536 | | |
| 10% | -.4134105 | -.9265525 | Obs | 100 |
| 25% | -.123869 | -.8520608 | Sum of Wgt. | 100 |
| 50% | .0365977 | | Mean | -6.61e-10 |
| | | Largest | Std. Dev. | .355381 |
| 75% | .2367961 | .4465707 | | |
| 90% | .3643847 | .5159919 | Variance | .1262956 |
| 95% | .4087117 | .5389749 | Skewness | -1.689324 |
| 99% | .5652141 | .5914534 | Kurtosis | 7.651801 |

Skewness and kurtosis tests for normality

| | | | | Joint test | |
|---|---|---|---|---|---|
| Variable | Obs | Pr(skewness) | Pr(kurtosis) | chi2(2) | Prob>chi2 |
| e | 100 | 0.0000 | 0.0000 | 47.33 | 0.0000 |

Since the skewness tests confirms that the model is a production frontier, the next step is to estimate the Cobb-Douglas stochastic frontier production function using maximum likelihood.

### 5.3.3 MLE of the Cobb-Douglas stochastic frontier production function

Table 5.6 presents the maximum likelihood estimates of the stochastic frontier production function. At this stage only the variables related to the production function are included, so no attempt is made yet to explain which variables affect inefficiencies. The results show that the coefficients of all the explanatory variables (farm size, permanent labour and fertiliser) are positive, implying that the increased use of the inputs increases sugarcane output. The coefficients for farm size and permanent labour are significant at 1%, whereas the coefficient for fertiliser is not significant. The coefficients and the returns to scale are discussed in more detail in the final model presented later in table 5.7.

**Table 5.6: MLE of the Cobb-Douglas stochastic frontier production function**[5]

```
                                                Number of obs     =        100
                                                Wald chi2(3)      =     962.40
Log likelihood = -24.905103                     Prob > chi2       =     0.0000
```

| lnoutput_f | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| frontier | | | | | | |
| lnfarmsize_f | .8974328 | .0944544 | 9.50 | 0.000 | .7123057 | 1.08256 |
| lnpermanentlab_f | .1383817 | .0478168 | 2.89 | 0.004 | .0446625 | .2321009 |
| lnfertiliser_f | .0190491 | .0863324 | 0.22 | 0.825 | -.1501594 | .1882576 |
| _cons | 4.585567 | .5798823 | 7.91 | 0.000 | 3.449019 | 5.722116 |
| usigmas | | | | | | |
| _cons | -1.261252 | .1890443 | -6.67 | 0.000 | -1.631772 | -.8907323 |
| vsigmas | | | | | | |
| _cons | -4.512008 | .5734322 | -7.87 | 0.000 | -5.635914 | -3.388101 |

*5.3.3.1. Likelihood ratio (LR) test of inefficiency*

According to Coelli (1995), the technical inefficiency model can only be estimated if the inefficiency effects are stochastic and the model have a particular distributional specification. Therefore, it is important to test the null hypothesis, which assumes no inefficiency effects. The null hypothesis is tested using the generalised likelihood-ratio test statistic. The test statistic (LR) has a mixed chi-square distribution.

The generalised likelihood-ratio test statistic is defined by: $LR = -2\,[\log(L_0) – \log(L_1)]$

Where $\log(L_0)$ is the log-likelihood value under the null hypothesis and $\log(L_1)$ is the log-likelihood value assuming the null is false. The degree of freedom equals the number of restrictions in the test (Kumbhakar *et al*., 2015). If the estimated likelihood ratio (LR) test statistic is greater than the critical chi-square value given by Kodde and Palm (1986), then the null hypothesis will be rejected and the alternative hypothesis will be accepted.

In this study the likelihood ratio (LR) was equal to 26.059 while the critical value of the mixed chi-square was 5.412 at 1% level of significance, for degrees of freedom equal to one because only one parameter (i.e., $\sigma^2_U$) was restricted in the test. The results

[5] Using the Stata Command: *sfmodel lnoutput_f, prod dist(h) frontier (lnfarmsize_f lnpermanentlab_f lnfertiliser_f ) usigmas( ) vsigmas( )*; followed by: *ml max, difficult gradient gtol(1e-5) nrtol(1e-5)*

indicate the rejection of the null hypothesis of no technical inefficiency. Thus, the traditional mean response model is inappropriate for the data set, and the specification of the stochastic frontier and inefficiency sub-model is appropriate.

*5.3.3.2 Gamma ratio*

If gamma (γ) is equal to zero, all deviation from the frontier is due to noise, while when γ is equal to 1 it means that all deviation is due to technical inefficiency (Coelli *et al*., 2005). The estimate for the variance parameter gamma (γ), which is the ratio of the variance of technical inefficiency effects ($U_i$) to the variance of random errors ($V_i$), for the study is equal to 0.963. Results indicated that the gamma ratio estimate of the small-scale sugarcane farmers is between 0 and 1 and statistically significant at 1%. It can thus be concluded that there are technically inefficiencies related to sugarcane output of the sampled farmers in the study area. The existence of technical inefficiencies implies that the same resources, used or organised in different ways, may obtain a higher level of output (Mohr and Seymore, 2012).

### 5.3.4 Productivity of farm inputs and the determinants of technical inefficiency effects in the Cobb-Douglas stochastic frontier production function

Table 5.7 shows the maximum likelihood estimates of the estimated stochastic frontier production function and the determinants of technical efficiency for the small-scale sugarcane farmers in the Nkomazi Local Municipality for the 2018/2019 production season. For the inefficiency model all the variables (cooperative membership, experience, training, age, education, off-farm income and gender) were included in the model initially (refer to table 8.3 in the appendix). However, the outcome was unsatisfactory because the variable for fertiliser showed a change in sign. Also, the majority of the variables in the inefficiency sub-model were not statistically significant. Various variables were tested, but in the end experience and cooperative membership were the only two variables that were included in the final model.

For the final model, the results for the production function are similar to that in table 5.6 that contained only the variables for the production function, namely all the coefficients of the production function variables are positive, and the coefficients for farm size and permanent labour are statistically significant at 1%, but the coefficient for fertiliser was not statistically significant.

**Table 5.7: MLE of the Cobb-Douglas stochastic frontier production function and the inefficiency sub-model**

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Number of obs | = | 100 | |
| | | | Wald chi2(3) | = | 1001.93 | |
| Log likelihood = -23.183464 | | | Prob > chi2 | = | 0.0000 | |

| lnoutput_f | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| frontier | | | | | | |
| lnfarmsize_f | .9062597 | .0964746 | 9.39 | 0.000 | .717173 | 1.095346 |
| lnpermanentlab_f | .141976 | .0469673 | 3.02 | 0.003 | .0499217 | .2340303 |
| lnfertiliser_f | .0052546 | .088548 | 0.06 | 0.953 | -.1682963 | .1788055 |
| _cons | 4.675974 | .5933544 | 7.88 | 0.000 | 3.513021 | 5.838927 |
| usigmas | | | | | | |
| coop | -.0884297 | .3027563 | -0.29 | 0.770 | -.6818211 | .5049617 |
| experience | -.0272116 | .0153276 | -1.78 | 0.076 | -.0572532 | .00283 |
| _cons | -.8487009 | .3131418 | -2.71 | 0.007 | -1.462448 | -.2349542 |
| vsigmas | | | | | | |
| _cons | -4.441092 | .5644047 | -7.87 | 0.000 | -5.547305 | -3.334879 |

Source: Estimated from own survey data (2020 - 2021) (n = 100 for both groups)

**Farm size:** Table 5.7 shows that farm size has the highest impact on sugarcane output with a coefficient of 0.906. That is, a one percent increase in farm size, could result in the increase of sugarcane output by 0.91%. This variable is positively significant at 1%. This result is consistent with the findings of Ma *et al*. (2019).

**Permanent labour:** Table 5.7 reveal that the coefficient of permanent labour has a positive sign and is statistically significant at 1% for both groups (cooperative member farmers and non-member farmers). It implies that a one percent increase in permanent labour could increase sugarcane output by 0.14%. Therefore, labour is an important input for production, especially for small-scale sugarcane farmers in the Nkomazi Local Municipality. This finding agrees with of work of Oppong *et al*. (2014) and Ma *et al*. (2019).

**Fertiliser:** As mentioned, the fertiliser variable was retained because it serves as a proxy for capital. Table 5.7 shows that the coefficient of fertiliser has a positive sign, and the coefficient of 0.005 implies that an increase in the use of fertiliser under sugarcane production by 1%, increases sugarcane output by 0.005%. However, this variable is not statistically significant. This result might reveal that some of the small-scale farmers are applying fertilisers based on the recommendation of the other farmers rather than results from their soil sample. Out of the 100 sampled small-scale sugarcane farmers, 48% use 16 bags of fertilisers per hectare. It is therefore important for each of the small-scale farmers in the Nkomazi Local Municipality area, to send their soil samples to a laboratory such as the SASRI'S Fertiliser Advisory Service, because the feedback results include a recommendation on the amount of N, P and K to be applied on the sugarcane field in kg/ha. This finding is line with the work of Mango *et al*. (2015).

**Returns to scale:** The returns to scale parameter for the Cobb-Douglas production frontier is estimated by the sum of the elasticities or coefficients of the three input variables (farm size, permanent labour and fertiliser). The returns to scale parameters for the small-scale sugarcane farmers in the Nkomazi Local municipality was found to be 1.0535, indicating increasing returns to scale, albeit very close to constant returns to scale. It implies that an increase in all inputs by 1% increases sugarcane output by 1.05%.

The estimated inefficiency parameters in the sub-model are shown in table 5.7 and they relate to farm-specific characteristic. The variables included were farming experience in number of years, and cooperative membership as a dummy variable. The cooperative membership variable was included because it is the focus of the study to determine whether belonging to a cooperative had a statistically significant impact on the technical efficiency level of the sugarcane farm. The experience variable was included because it was the only variable with a statistically significant coefficient (refer to appendix table 8.3 that present the model results when all the inefficiency variables were included).

**Cooperative membership:** The negative sign of the coefficient implies that being a member of a cooperative (dummy = 1) reduces technical **in**efficiency in sugarcane production. However, the estimated variable was found to be statistically insignificant. This finding is in line with the work of Wang *et al*. (2014) who mentioned that the presence of cooperatives positively impacts efficiency.

The statistically insignificance of cooperative membership of small-scale sugarcane farmers in the Nkomazi Local Municipality, was not expected for this study due to the belief that producer cooperatives have been regarded as a way of improving farming activities for small-scale farmers in rural areas and with the expectation that farmers who operate together as cooperatives compared to those who operate as individuals would have different technical efficiencies. Additionally, Jaime and Salazar (2011) indicated that participating in cooperatives improves technical efficiency. Rahaman and Abdulai (2018), also stated that farmers who are part of a farming group operate closer to their production frontier than those farmers who produce individually. This finding is not in line with the work of Abate *et al*. (2014) who argued that agricultural cooperative members are technically efficient because of the support services provided by cooperatives.

**Experience:** The negative sign of the coefficient implies that farming experience reduces technical **in**efficiency in sugarcane production. It is thus found that experience positively influences technical efficiency as expected and the coefficient for experience is statistically significant at 10%. The finding is according to expectation, since farmers who have been involved in farming for more years, are expected to have acquired more knowledge and skills through learning-by-doing regarding sugarcane farming. This result is consistent with those of Hossain *et al*. (2008), Bäckman *et al*. (2011) and Ehirim *et al*. (2016).

### 5.3.5 Technical efficiency levels of small-scale sugarcane farmers

Table 5.8 presents the frequency distribution of the technical efficiencies (TE) of the small-scale sugarcane cooperative member and non-member farmers in the Nkomazi Local Municipality. The results show that the estimated technical efficiency is less than 100%, that is, none of the farmers are operating on the expected production frontier or maximum efficiency. The predicted technical efficiencies for cooperative members ranged between 19.81% and 93.10% with a mean TE of 70.77% and for non-members it ranged between 14.08% and 95.76% with a mean TE of 69.57%.

When comparing the mean technical efficiencies of the two groups, the results suggest that there is a slight difference of 1.2%. That is, cooperative farmers are slightly more technically efficient than non-member farmers with a mean technical efficiency of 70.77% compared to mean technical efficiency of 69.57% for non-member farmers.

**Table 5.8: Frequency distribution of technical efficiency estimates of sugarcane production by cooperative member and non-member farmers in the Nkomazi Local Municipality**

| | Cooperative members (N=50) | | | Non-members (N=50) | | |
|---|---|---|---|---|---|---|
| **Range of TE (%)** | **Frequency** | **Share** | **Cum share** | **Frequency** | **Share** | **Cum share** |
| 10-19 | 0 | 0% | 0% | 1 | 2% | 2% |
| 20-29 | 2 | 4% | 4% | 1 | 2% | 4% |
| 30-39 | 1 | 2% | 6% | 1 | 2% | 6% |
| 40-49 | 3 | 6% | 12% | 4 | 8% | 14% |
| 50-59 | 3 | 6% | 18% | 7 | 14% | 28% |
| 60-64 | 3 | 6% | 24% | 5 | 10% | 38% |
| 65-69 | 8 | 16% | 40% | 5 | 10% | 48% |
| 70-74 | 7 | 14% | 54% | 5 | 10% | 58% |
| 75-79 | 4 | 8% | 62% | 4 | 8% | 66% |
| 80-84 | 8 | 16% | 78% | 4 | 8% | 74% |
| 85-89 | 5 | 10% | 88% | 5 | 10% | 84% |
| 90-94 | 6 | 12% | 100% | 6 | 12% | 96% |
| 95-99 | 0 | 0% | 100% | 2 | 4% | 100% |
| Total | 50 | 100% | | 50 | 100% | |
| Mean TE | 70.77% | | | 69.57% | | |
| Min TE | 19.81% | | | 14.08% | | |
| Max TE | 93.10% | | | 95.76% | | |

The mean technical efficiencies suggest that cooperative members and non-member farmers have potential to improve sugarcane output by 29.23% and 30.43%, to meet the frontier level which can be achieved through resource allocation.

It is also evident from table 5.8 that 54% of cooperative sugarcane farmers and 58% of non-member sugarcane farmers are operating at 74% level and below technical efficiency, whereas only 12% of cooperative farmers and 16% of non-member farmers are operating above 90% technical efficiency level.

### 5.4 Challenges faced by cooperative member farmers

During the survey some cooperative member farmers mentioned challenges that they face, some of which are mentioned here. Some sugarcane small-scale farmers in cooperatives in the Nkomazi Local Municipality have poor irrigation infrastructure, and because of this these farmers cannot access water regularly, since the water-pump must be taken for maintenance and mainline pipes must be repaired due to bursts.

This in return hinders sugarcane production. Natural disasters, which include the destruction of irrigation systems caused by fire and the loss of harvest due to waterlogging that is caused by heavy rains, are factors that a have negative impact on sugarcane yield in both groups.

There is limited information-symmetry in some of the agricultural cooperatives which leads to conflicts among the committee members and farmers. There is limited trust among themselves. Simply put organisation members are not driven by the same goals. Some farmers believe there is corruption within the organisations.

Some farmers have altered the original design of the irrigation infrastructure, resulting in a drop in pressure from the water-pumps, which tend to affect some other farmers' output. One agricultural cooperative (Mbongozi cooperative) needed some loans to replant some of the farms that were uncultivated, and to replace an irrigation system (pivot spray) that is being utilised, for they are expensive to maintain. Such challenge makes these farmers to have reduced or decline output for sugarcane, hence low income from their farming activities.

### 5.5 Challenges faced by non-member farmers

During the survey some non-member farmers mentioned challenges that they face, some of which are mentioned here. Some of the non-member sugarcane farmers argue that electricity and transport cost are so high to the extent that it affects their profit and lower their retention savings used for ratoon management, crop re-establishment (replanting) and irrigation maintenance. This results in farmers not having enough money to purchase the required inputs such as herbicides, neither money for workers' salaries.

Access to loans is one of the challenges that both groups were contending with. Some farmers highlighted that because of debt and interest they do not see the benefit of farming. This kind of challenge has caused many farmers to exit sugarcane farming in the Nkomazi Local Municipality. Additionally, some farms were left uncultivated in 2019, the reason being that owners of those farms were not given loans because of their old age.

Non-member farmers highlighted that precise training regarding sugarcane farming is needed, as well as credit for their businesses to keep on operating. Another challenge is the loss of sugarcane, which is consumed by cattle. There are loopholes in the security system of some farms. Some farmers are encountering irrigation pipe theft (dragline hose pipes and sprinklers sprayers), and because of this, farmers encounter difficulties in accessing water. There is theft of sugarcane by the surrounding community members. They are experiencing weed problems and some of the workers who are removing weed are not diligent in their jobs, requiring constant supervision.

# 6. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## 6.1 Introduction

This chapter summarises the results of the study. Further, this chapter examines the extent to which the objectives and hypotheses made at the beginning of the study were considered during the analysis. This chapter also makes recommendations based on the results.

## 6.2 Summary

The constraints and limitations in the availability of resources faced by the entire society and country makes increasing technical efficiency to be a potential goal for every individual in the production process in South Africa, since improved technical efficiency results in productivity growth. Efficiency is an important factor in economics. Thus, a study on technical efficiency of small-scale sugarcane farmers was conducted.

The aim of the study was to determine if there is a statistically significant difference in technical efficiency between cooperative member and non-member sugarcane farmers in the Nkomazi Local Municipality, in order to test the relevance of the motivation surrounding cooperative formation.

The first objective was to determine and compare the level of technical efficiency of cooperative member and non-member small-scale sugarcane farmers in Nkomazi. The second objective was to determine if cooperative membership reduces technical inefficiency and the third objective was to identify sources that reduces technical inefficiency for both groups.

The study used a set of analytical techniques to analyse the data such as descriptive statistics and a stochastic frontier production model whereby the significant and the non-significant variables were identified. The descriptive statistics revealed that small-scale sugarcane farmers in the Nkomazi Local Municipality on average are older farmers, especially in cooperatives. The survey results highlighted that sugarcane farming in the area are mostly done by male farmers. Cooperative member farmers were found to have a higher education level as compared to non-member farmers. Further, the descriptive statistics revealed that there was a difference in the usage of fertilisers and herbicides between cooperative member farmers and non-member farmers. Both groups depend on permanent workers for sugarcane farming in addition to seasonal labour. The majority of the small-scale sugarcane farmers in both groups have been producing sugarcane for more than ten years in the study area. As revealed by the survey results the majority of the non-member farmers are owning less than 6.9 hectares of land whereas the majority of cooperative member farmers own between 7 and 9.9 hectares of land that they use for sugarcane production. The majority of the small-scale sugarcane farmers are using land given to them by tribal authorities. Descriptive statistics were used to summarise the survey data of the study.

The Cobb-Douglas stochastic frontier production function was used to estimate production in terms of sugarcane output. The results for both groups indicated that out of the three included production variables (farm size, fertilisers and permanent labour), fertiliser was found to be statistically insignificant, whereas farm size and permanent labour were statistically significant at 1%. All the coefficient of the three variables were positive as expected.

To determine and compare the level of technical efficiency of cooperative member and non-member small-scale sugarcane farmers in the Nkomazi Local Municipality, a stochastic frontier production model was used to estimate the technical efficiencies of the small-scale sugarcane farmers. For cooperative member farmers, the estimated technical efficiency ranged from 19.81% to 93.10% with a mean TE of 70.77% and for non-members it ranged between 14.08% and 95.76% with a mean TE of 69.57%.

The mean technical efficiency score of 70.77% for cooperative member farmers suggests that the average small-scale sugarcane farmers would have produced 29.23% more sugarcane output with the same level of inputs if the farmers were to produce at maximum technical efficiency. Whereas for non-member farmers, small-scale sugarcane farmers would have produced on average 30.43% more sugarcane output with the same level of inputs, if the farmers were to produce at maximum technical efficiency, given their mean technical efficiency of 69.57%.

An attempt was made to identify the socio-economic characteristics that influence the technical efficiency of small-scale sugarcane farmers in the Nkomazi Local Municipality. The results of the inefficiency sub-model for both groups were presented. Farming experience was found to have a positive effect on technical efficiency and was statistically significant at 10% level. Whereas cooperative membership was found to have a positive effect on technical efficiency, however, the variable was statistically insignificant.

When comparing the mean technical efficiencies of the two groups, the results suggest that there is an almost negligible difference of 1.2%. Additionally, cooperative membership was found to be statistically insignificant. Based on these results one can conclude that cooperative organisation for small-scale sugarcane farmers in the Nkomazi Local Municipality is not contributing to the farmers' maximum technical efficient. This finding is in line with the work of Deininger (1995) who stated that agricultural collectives are far less efficient than independent family farms. Therefore, the theory surrounding agricultural cooperatives being technically inefficient does apply to cooperative member small-scale sugarcane farmers in the Nkomazi Local Municipality.

### 6.3 Conclusions

The hypothesis of the study was that small-scale sugarcane farmers who are part of a cooperative are technically efficient, compared to non-member farmers. The findings of the study have shown that cooperative member sugarcane farmers are slightly more technical efficient than non-members by 1.2%. Further, the inefficiency model has shown that cooperative membership has a positive impact on technical efficiency, however, this variable was found to be statistically insignificant. It implies that producer cooperative for small-scale sugarcane farmers does not notably contribute to increasing efficiency in sugarcane production in the Nkomazi Local Municipality. This finding is in line with the work of Ortmann and King (2007a) who argues that agricultural cooperatives serving small-scale famers in South Africa did not contribute to improving agricultural development and the economic well-being of its members.

Moreover, this study has revealed that small-scale sugarcane farmers in the Nkomazi Local Municipality are not fully technically efficient and therefore there is the potential for efficiency improvement by addressing some important policy variables that negatively and positively influenced farmers' levels of technical efficiency in the area.

Given the result that cooperative member farmers were not found to be significantly more technically efficient compared to non-members, one can conclude that being a member of an agricultural cooperative is not an assurance of improved technical efficient nor does it serve as a beneficial factor to increase technical efficiency. Rather, the cooperatives' quality and response to market failures are of importance. This is in line with work of Valentinov and Iliopoulos (2013), who indicated that cooperatives are being formed due to market failure and the market failure prevents an efficient allocation of resources (Samuelson and Nordhaus, 1992). Adverse selection (market failure) is due to asymmetric information that arises when a seller (contractual partner) has more knowledge about the qualities (characteristics) or price of the good that is traded in the markets than the buyer (farmer) (Mankiw, 2008).

### 6.4 Recommendations

Given the empirical findings, it is important for small-scale sugarcane farmers in the Nkomazi Local Municipality area to follow the correct and optimum use of fertiliser based on recommendations from the Fertiliser Advisory Service as this would increase sugarcane output.

Technical efficiency of small-scale sugarcane farmers can be increased by the identification of the factors that contributes positively to the improvement of technical efficiency. For instance, the findings of the study have shown that experience of the small-scale sugarcane farmers was found to increase technical efficiency. Hence, the study encourages that new entrants should learn from the older farmers before they exit, in order for them to gain practical knowledge of farming to increase technical efficiency.

The study recommends that those farmers that achieved high sugarcane output as well as high technical efficiencies, can be used to demonstrate the benefit of good agricultural practices in reducing the gap between actual and potential sugarcane output.

Moreover, the results indicates that there is 0.963% variation in sugarcane output due to technical inefficiency. Therefore, the study recommends further research on identification of sources of technical inefficiency of the small-scale sugarcane farmers that can lead to possible pathways to improve productivity over time.

Given the result that cooperative member farmers were not found to be significantly more technically efficient compared to non-members, the study suggests that farm supply cooperative in the Nkomazi Local Municipality should carefully consider how they can improve their service to their members.

# 7. REFERENCES


Abate, G.T., Francesconi, G.N. and Getnet, K. 2014. Impact of agricultural cooperatives on smallholders' technical efficiency: empirical evidence from Ethiopia. *Annals of Public and Cooperative Economics*, *85*(2), pp.257-286.

Abdul-Rahaman, A. 2016. Stochastic frontier analysis (SFA) of technical efficiency, insights from smallholder cotton farmers in the Northern Region of Ghana. *Global Journal of Agricultural Economics, Extension and Rural Development*, *4*(1), pp.361-367.

Abdul-Rahaman, A. and Abdulai, A. 2018. Do farmer groups impact on farm yield and efficiency of smallholder farmers? Evidence from rice farmers in northern Ghana. *Food Policy*, *81*, pp.95-105.

Addai-Asante, J. and Sekyi, S. 2016. Stochastic Frontier Analysis of Production Technology: An Application to the Pharmaceutical Manufacturing Firms in Ghana. *World Journal of Current Economics Research 2(1)*, pp.1-20.

Aigner, D., Lovell, C.K. and Schmidt, P. 1977. Formulation and estimation of stochastic frontier production function models. *Journal of econometrics*, *6*(1), pp.21-37.

Ajibefun, I.A. and Daramola, A.G. 2003. Determinants of technical and allocative efficiency of micro-enterprises: firm-level evidence from Nigeria. *African development review*, *15*(2-3), pp.353-395.

Albæk, S. and Schultz, C. 1998. On the relative advantage of cooperatives. *Economics Letters*, *59*(3), pp.397-401.

Amornkitvikai, Y., Harvie, C. and Charoenrat, T. 2014. Estimating a technical inefficiency effects model for Thai manufacturing and exporting enterprises (SMEs): A stochastic frontier (SFA) and data envelopment analysis (DEA) approach. In *Proceedings of Informing Science & IT Education Conference (InSITE)* 2014, pp. 363-390.

Amsler, C., Prokhorov, A. and Schmidt, P. 2016. Endogeneity in stochastic frontier models. *Journal of Econometrics*, *190*(2), pp.280-288.

Arnold R.A. 2018. *Macroeconomics* 4th edn.United Kingdom: Cengage Learning EMEA.

Banker, R.D., Gadh, V.M. and Gorr, W.L. 1993. A Monte Carlo comparison of two production frontier estimation methods: corrected ordinary least squares and data envelopment analysis. *European Journal of Operational Research*, *67*(3), pp.332-343.

Battese, G.E. and Coelli, T.J. 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical economics*, *20*(2), pp.325-332.

Belotti, F., Daidone, S., Ilardi, G. and Atella, V. 2013. Stochastic frontier analysis using Stata. *The Stata Journal*, *13*(4), pp.719-758.

Bless, C., Higson-Smith, C. and Sithole, S.L. 2013. *Fundamentals of social research methods: An African perspective*. 5th edn. Cape Town, South Africa. Juta and Company Ltd.

Bravo-Ureta, B.E. and Pinheiro, A.E.1993. Efficiency analysis of developing country agriculture: a review of the frontier function literature. *Agricultural and resource economics Review*, *22*(1), pp.88-101.

Chaddad, F.R. 2006. Investment constraints in agricultural cooperatives: theory, evidence and solutions*. questões agrárias, educação no campo e desenvolvimento, 105(2),* pp.1-14.

Charnes, A., Cooper, W.W. and Rhodes, E.1978. Measuring the efficiency of decision-making units. *European Journal of Operational Research*, *2*(6), pp.429-444.

Chavas, J.P. and Aliber, M. 1993. An analysis of economic efficiency in agriculture: a nonparametric approach. *Journal of Agricultural and Resource Economics*, *18*(1) pp.1-16.

Chibanda, M., Ortmann, G.F. and Lyne, M.C. 2009. Institutional and governance factors influencing the performance of selected smallholder agricultural cooperatives in KwaZulu-Natal. *Agrekon*, *48*(3), pp.293-315.

Chisasa, J. and Makina, D. 2012. Trends in credit to smallholder farmers in South Africa. *International Business & Economics Research Journal (IBER)*, *11*(7), pp.771-784.

Christiansen, L., Demery, L. and Kuhl, J. 2011. The (evolving) role of agriculture in poverty reduction—An empirical perspective. *Journal of Development Economics*, *96*(2), pp.239-254.

Cockburn, J.J., Coetzee, H.C., Van den Berg, J., Conlong, D.E. and Witthöft, J. 2014. Exploring the role of sugarcane in small-scale farmers' livelihoods in the Noodsberg area, KwaZulu-Natal, South Africa. *South African Journal of Agricultural Extension*, *42*(1), pp.80-97.

Coelli, T.J., Rao, D.P., O'Donnell, C.J. and Battese, G.E. 1998. An introduction to productivity and efficiency analysis. Boston, Estados Unidos: Kluwer academic publishers.

Coelli, T.J., Rao, D.S.P., O'Donnell, C.J. and Battese, G. 2005. An Introduction to Efficiency and Productivity Analysis, 2nd edition. New York: Springer.

Coelli, T., Rahman, S. and Thirtle, C. 2002. Technical, allocative, cost and scale efficiencies in Bangladesh rice cultivation: a non-parametric approach. *Journal of Agricultural Economics*, *53*(3), pp.607-626.

Coelli, T.J. 1996. *A guide to FRONTIER version 4.1: a computer program for stochastic frontier production function and cost function estimation*. CEPA Working Paper 96/07, Department of Econometrics, University of New England, Armidale, Australia.

Coelli, T. 1995. Estimators and hypothesis tests for a stochastic frontier function: A Monte Carlo analysis. *Journal of Productivity Analysis*, *6*(3), pp.247-268.

Coelli, T.J. and Battese, G.E. 1996. Identification of factors which influence the technical inefficiency of Indian farmers. *Australian Journal of Agricultural Economics*, 40(2), pp.103-128.

Conradie, B., Piesse, J., Thirtle, C. and Vink, N. 2019. South African wine grape production, 2005–2015: regional comparisons of scale and technical efficiencies and total factor productivity. *Agrekon*, *58*(1), pp.53-67.

Cook, M.L. 1995. The future of US agricultural cooperatives: A neo-institutional approach. *American Journal of Agricultural Economics*, *77*(5), pp.1153-1159.

Cornwell, C. and Schmidt, P. 2008. Stochastic frontier analysis and efficiency estimation. In *The Econometrics of Panel Data* (pp. 697-726). Springer, Berlin, Heidelberg.

DAFF. 2014. The 4th annual report on the status of cooperatives in agriculture, forestry and fisheries 2014/2015. Department of Agriculture, Forestry and Fisheries. [Online] available at: http://www.nda.agric.za/doaDev/sideMenu/cooperativeandenterprisedevelopment/docs/4th%20Cooperatives%20Annual%20Report_.pdf. [Accessed 26 May 2020].

DAFF. 2019. Abstract of agricultural statistics 2019. Department of Agriculture, Forestry and Fisheries. [Online] available at: https://www.daff.gov.za/Daffweb3/Portals/0/Statistics%20and%20Economic%20Analysis/Statistical%20Information/Abstract%202019.pdf. [Accessed 25 May 2020].

Daniel, J.D., Adebayo, E.F., Shehu, J.F. and Tashikalma, A.K. 2013. Technical efficiency of resource-use among sugarcane farmers in the North East of Adamawa State, Nigeria. *International Journal of Management and Social Sciences Research, 2(6),* pp. 13-18.

Deininger, K.W. 1993. *Cooperatives and the breakup of large mechanized farms theoretical perspectives and empirical evidence: World Bank discussion papers* (No. 218). Washington, DC: The International Bank for Reconstruction and Development. The World Bank.

Deininger, K. 1995. Collective agricultural production: A solution for transition economies? *World Development*, *23*(8), pp.1317-1334.

Dejene, M.D. 2013. *Analysis of technical efficiency of sugarcane producing farm units: the case of fincha sugar factory.* Doctoral dissertation. Wollega University. Ethiopia.

Dey, M.M., Paraguas, F.J., Bimbao, G.B. and Regaspi, P.B. 2000. Technical efficiency of tilapia grow out pond operations in the Philippines. *Aquaculture Economics & Management*, *4*(1-2), pp.33-47.

Debertin, D.L. 2012. *Agricultural Production Economics,* 2nd ed. Amazon Createspace: University of Kentucky.

Dlamini, S., Rugambisa, J.I., Masuku, M.B. and Belete, A. 2010. Technical efficiency of the small-scale sugarcane farmers in Swaziland: A case study of Vuvulane and Big bend farmers. *African Journal of Agricultural Research*, *5*(9), pp.935-940.

Dong, F., Hennessy, D.A., Jensen, H.H. and Volpe, R.J. 2016. Technical efficiency, herd size, and exit intentions in US dairy farms. *Agricultural Economics*, *47*(5), pp.533-545.

Ehirim, N., Onyeagocha, S., Ben-Chendo, G., Essien, U., Osuji, E. and Okwara, M. 2016. Farming Techniques, Environmental Challenges, and Technical Efficiency of Sweet Potato Production in Abia State, Nigeria. *International Journal of Agricultural Management and Development (IJAMAD)*, *6*(1047-2017-1696), pp.409-420.

Erkoc, T.E. 2012. Estimation methodology of economic efficiency: stochastic frontier analysis vs data envelopment analysis. *International Journal of Academic Research in Economics and Management Sciences*, *1*(1), pp.1-23.

Farmer's Weekly. 2015. *Sugarcane industry – beating the dry season*. [online] Available at: https://www.farmersweekly.co.za/crops/field-crops/sugarcane-industry-beating-the-dry-season/ [Accessed 29 Feb. 2020].

Farrell, M.J. 1957. The measurement of productive efficiency. *Journal of the Royal Statistical Society: Series A (General)*, *120*(3), pp.253-281.

Fatima, H., Almas, L.K. and Yasmin, B. 2017. Production Efficiency Analysis of Capsicum (Bell Pepper) Cropping System under the Tunnels in Punjab, Pakistan. The 49th Annual Meeting of the Southern Agricultural Economics Association, Mobile, Alabama, 4-7 February, pp 2-25.

Hlali, A. 2018. Efficiency Analysis with Different Models: The Case of Container Ports. *Journal of Marine Science Research and Development*, *8(2)*, pp 1-10.

Holloway, G., Nicholson, C., Delgado, C., Staal, S. and Ehui, S. 2000. Agro-industrialization through institutional innovation transaction costs, cooperatives and milk-market development in the East-African highlands. *Agricultural Economics*, *23*(3), pp.279-288.

Hossain, M.A., Hasan, M.K. and Naher, Q. 2008. Assessment of technical efficiency of potato producers in some selected areas of Bangladesh. *Journal of Agriculture & Rural Development*, *6*(1), pp.113-118.

ICA. 2005. International Co-operative Alliance Annual Report. [online] available at: https://www.ica.coop/sites/default/files/publication-files/ica-annual-report-2005-1031559218.pdf. [Accessed 16 April 2020].

IDP. 2015. Nkomazi local municipality integrated development plan 2015/2016. [online] available at: https://www.nkomazi.gov.za/documents/Legislation%20and%20Documents/IDP/Final%20IDP%202015%20-%202016.pdf. [Accessed 29 June 2020].

IDP. 2016. Nkomazi Local Municipality Integrated Development Plan 2016/2017. [online] available at: https://www.nkomazi.gov.za/documents/Legislation%20and%20Documents/IDP/IDP%202016-2017.pdf. [Accessed 26 June 2020].

IDP. 2017. Nkomazi Local Municipality Integrated Development Plan 2017/2022. [online] available at: https://www.nkomazi.gov.za/documents/Legislation%20and%20Documents/IDP/IDP%202017-2022.pdf.pdf. [20 August 2021].

Idiong, I.C. 2007. Estimation of farm level technical efficiency in small-holder swamp rice production in cross river state of Nigeria: a stochastic frontier approach. *World Journal of Agricultural Sciences*, *3*(5), pp.653-658.

Jaime, M.M. and Salazar, C.A. 2011. Participation in organisations, technical efficiency and territorial differences: A study of small wheat farmers in Chile. *Chilean Journal of Agricultural Research*, *71*(1), pp.104.

James, P. and Woodhouse, P. 2015. Rural Livelihoods and Small-Scale Sugarcane Farming in Nkomazi, Mpumalanga province, South Africa. Working Paper 2. UK: University of Manchester.

James, P. and Woodhouse, P. 2017. Crisis and differentiation among small-scale sugar cane growers in Nkomazi, South Africa. *Journal of Southern African Studies*, *43*(3), pp.535-549.

Jordaan, D., Louw, M., Garland, S., Toit, A., Stroebel., L and Kapuya, T. 2017. *Finance and Farm Management,* 6th, Standard Bank Agribusiness SA: South Africa.

Kirsten, J.F. and Van Zyl, J. 1998. Defining small-scale farmers in the South African context. *Agrekon*, *37*(4), pp.551-562.

Kopp, R.J. and Smith, V.K. 1980. Frontier production function estimates for steam electric generation: A comparative analysis. *Southern Economic Journal*, pp.1049-1059.

Kodde, D.A. and Palm, F.C. 1986. Wald criteria for jointly testing equality and inequality restrictions. *Econometrica: Journal of the Econometric Society*, 54(5), pp.1243-1248.

Kolleh, R.R. 2016. *Determinants of farmers' participation in agricultural production cooperatives and impact of cooperative membership on farm income in Liberia.* Doctoral dissertation. Liberia. Kwame Nkrumah University of Science and Technology.

Kumbhakar, S.C., Wang, H. and Horncastle, A.P. 2015. *A practitioner's guide to stochastic frontier analysis using Stata*. Cambridge University Press.

Ma, W., Bicknell, K. and Renwick, A. 2019. Feed use intensification and technical efficiency of dairy farms in New Zealand. *Australian Journal of Agricultural and Resource Economics*, *63*(1), pp.20-38.

Ma, W., Renwick, A., Yuan, P. and Ratna, N. 2018. Agricultural cooperative membership and technical efficiency of apple farmers in China: An analysis accounting for selectivity bias. *Food policy*, *81*, pp.122-132.

Madau, F.A. 2015. Technical and Scale Efficiency in the Italian Citrus Farming: Comparison between SFA and DEA Approaches. *Agricultural Economics Review*, *16*(389-2016-23523), pp.15-27.

Maietta, O.W. and Sena, V. 2010. Financial constraints and technical efficiency: some empirical evidence for Italian producers' cooperatives. *Annals of Public and Cooperative Economics*, *81*(1), pp.21-38.

Makwakwa, R.S. 2017. *Leadership in the delivery of services at Kamhlushwa Township in the Nkomazi Local Municipality*. Masters dissertation. South Africa: University of Witwatersrand.

Mankiw, N.G. 2008. Principles of microeconomics. 5th ed. South Western. Cengage Learning.

Mango, N., Makate, C., Hanyani-Mlambo, B., Siziba, S. and Lundy, M. 2015. A stochastic frontier analysis of technical efficiency in smallholder maize production in Zimbabwe: The post-fast-track land reform outlook. *Cogent Economics & Finance*, *3*(1), pp .117-189.

Mathews, C. 2010. An overview of indigenous crop development by the Mpumalanga Department of Agriculture and Land Administration (DALA). *South African Journal of Plant and Soil*, *27*(4), pp.337-340.

Mavimbela, P., Masuku, M.B. and Belete, A. 2010. Contribution of savings and credit cooperatives to food crop production in Swaziland: A case study of smallholder farmers. *African Journal of Agricultural Research*, *5*(21), pp.2868-2874.

Merriam, S.B. 2002. Introduction to qualitative research. *Qualitative research in practice. Examples for discussion and analysis*, *1*(1), pp.1-17.

Metiso, H. and Tsvakirai, C.Z. 2019. Factors affecting small-scale sugarcane production in the Nkomazi Local municipality in Mpumalanga province, South Africa. *South African Journal of Agricultural Extension*, *47*(4), pp.1-8.

Mhembwe, S. and Dube, E. 2017. The role of cooperatives in sustaining the livelihoods of rural communities: The case of rural cooperatives in Shurugwi District, Zimbabwe. *Jàmbá: Journal of Disaster Risk Studies*, *9*(1), pp.1-9.

Mkhabela, T. 2005. Technical efficiency in a vegetable based mixed-cropping sector in Tugela Ferry, Msinga District, KwaZulu-Natal. *Agrekon*, *44*(2), pp.187-204.

Mkhabela, T., Ntombela, S. and Mazibuko, N. 2018.' Pro et Contra of Agriculture Land Reform in South Africa: A Policy Brief'. *The 56th Annual Conference of the Agriculture Economics Association of South Africa* Lord Charles Hotel, Somerset West, 25-27 September, pp 1-24.

Mohr, P. and Seymore, R. 2012. *Understanding Microeconomics.* First edition. Van Schaik. Pretoria.

Moriarty, J. 2011. Qualitative Methods Overview. King's college London. *National Institute for Health Research* Method review 1: *School for Social Care Research.*

Msimango, B. and Oladele, O.I. 2013. Factors influencing farmers' participation in agricultural cooperatives in Ngaka Modiri Molema District. *Journal of Human Ecology*, *44*(2), pp.113-119.

Msuya, E. and Ashimogo, G. 2005. *Estimation of technical efficiency in Tanzanian sugarcane production: A case study of Mtibwa sugar Estate outgrowers scheme*. University of Munich: Munich Personal RePEc Archive (MPRA).

Murali, P. and Prathap, D.P. 2017. Technical efficiency of sugarcane farms: an econometric analysis. *Sugar Tech*, *19*(2), pp.109-116.

Murillo-Zamorano, L.R. 2004. Economic efficiency and frontier techniques. *Journal of Economic Surveys*, *18*(1), pp.33-77.

Myburgh, A.C. 1949. The Tribes of Barberton District. Pretoria, South Africa: Government Printer.

Nguyen, T.P.T., Nghiem, S.H., Roca, E. and Sharma, P. 2016. Bank reforms and efficiency in Vietnamese banks: evidence based on SFA and DEA. *Applied Economics*, *48*(30), pp.2822-2835.

Ngwamba, M.P. 2017. *Assessing the operations of agricultural cooperatives at Nkomazi Local Municipality, Mpumalanga Province*. Doctoral dissertation. South Africa. University of Zululand.

Nowak, P., Jastrzębiec-Witowska, A. and Gorlach, K. 2016. Cooperative Movements in Rural Areas in Contemporary Poland: A brief comparison of farmers' attitudes of members and non-members of Cooperatives. *Eastern European Countryside*, *22*(1), pp.151-164.

Obwona, M.B. 1994. Production frontiers and efficiency measures: concepts and applications. Doctor of Philosophy. Australia: Australian National University.

Olarinde, L.O. 2011. *Analysis of technical efficiency differentials among maize farmers in Nigeria. African. AERC Research Paper 232.* Nairobi. Economic Research Consortium.

Oppong, B.A., Onumah, E.E. and Asuming-Brempong, S. 2014. Stochastic frontier modeling of maize production in Brong-Ahafo Region of Ghana. *Agris on-line Papers in Economics and Informatics*, *6*(665-2016-45017), pp.67-75.

Ortmann, G.F. and King, R.P. 2007a. Agricultural cooperatives I: History, theory and problems. *Agrekon*, *46*(1), pp.18-46.

Ortmann, G.F. and King, R.P. 2007b. Agricultural cooperatives II: Can they facilitate access of small-scale farmers in South Africa to input and product markets? *Agrekon*, *46*(2), pp.219-244.

Ouattara, W. 2010. Economic efficiency analysis in Côte d'Ivoire. *Journal of Development and Agricultural Economics*, *2*(9), pp.316-325.

Padilla-Fernandez, M.D. and Nuthall, P.L. 2009. Technical efficiency in the production of sugar cane in central Negros area, Philippines: An application of data envelopment analysis. *Journal of ISSAAS*, *15*(1), pp.77-90.

Piesse, J., Conradie, B., Thirtle, C. and Vink, N. 2018. Efficiency in wine grape production: comparing long-established and newly developed regions of South Africa. *Agricultural Economics*, *49*(2), pp 203-212.

Piesse, J., Doyer, T., Thirtle, C. and Vink, N. 2005. The changing role of grain cooperatives in the transition to competitive markets in South Africa. *Journal of Comparative Economics*, *33*(1), pp.197-218.

Porter, P.K. and Scully, G.W. 1987. Economic efficiency in cooperatives. *The Journal of Law and Economics*, *30*(2), pp.489-512.

Ray, S.C., Chambers, R.G. and Kumbhakar, S.C. 2022. *Handbook of production economics.* Springer Nature: Singapore.

RCL Corporate Brochure (2019). More food to more people, more often. [online] available at: https://rclfoods.com/wp-content/uploads/2019/12/RCL_Corporate-Brochure_02.12.19-FINAL.pdf. [Accessed 22 July 2022].

Rena, R. 2017. Cooperatives in South Africa: A Review. *Indian journal of Science and Technology*, *10*(45), pp.1-12.

Rosenthal, G. and Eiges, H. 2014. Agricultural cooperatives in Israel. *Journal of Rural Cooperation*, *42* (1), pp.1-29.

Rother, H.A., Hall, R. and London, L. 2008. Pesticide use among emerging farmers in South Africa: contributing factors and stakeholder perspectives. *Development Southern Africa*, *25*(4), pp.399-424.

Royer, J.S. 1999. Cooperative organisational strategies: A neo-institutional digest. *Journal of Cooperatives*, *14*(1142-2016-92748), pp.44-67.

RSA. 2005. No 14 of 2005: Co-operatives Act, 2005. Government Gazette, Cape Town Republic of South Africa. [Online] available at: https://www.gov.za/sites/default/files/gcis_document/201409/a14-050.pdf [Accessed 12 April 2020].

Ruggiero, J. 2007. A comparison of DEA and the stochastic frontier model using panel data. *International Transactions in Operational Research*, *14*(3), pp.259-266.

Samuelson, P.A. and Nordhaus, W.D. 1992. *Economics*. 14th ed. New York: McGraw-Hill.

SASA. 2016. The South African sugar industry and potential expansion of its product chain. South African Sugar Association. [online] available at: http://pmg-assets.s3-website-eu-west-1.amazonaws.com/150513SASA.pdf. [Accessed 23 May 2020].

SASA. 2019a. The Sugar Industry. South African Sugar Association. [online] Available at: https://sasa.org.za/the-sugar-industry-at-a-glance/ [Accessed 27 Sep. 2019].

SASA. 2019b. South African Sugar Industry Directory 2019/ 2020. South African Sugar Association. [online] available at: https://sasa.org.za/custom_content/downloads/SASA-ID-2019-20.pdf [Accessed 15 March 2020].

Schmidt, P. 1976. On the statistical estimation of parametric frontier production functions. *The Review of Economics and Statistics*, *58*(2), pp.238-239.

Sekhon, M.K., Mahal, A.K., Kaur, M. and Sidhu, M.S. 2010. Technical Efficiency in Crop Production: A Region-wise Analysis. *Agricultural Economics Research Review*, *23*(2), pp.367-374.

Sexton, R.J. and Iskow, J. 1993. What do we know about the economic efficiency of cooperatives: an evaluative survey. *Journal of Agricultural Cooperation*, *8*(1141-2016-92584), pp.15-27.

Seymour, G. 2017. Women's empowerment in agriculture: Implications for technical efficiency in rural Bangladesh. *Agricultural Economics*, *48*(4), pp.513-522.

Siddaraju, V.G. and Indira, M. 2014. Comparative Analysis of Organic and Modern Agriculture Systems: A Critical Assessment of Technical Efficiency. *Productivity*, *55*(1), p.35.

Singh, S., Coelli, T and Fleming, E. 2001. Performance of dairy plants in the cooperative and private sectors in India. *Annals of Public and Cooperative Economics, 72(4)*, pp.453-479.

Soboh, R.A., Lansink, A.O., Giesen, G. and Van Dijk, G. 2009. Performance measurement of the agricultural marketing cooperatives: the gap between theory and practice. *Review of Agricultural Economics*, *31*(3), pp.446-469.

Staatz, J.M. 1987. Farmers' incentives to take collective action via cooperatives: a transaction cost approach. *Cooperative Theory: New Approaches*, *18*, pp.87-107.

Stats SA. 2020. Census of commercial agriculture, 2017. Financial and production statistics. Statistics South Africa. [online] available at: http://www.statssa.gov.za/publications/Report-11-02-01/Report-11-02-012017.pdf. [Accessed 25 May 2020].

Stats SA. 2021. Gross domestic product, Fourth quarter 2021. Statistic South Africa. [online] Available at: http://www.statssa.gov.za/publications/P0441/P04414thQuarter2021.pdf. [Accessed 11 December 2022].

Tchereni, B.H., Ngalawa, H.P. and Sekhampu, T.J. 2012. Technical efficiency of smallholder sugarcane farmers in Malawi: The case of Kasinthula cane growing scheme. *Studia Universitatis Babes-Bolyai*, 57(2), pp 3-84.

Thabethe, L.S. 2014. *Estimation of technical, economic and allocative efficiencies in sugarcane production in South Africa: A case study of Mpumalanga growers*. Doctoral dissertation: University of Pretoria.

Thiam, A., Bravo-Ureta, B.E. and Rivas, T.E. 2001. Technical efficiency in developing country agriculture: a meta-analysis. *Agricultural Economics*, *25*(2-3), pp.235-243.

Torgerson, R.E. 1977. Farmer cooperatives. *The Annals of the American Academy of Political and Social Science*, *429*(1), pp.91-102.

Ueasin, N., Liao, S.Y. and Wongchai, A. 2015. The technical efficiency of rice husk power generation in Thailand: comparing data envelopment analysis and stochastic frontier analysis. *Energy Procedia*, *75*, pp.2757-2763.

Valentinov, V. and Iliopoulos, C. 2013. Economic theories of nonprofits and agricultural cooperatives compared: New perspectives for nonprofit scholars. *Nonprofit and Voluntary Sector Quarterly*, *42*(1), pp.109-126.

Vink, N. and Van Rooyen, J. 2009. Perspectives on the Performance of Agriculture in South Africa since 1994 and implications for its Role in Achieving Sustainable Food Security Department of Agricultural Economics, Extension and Rural Development. Working Paper: University of Pretoria.

Wagner, C., Kawulich, B. and Garner, M. eds. 2012. *Doing social research: A global context*. McGraw-Hill Higher Education.

Wheat, P., Greene, W. and Smith, A. 2014. Understanding prediction intervals for firm specific inefficiency scores from parametric stochastic frontier models. *Journal of Productivity Analysis*, *42*(1), pp.55-65.

Xaba, T., Marwa, N. and Mathur-Helm, B. 2018. Efficiency and profitability analysis of agricultural cooperatives in Mpumalanga, South Africa. *Journal of Economics and Behavioral Studies, 10(6*), pp. 1-10.

Zamani, O., Mojaverian, M. and Nader, H. 2019. Comparing Efficiency Between Cooperative and Non-Cooperative Farms: A Case of Sugar Beet Farmers of West Azerbaijan, Iran. *International Journal of Rural Management*, *15*(1), pp.78-96.

Zantsi, S., Greyling, J.C. and Vink, N. 2019. Towards a common understanding of 'emerging farmer' in a South African context using data from a survey of three district municipalities in the Eastern Cape Province. *South African Journal of Agricultural Extension*, *47*(2), pp.81-93.

Zulu, N.S., Sibanda, M. and Tlali, B.S. 2019. Factors Affecting Sugarcane Production by Small-Scale Growers in Ndwedwe Local Municipality, South Africa. *Agriculture*, *9*(8), p.170.

# 8. APPENDIX: PRELIMINARY MODEL RESULTS

Table 8.1 below shows the preliminary regression results of the Cobb-Douglas production function, the dependent variable being sugarcane output and independent variables being the farm size, permanent labour, fertiliser and herbicides, with the sample size of small-scale sugarcane farmers being 100.

**Table 8.1: Cobb Douglas production function – preliminary results**

```
. regress lnoutput_f lnfarmsize_f lnpermanentlab_f lnfertilizer_f lnherbicides_f, vce(robust)

Linear regression                               Number of obs     =        100
                                                F(4, 95)          =     266.16
                                                Prob > F          =     0.0000
                                                R-squared         =     0.8485
                                                Root MSE          =     .36248
```

| lnoutput_f | Coef. | Robust Std. Err. | t | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| lnfarmsize_f | .7491606 | .3105707 | 2.41 | 0.018 | .1325998 | 1.365721 |
| lnpermanentlab_f | .1096742 | .0563258 | 1.95 | 0.054 | -.0021466 | .221495 |
| lnfertilizer_f | .0459278 | .1781284 | 0.26 | 0.797 | -.3077017 | .3995574 |
| lnherbicides_f | .183371 | .2688205 | 0.68 | 0.497 | -.3503052 | .7170472 |
| _cons | 3.086693 | 1.627825 | 1.90 | 0.061 | -.1449475 | 6.318334 |

Table 8.2 below shows the results of testing for multicollinearity between the explanatory variables included in the model presented in table 8.1, using the variance inflation factor (VIF). The results showed that there is significant multicollinearity among the explanatory variables (the farm size, herbicides and fertiliser) that needed to be corrected.

Table 8.2: Test for multicollinearity

```
. vif
```

| Variable | VIF | 1/VIF |
|---|---|---|
| lnfarmsize_f | 105.94 | 0.009440 |
| lnherbicid~f | 102.37 | 0.009769 |
| lnfertiliz~f | 8.95 | 0.111773 |
| lnpermanen~f | 1.93 | 0.518131 |
| Mean VIF | 54.79 | |

Table 8.3 below shows the preliminary MLE results of the stochastic frontier production function and inefficiency sub-model. Where 10 variables are included, out of which three variables (farm size, permanent labour and fertiliser) are for the stochastic production function and the remaining seven variables are for the inefficiency sub-model.

**Table 8.3: Stochastic frontier production function – preliminary results**[6]

```
                                                Number of obs     =        100
                                                Wald chi2(3)      =    1190.29
Log likelihood = -20.832087                     Prob > chi2       =     0.0000
```

| lnoutput_f | Coef. | Std. Err. | z | P>\|z\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| **frontier** | | | | | | |
| lnfarmsize_f | .9255476 | .0989253 | 9.36 | 0.000 | .7316576 | 1.119438 |
| lnpermanentlab_f | .147278 | .045825 | 3.21 | 0.001 | .0574627 | .2370933 |
| lnfertilizer_f | -.0301845 | .0929104 | -0.32 | 0.745 | -.2122855 | .1519166 |
| _cons | 4.925328 | .6217122 | 7.92 | 0.000 | 3.706795 | 6.143862 |
| **usigmas** | | | | | | |
| coop | -.1755019 | .3341868 | -0.53 | 0.599 | -.830496 | .4794922 |
| experience | -.0385943 | .0181741 | -2.12 | 0.034 | -.0742149 | -.0029737 |
| training | -.0070818 | .010652 | -0.66 | 0.506 | -.0279593 | .0137957 |
| age | -.0632101 | .4804788 | -0.13 | 0.895 | -1.004931 | .8785111 |
| education | .307548 | .4158254 | 0.74 | 0.460 | -.5074548 | 1.122551 |
| offfarmincome | .390099 | .4012691 | 0.97 | 0.331 | -.3963741 | 1.176572 |
| gender | .5228745 | .3553085 | 1.47 | 0.141 | -.1735174 | 1.219266 |
| _cons | -1.31357 | .5206105 | -2.52 | 0.012 | -2.333948 | -.2931925 |
| **vsigmas** | | | | | | |
| _cons | -4.329314 | .5207087 | -8.31 | 0.000 | -5.349884 | -3.308744 |

[6] Using the Stata Command: *sfmodel lnoutput_f, prod dist(h) frontier(lnfarmsize_f lnpermanentlab_f lnfertiliser_f) usigmas(coop experience training age education offfarmincome gender ) vsigmas( );* followed by: *ml max, difficult gradient gtol(1e-5) nrtol(1e-5)*

# 9. APPENDIX: QUESTIONNAIRE

RESEARCH QUESTIONNAIRE

This research is a partial fulfilment of the requirements for the degree of Master of Science in Agriculture (Agricultural Economics) at Stellenbosch University.

The aim of the study is to compare technical efficiency of cooperative and non-cooperative sugarcane farms in the Nkomazi Local Municipality, Mpumalanga Province. The study will not cause any harm to small-scale sugarcane farmers and therefore I humbly request you to participate in this research questionnaires.

Participation is entirely voluntary, and information provided will be treated as confidential, to the extent that it will only be used for purposes of this research, no individual responses will be published, and the information will not be distributed to a third party.

Name of the enumerator : ……………………………………………

Date of interview : ……………………………………………

Village name : ……………………………………………

Questionnaire number : ……………………………………………

Name of the farmer (optional) : ……………………………………………

Ward number : ……………………………………………

Famers' contact details : ……………………………………………

Requesting permission to contact the farmer, if any questions might arise concerning clarification of data provided. Please mark on the appropriate box below:

| | | | |
|---|---|---|---|
| Yes | | No | |

THANK YOU FOR YOUR TIME

Lonhlanhla Samantha Mkhabela

## SECTION 1: SOCIO-ECONOMIC QUESTIONS

1.1. Gender of the farmer

| | | | |
|---|---|---|---|
| 1 Female | | 0 Male | |

1.2. Age of the farmer in years

| 1 < 25 | 2 26 to 30 | 3 31 to 35 | 4 36 to 40 | 5 41 to 45 | 6 46 to 50 | 7 > 50 |
|---|---|---|---|---|---|---|
| | | | | | | |

1.3. Level of education

| | | | |
|---|---|---|---|
| 1 Formal education | | 0 Informal education | |

1.4 If formal education, what is the highest educational qualification have you obtained?

| | | | | | |
|---|---|---|---|---|---|
| 1 Primary school | | 2 Secondary school | | 3 Tertiary education | |

1.5. How many family members are actively working on the sugarcane farm?

| |
|---|
| |

1.6. Are you a member of a cooperative?

| | | | |
|---|---|---|---|
| 1 Yes | | 0 No | |

1.7. Do you have off-farm income?

| | | | |
|---|---|---|---|
| 1 Yes | | 0 No | |

1.8. Main source of income of the farmer

| 1 Salaries and wages | 2 Grant - old age pensions | 3 Grant - disability | 4 Farming | 5 Other |
|---|---|---|---|---|
| | | | | |

1.8.1. If you answered ‘other’ in the previous question, please specify.

| |
|---|
| |

1.9. How long, in terms of years, have you been farming with sugarcane?

| |
|---|
| |

1.10. How long, in terms of years, were you working on someone else’s sugarcane farm before you became a farmer?

| |
|---|
| |

SECTION 2: INFORMATION ON THE OPERATION OF THE FARM

2.1. What type of tenure arrangement is in place for the land that you use for sugarcane ploughing / cultivation?

| 1 Own the land | 2 Rent the land | 3 Use the land without payment |
|---|---|---|
| | | |

2.2. If you own the land, how did you obtain it?

| 1 Traditional authority | 2 Land reform | 3 Bought | 5 Other |
|---|---|---|---|
| | | | |

2.2.1. If you answered ‘other’ in the previous question, please specify.

| |
|---|
| |

2.3. What motivated you for the first time to cultivate sugarcane?

| | | | | | |
|---|---|---|---|---|---|
| 1 Employment | | 2 Income generation | | 3 Other | |

2.3.1. If you answered ‘other’ in the previous question, please specify.

| |
|---|
| |

2.4. What is the size of the land in hectares used for sugarcane production?

| |
|---|
| |

2.5. What was your sugarcane yield (t/ha) harvested for the year 2019?

| |
|---|
| |

2.6. What was the total production (tonnes) of sugarcane for the year 2019?

| |
|---|
| |

2.7. Do you normally hire labourers to produce sugarcane?

| | | | |
|---|---|---|---|
| 1 Yes | | 0 No | |

2.7.1. If yes, how many labourers do you normally hire per hectare per day during the sugarcane production season?

| |
|---|
| |

2.7.2. If yes, how many labourers do you normally hire per hectare per day during the sugarcane harvesting period?

| |
|---|
| |

2.7.3. How many days of labour did you use for the 2019 sugarcane production season?

| |
|---|
| |

2.7.4. How many days of labour did you use for the 2019 sugarcane harvesting period?

| |
|---|
| |

2.7.5. If you do not hire labour, what alternative arrangement do you make to get labour?

| |
|---|
| |

2.8. Do you normally hire a tractor for ploughing sugarcane?

| | | | |
|---|---|---|---|
| 1 Yes | | 0 No | |

2.8.1. If yes, how much does it cost to rent a tractor per ha?

| |
|---|
| |

2.8.2. If no, how do you compensate for the tractor?

| 1 Owning a tractor | 2 Borrowing from other farmers for free | 3 Using joint tractor | 4 Renting | 4 Other |
|---|---|---|---|---|
| | | | | |

2.8.3. If you answered ‘other’ in the previous question, please specify.

| |
|---|
| |

2.9. Do you apply fertiliser for the sugarcane production?

| | | | |
|---|---|---|---|
| 1 Yes | | 0 No | |

2.9.1. If yes, how many kilogrammes do you apply per hectare during the production season?

| |
|---|
| |

2.10. Do you use manure?

| | | | |
|---|---|---|---|
| 1 Yes | | 0 No | |

2.11. Do you use herbicides for sugarcane?

| | | | |
|---|---|---|---|
| 1 Yes | | 0 No | |

2.11.1. If yes, how many litres of herbicides are used per hectare during the production season?

| |
|---|
| |

2.11.2. If not, how do you compensate for the herbicides?

| 1 Crop rotation | 2 Mulching | 3 Hand removal | 4 Other |
|---|---|---|---|
| | | | |

2.11.2.1. If you answered ‘other’ in the previous question, please specify.

| |
|---|
| |

2.12. What is the type of sugarcane seed that is being used?

| | | | |
|---|---|---|---|
| 1 GMO | | 0 Non-GMO | |

2.13. Where do you get your inputs?

| 1 Cooperatives | 2 Self-purchase from retailers | 3 Mills | 4 Other |
|---|---|---|---|
| | | | |

2.13.1. If you answered 'other' in the previous question, please specify.

| |
|---|
| |

2.14. For the past ten years operating or managing the farm, have you ever been liquidated?

| | | | |
|---|---|---|---|
| 1 Yes | | 2 No | |

2.14.1. If yes, what was the reason?

| |
|---|
| |

2.15. To which mill do you supply the sugarcane?

| 1 Malelane Mill | 2 Komatipoort Mill |
|---|---|
| | |

2.16. Do you participate in other farming activities on your own farm?

| | | | |
|---|---|---|---|
| 1 Yes | | 0 No | |

2.16.1. If yes, specify the activities.

| |
|---|
| |

2.17. Which vehicles do you use to transport sugarcane to the mill?

| | | | |
|---|---|---|---|
| 1 Owned vehicles | | 0 Rented vehicles | |

2.18. Have you received extension services during the past five years?

| | | | |
|---|---|---|---|
| 1 Yes | | 2 No | |

2.18.1. If yes, how often did the extension officers visit in 2019?

| |
|---|
| |

2.19. Have you received formal training on sugarcane farming during the last five years?

| | | | |
|---|---|---|---|
| 1 Yes | | 2 No | |

2.19.1. If yes, how many times and who was responsible for the training in 2019?

| |
|---|
| |

SECTION 3: FINANCIAL SUPPORT

3. Do you use credit for farming operations?

| | | | |
|---|---|---|---|
| 1 Yes | | 0 No | |

3.1.1. Where do you acquire the credit from?

| 1 Land Bank | 2 Money lenders | 3 Relative or friend | 4 Akwanze | 5 Other specify |
|---|---|---|---|---|
| | | | | |

3.2. Do you have any outstanding debts?

| | | | |
|---|---|---|---|
| 1 Yes | | 0 No | |

3.2.1. If yes how are you repaying them?

| |
|---|
| |

4. What are the challenges you face in producing sugarcane?

| |
|---|
| |

SECTION 4: COOPERATIVES

**If you are a member of a cooperative, kindly complete this section as well.**

4.1. What is the name of your cooperative?

| |
|---|
| |

4.2. Were you part of the cooperative since you started farming?

| | | | |
|---|---|---|---|
| 1 Yes | | 2 No | |

4.2.1. If no, what motivated you to join the organisation?

| |
|---|
| |

4.3. When was the cooperative established?

| |
|---|
| |

4.4. When did you join the cooperative?

| |
|---|
| |

4.5. What was the motivation behind the formation of this organisation?

| |
|---|
| |

4.6. What are the main activities associated with the cooperative?

| |
|---|
| |

4.7. Would you advice other farmers to be part of your organisation? Motivate your answer.

| |
|---|
| |

4.8. What are the benefits of being a member of a cooperative?

| |
|---|
| |

4.9. Can you say that being part of the cooperative has improved the cooperative in anyway? Please mark the appropriate box(es) below.

| 1 Increase profit / returns | 2 Stability of the organisation | 3 Improve technical skills | 4 Decrease costs | 5 Improve credit | 6 Other |
|---|---|---|---|---|---|
| | | | | | |

4.9.1. If you answered ‘other’ in the previous question, please specify.

| |
|---|
| |

4.10. Do cooperative members receive any type of training?

| | | | |
|---|---|---|---|
| 1 Yes | | 2 No | |

4.11. If yes, what kind of training is provided to cooperative owners and employees and who provides the training?

| |
|---|
| |

# 10. APPENDIX: ETHICS CLEARANCE LETTER

UNIVERSITEIT
STELLENBOSCH
UNIVERSITY

**NOTICE OF APPROVAL**

REC: Social, Behavioural and Education Research (SBER) - Initial Application Form

16 November 2020

Project number: 16965

Project Title: Comparison of technical efficiency between cooperative and non-cooperative farms. A case of small-scale sugarcane farmers in Nkomazi municipality, Mpumalanga province, South Africa

Dear Miss LONHLANHLA MKHABELA

Your REC: Social, Behavioural and Education Research (SBER) - Initial Application Form submitted on 27 October 2020 was reviewed and approved by the REC: Social, Behavioural and Education Research (REC: SBE).

Please note below expiration date of this approved submission:

**Ethics approval period:**

| Protocol approval date (Humanities) | Protocol expiration date (Humanities) |
|---|---|
| 16 November 2020 | 15 November 2023 |

**GENERAL REC COMMENTS PERTAINING TO THIS PROJECT:**

**INVESTIGATOR RESPONSIBILITIES**

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

**If the researcher deviates in any way from the proposal approved by the REC: SBE, the researcher must notify the REC of these changes.**

Please use your SU project number (16965) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

**CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD**

You are required to submit a progress report to the REC: SBE before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary).

Once you have completed your research, you are required to submit a final report to the REC: SBE for review.

**Included Documents:**

| Document Type | File Name | Date | Version |
|---|---|---|---|
| Data collection tool | Mkhabela Lonhlanhla Research Questionnaire | 10/08/2020 | 1 |
| Default | Liphepha mbuto yelucwaningo Mkhabela L | 10/08/2020 | 1 |
| Research Protocol/Proposal | Research propsal _LS Mkhabela 2020 | 26/10/2020 | 1 |
| Budget | budget for fieldwork 2 | 26/10/2020 | 1 |
| Informed Consent Form | Verbal-Consent | 27/10/2020 | 1 |
| Default | LIFOMU LOKUTIBOPHELELA 2 | 27/10/2020 | 1 |
| Default | Response letter | 27/10/2020 | 1 |

If you have any questions or need further help, please contact the REC office at cgraham@sun.ac.za.

Sincerely,

Page 1 of 3

Clarissa Graham

REC Coordinator: Research Ethics Committee: Social, Behavioral and Education Research

*National Health Research Ethics Committee (NHREC) registration number: REC-050411-032.*
*The Research Ethics Committee: Social, Behavioural and Education Research complies with the SA National Health Act No.61 2003 as it pertains to health research. In addition, this committee abides by the ethical norms and principles for research established by the Declaration of Helsinki (2013) and the Department of Health Guidelines for Ethical Research: Principles Structures and Processes (2nd Ed.) 2015. Annually a number of projects may be selected randomly for an external audit.*

# Principal Investigator Responsibilities

## Protection of Human Research Participants

As soon as Research Ethics Committee approval is confirmed by the REC, the principal investigator (PI) is responsible for the following:

**Conducting the Research**: The PI is responsible for making sure that the research is conducted according to the REC-approved research protocol. The PI is jointly responsible for the conduct of co-investigators and any research staff involved with this research. The PI must ensure that the research is conducted according to the recognised standards of their research field/discipline and according to the principles and standards of ethical research and responsible research conduct.

**Participant Enrolment**: The PI may not recruit or enrol participants unless the protocol for recruitment is approved by the REC. Recruitment and data collection activities must cease after the expiration date of REC approval. All recruitment materials must be approved by the REC prior to their use.

**Informed Consent**: The PI is responsible for obtaining and documenting affirmative informed consent using **only** the REC-approved consent documents/process, and for ensuring that no participants are involved in research prior to obtaining their affirmative informed consent. The PI must give all participants copies of the signed informed consent documents, where required. The PI must keep the originals in a secured, REC-approved location for at least five (5) years after the research is complete.

**Continuing Review**: The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period.** Prior to the date on which the REC approval of the research expires, **it is the PI's responsibility to submit the progress report in a timely fashion to ensure a lapse in REC approval does not occur.** Once REC approval of your research lapses, all research activities must cease, and contact must be made with the REC immediately.

**Amendments and Changes**: Any planned changes to any aspect of the research (such as research design, procedures, participant population, informed consent document, instruments, surveys or recruiting material, etc.), must be submitted to the REC for review and approval before implementation. Amendments may not be initiated without first obtaining written REC approval. The **only exception** is when it is necessary to eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

**Adverse or Unanticipated Events**: Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research-related injuries, occurring at this institution or at other performance sites must be reported to the REC within **five (5) days** of discovery of the incident. The PI must also report any instances of serious or continuing problems, or non-compliance with the RECs requirements for protecting human research participants.

**Research Record Keeping**: The PI must keep the following research-related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; all informed consent documents; recruiting materials; continuing review reports; adverse or unanticipated events; and all correspondence and approvals from the REC.

**Provision of Counselling or emergency support**: When a dedicated counsellor or a psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

**Final reports**: When the research is completed (no further participant enrolment, interactions or interventions), the PI must submit a Final Report to the REC to close the study.

**On-Site Evaluations, Inspections, or Audits**: If the researcher is notified that the research will be reviewed or audited by the sponsor or any other external agency or any internal group, the PI must inform the REC immediately of the impending audit/evaluation.