Analysis of factors influencing the technical efficiency of maize small-scale farmers of Kavango East Region

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DECLARATION

I, *Saija-Kristophine Tegelela Kristof*, hereby declare that the work contained in the thesis entitled: *Analysis of factors influencing the technical efficiency of maize small-scale farmers of Kavango East Region,* is my own original work and that I have not previously in its entirety or in part submitted it at any university or higher education institution for the award of a degree.

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GDP	Gross Domestic Product
UNEP	United Nations Environment Programme
NSA	Namibia Statistics Agency
MAWLR	Ministry of Agriculture, Water and Land Reform
NAB	Namibian Agronomic Board
FAO	Food and Agriculture Organisation
AGRIBANK	Agricultural Bank
AgriBusDev	The Agricultural Business Development Agency
DEA	Data Envelopment Analysis
SADC	Southern Africa Development Community
TE	Technical Efficiency
AE	Allocative Efficiency
EE	Economic Efficiency
SFA	Stochastic Frontier Analysis
OLS	Ordinary Least Squares
LR	Likelihood Ratio
SPSS	Statistical Package of the Social Science

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Abstract

This study analysed the factors affecting the technical efficiency of the small-scale maize farmers of Kavango East Region with the aim of generating reliable information about the level of technical efficiency and the factors affecting technical inefficiency of small-scale maize farmers. Cross-sectional data was collected from a total of 72 small-scale maize farmers located in four (4) different irrigation schemes in the Kavango East Region (i.e. Uvhungu Vhungu Green Scheme Project, Ndonga-Linena Green Scheme Project, Shadikongoro Green Scheme Project and Salem Irrigation Project). This number of small-scale maize farmers in the Kavango East region was relatively low, hence there was no need for sampling, and as such all the 72 farmers were interviewed. Data was collected through a structured questionnaire in formal face-to-face interviews. The Statistical Package for the Social Sciences (SPSS) was used to generate descriptive statistics from quantitative data. Stochastic Frontier Analysis technique was employed for analysing technical efficiency of the farmers and its determinants. From the empirical estimation, it was found that inorganic fertilisers are an important input that can increase maize productivity significantly. Seed and labour inputs were statistically insignificant in explaining maize production. The estimated value of γ, which is a parameter used to indicate the proportion of total variance attributed to technical inefficiency is 0.99 and significant. This means that 99% of the random variation in output of maize production is attributed to the technical inefficiency component, which indicates the importance of examining technical inefficiencies in maize production. The estimated mean technical efficiency score of the sample is 0.584 or 58.4%. This indicates that on average, the interviewed small-scale maize farmers are able to obtain only 58.4% of potential output from the given mix of production inputs. This finding suggests the presence of a considerable level of technical inefficiency of about 41.6% among the sampled farmers. While examining the determinants of technical efficiency, age, highest education attained, access to formal sources of credit, seed type, weeding frequency, extension office visit and training were found to be important factors affecting the technical efficiency of the small-scale maize farmers of Kavango East Region. The study, therefore, recommends enforcing extension service visits to the small-scale farmers more so that all small-scale farmers are up to date with the current, relevant and important farming information. The study also recommends improving farmers' education through provision of continuous training programs to the farmers as well as follow up on the application of improved farming and farm management practices.

Key Words: productivity, small-scale farmers, Kavango East Region, maize, technical efficiency, factors affecting technical efficiency, Stochastic Frontier Analysis

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CHAPTER 1: INTRODUCTION

1.1. Background

Agriculture is one of the most important sectors that plays a major role in the growth of the economy of many developing nations (Diao, Hazell, & Thurlow, 2010). It is solely responsible for providing food security for both the rural and urban population. Agriculture plays a role by supplying food items, industrial inputs, generating foreign exchange, creating employment opportunities and contributing to Gross Domestic Product (GDP) (Valdés & Foster, 2010). However, agricultural productivity in Africa has declined over the last two decades leading to progressive increase in food imports in most of the developing African countries. The low productivity prohibits farmers from earning significant returns from their farming activities, thereby reducing their farm incomes (Valdés & Foster, 2010). In most of these developing countries, the major challenge faced by policy makers remains efficient resource and initiatives which are targeted at improving the livelihoods of the rural communities (Wiggins, Kirsten, & Llambí, 2010). Namibia being a developing country itself, the agriculture sector is of great importance to the economy of the country. It employs nearly 27% of the active population, contribute to the country's food security, generates foreign exchange and contributes for up to 5% of the GDP excluding fishing (Namibia Statistic Agency, 2011).

The Namibian population at large has a large number of people that live in the rural areas. According to the United Nation's world population Prospects of 2019, the Namibian population is currently estimated to be at 2,539,771 people(United Nations Environment Programme (UNEP), 2012). Of this population, Namibia Population and Housing Census (2011) noted that 49.97% is the rural population. According to Mwoombola (2017), about 70 percent of these people depend on agriculture for sustenance. In these areas, Maize forms the base of the staple food for most of the population which are predominantly produced by smallholder farmers under rain-fed conditions. The crop farming system is encountered in both commercial and communal areas. Crop production in the commercial areas is aimed for market, while production in the communal areas is mainly for household consumption. Maize is produced in both communal (under rain-fed conditions) and commercial (irrigation and rain-fed conditions) areas (Namibia Agronomic Board, 2020). This crop is an indigenous crop in Namibia. It is mostly grown in the northern and central northern (Zambezi, Kavango East, Kavango West, Ohangwena, Omusati, Oshana, Oshikoto, and; in parts of the Otjozondjupa region, in the Tsumkwe area.) part of the country due to the favourable environmental conditions (Namibia Agronomic Board, 2020).

Although the agriculture industry plays a very important role in the growth of the economy of the country, the agricultural industry's contribution to the GDP has been declining. According to the Namibia Statistic Agency (2011), the industry's contribution to the GDP was 5.3% in 2007, declining to 4% in 2008. The contribution continued to decline to 3.3% in 2015, and 3.4% in 2016, before increasing to 4.5% in 2017, thus causing a serious decrease in producer income. Montle, Uchezuba and Mbai (2016) noted that in recent years, there has been a declining trend in agricultural productivity and often the practice is seldom sustainable. This decline is largely evident because of a continuous decline in output produced in most agricultural firms around the country (Montle et al., 2016). The crop production in Namibia was threatened by continued drought, leading to a significant drop in cereal output recorded in 2015 (World Food Programme, 2016). The same authors further noted that the Maize production declined by 73% from the above average yield in 2014. The production of other cereal crops such as Mahangu and sorghum have also decreased by 65 and 60 percent respectively (World Food Programme, 2016).

Raising agricultural productivity is one key to increasing food production. This is done by improving technical efficiency of resource use in agriculture. Therefore, in order to improve production efficiency of smallholder maize irrigation producers, farmers need to be taught how to use their production inputs efficiently. Efficiency is the relative performance of the processes used in transforming given input into output (Mukete et al., 2016). Economic theory has identified three measures of efficiency. These measures include, technical efficiency, allocative efficiency and economic efficiency (Farrell, 1957). According to Farrell (1957), the technical efficiency is the measure of the farm's success in producing maximum output from a given set of inputs. It is also referred to as the ability to operate on the production frontier or isoquant frontier (Effiong & Onyenweaku, 2006). Allocative efficiency (AE) is defined by Effiong & Onyenweaku (2006) as the ability of the farm to use inputs in optimum proportions given their respective prices and the production technology. Economic efficiency (EE) is referred as the capacity of a firm to produce a predetermined quantity of output at minimum cost for a given level of technology (Leachman, Ding & Chien, 2007).

It is very important to measure efficiency because it can guide resource utilization for farmers, leading to resource savings, which have important implications for both policy formulation and farm management (Bravo-Ureta & Pinheiro, 1997). Despite the various past efforts by the Namibian government to increase food security, food security continues to be a challenge in Namibia. This is so because of low and stagnant agricultural productivity growth associated with major crops like maize which are predominantly produced mostly by small-scale farmers and rural subsistence farmers, producing mainly for consumption under rain-fed conditions (United Nations Environment Programme, 2012). It is for these reasons that more effort is required for total eradication of poverty and food insecurity. Therefore, there is the need for a study that will analyse the factors that influence technical efficiency of the small-scale maize farmers. This will help policy makers in the formulation of specific policies for boosting the efficiency of maize production and other cereal crops in the study area to improve food production. The aim of this study is therefore to analyse the factors that influence technical efficiency of the Maize farmers of Kavango East Region.

1.2. Problem statement

Empirical studies suggest that most under developed and developing countries are still facing the problem of high poverty levels (United Nations Environment Programme (UNEP), 2012; World Food Programme, 2016) . In addition to poverty, Namibia's population growth rate is high (2.2%) (Namibia Statistic Agency, 2011) yet agricultural arable land remains limited. This calls for improving yields of major staples, such as maize and mahangu for better food security. Despite the various government efforts to improve food security in the country, food insecurity remains a challenge in Namibia. This is because of low and stagnating agricultural productivity, particularly in the crop sector where major crops such as maize is predominantly produced by small-scale farmers, usually under the rain-fed conditions. For example, maize yields fluctuated between 1400 kg / ha in 2018 and 1600 kg /ha in 2020, with no clear upward trend (Namibia Agronomic Board, 2020). Similar trends and fluctuations were also observed in total maize production, with a minimum total production of 40 000 metric tons recorded in 2018 and a maximum of 68 000 metric tons in 2020 (Namibia Agronomic Board, 2020).

The total domestic demand of maize in the years 2018/2019, was 5813 tons/ha. 3469 tons/ha of this total demand is imports (Namibia Agronomic Board, 2019). This means that only 2344 tons/ha was locally produced. The gap in production is still high with the percentage local market share of only 40% as compared to that of imports which stands at 60%. In comparison to the previous production season (2016/2017), the total domestic demand of maize was 7125 tons/ha of which 5542 tons/ha is imports and only 1584 tons/ha was locally produced. The percentage local market share was only 22%. Although the local production has shown a gradual increase during the past good rainy seasons (2016-2018), Namibia remains a net grain importer (Namibia Agronomic Board, 2018). In the face of all these facts and the various efforts by the Namibian government, there is still little knowledge within Namibia on sources of technical inefficiency of small-scale maize farmers.

There is a lot of international research around the topic of technical efficiency among the small-scale maize farmers. For example, Chirwa (2007), who found that many small-scale maize farmers are technically inefficient, with a mean score of 46.23%. The use of hybrid seeds, club membership, farm size and regular extension visits were found to be some of the factors that contributed to high levels of technical efficiencies of the farmers in the study area. Other researchers include Dlamini (2012) and Oyewo (2011) who found that farm size and seed quality significantly affected technical efficiency. They concluded that, with the current level of input used and existing technology set, more land could still be available for maize production in the area and more quality seeds should be provided to farmers.

Furthermore, Gunda (2013) carried out a study on the productivity of small-scale maize farmers at Towkane–Ngundu Irrigation Scheme in Masvingo District in Zimbabwe. The findings of this study indicated a high mean technical efficiency score of 77%. The study noted that high technical efficiency is associated with increased formal education, farming experience, household size, English proficiency, arithmetic abilities, extension visit and compliance with best management practices. Another technical efficiency study is that of Alene and Hassan (2003). They examined the determinants of farm level technical efficiency among the adopters of improved maize production technology in Western Ethiopia and obtained an average technical efficiency of 76%. The study indicated that farm size, education, access to credit, timely availability of modern inputs, extension, plot quality, tenure and age are factors that decrease technical inefficiency while distance from the market increases technical inefficiency. Similarly, Geta et al. (2010) analysed the productivity and efficiency of smallholder maize producers in Southern Ethiopia. They found an average technical efficiency of 40%. They also noted that agro- ecology, oxen holding, farm size and the use of improved seed are important factors that influence technical efficiency among the farmers.

In Namibia, only two studies focused on technical efficiency among the small-scale maize farmers. Ndjodhi (2016) analysed the sources of technical efficiency of the smallholder maize farmers at Etunda Irrigation Project in Omusati Region, Namibia. The study found that the technical efficiency of small-scale maize farmers is relatively high with an average score of 72%. They also noted that included that age of the farmers, plot size, livestock manure, planting in summer, market access and training were the main factors that contribute positively to the high levels of technical efficiency among the small-scale farmers of Etunda Irrigation Project. Another technical efficiency study conducted in Namibia is that Montle (2016). He conducted a production frontier of small-scale Pearl Millet farmers under conservation agriculture in northern Namibia. The efficiency analysis results show that farm level technical efficiency for Conservation Agriculture and Traditional Agriculture were 32% and 33% respectively. This indicates that overall, there is a potential to improve efficiency in pearl millet production among smallholder farmers in the study area by 68% through the efficient use of Conservation Agriculture. Given the only two efficiency studies conducted in Namibia, this means that there is no or very little information available to guide the efforts to reduce technical inefficiency of small-scale maize farmers and increase maize production in Namibia. Thus, this study will contribute to the body of knowledge on technical efficiency of the maize small-scale farmers in Namibia.

1.3. Research objectives

- The overall objective of this study is to analyse the technical efficiency of the maize small-scale farmers of Kavango East Region and determine factors influencing technical efficiency of maize small-scale farmers in Kavango East Region. The overall objective of this study will be achieved through the completion of the following specific objectives:
  - To analyse the technical efficiency of the small-scale maize farmers of Kavango East Region
  - To identify factors influencing technical efficiency of the small-scale maize farmers of Kavango East Region.
  - To examine the relationship between socio-economic characteristics of the small-scale maize farmers of Kavango East Region and their farm technical efficiency.

1.4. Research hypothesis

The following null hypotheses will be tested:

H_0: Maize small-scale farmers of Kavango East Region are not technically efficient.

H_0: The socio-economic characteristics (age, gender, educational level, experience of farmers, farm size etc.) do not significantly influence the farmer’s technical efficiency.

1.5. Thesis outline

The thesis is organised into five chapters. Chapter two will address the review of relevant literature on technical efficiencies of farmers. The chapter covers the relevant subtopics such as maize production in Africa, maize production in Namibian, maize production as well as smallholder maize farmers. It will also cover complementary topics such as the concept of efficiency, review empirical studies of efficiency in Africa, methods used to measure efficiency, and factors hypothesised to affect technical efficiency. Chapter three provides an overview of the study area, the method used in data collection, the questionnaire design, field work procedures, and characteristics of the respondents, as well as the model used to analyse data. Chapter four presents a discussion of results and chapter five provides the conclusion to the study, give recommendations made by the study as well as the recommendation for further research.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

This chapter presents a review of relevant literature on the technical efficiency of small-scale maize farmers. It is also aimed at enhancing the understanding of factors that influence maize productivity and how these factors impact on the levels of technical efficiencies among the small-scale farmers in the study area. The chapter begins by providing information on the maize production in Africa and narrow it down to the Namibian context. It also gives a brief overview of the small-scale maize farmers in Namibia. This chapter further describes the concept of efficiency, give a review of efficiency studies done in Africa, discuss the methods used to measure efficiency and finally discuss the factors affecting technical efficiency among smallholder farmers.

2.2. Maize production in Africa

Maize has become the second most produced crop in the world. Specifically, in sub-Saharan Africa, global statistics show that more and more land is being used for (small-scale) maize production to meet future food demands (Santpoort, 2020). In Africa, maize is known to be the most important cereal crop for both large scale and small-scale production, especially in the sub-Sahara regions where it is regarded as the most important staple food for over 1.2 billion people (FAO, 2018). Maize production in Africa represents about 7% of the world total production, of which the largest producer is Nigeria with nearly 8 million tons, followed by South Africa and Tanzania (FAO, 2018). Most maize production in Africa is rain fed and as a result it is vulnerable to droughts, floods and other unpredictable weather patterns.

According to Byerlee and Heisey (1997), Africa was known to be self-sufficient in food production, as well as being a leading exporter of agricultural produce at the beginning of the era of the independence movement in the 1960s. Byerlee and Heisey (1997) further noted that the food crisis in the early 1970s began shifting to Africa and as a result, the continent's food balance sheet changed from positive to negative. For example, the annual food production grew at half (1.5%) the rate of population growth of 3% per year in the year 1970 and 1985 respectively. Since then, the situation continues to deteriorate and consequently leads to a significant decline in per capita food consumption (Byerlee & Heisey., 1997). In developing countries, climate change and other environmental stresses have diminished soil fertility, affecting crop production (Mulungu, & Ng'ombe, 2019). The same authors further stated that Africa in one of the continents that is projected to experience raising temperatures of at least 1 to 2°C and higher likelihood of extreme weather. Thus, the effects of climate change will more directly affect agriculture. Byerlee and Heisey (1997) argued that crop productions in developing countries is mainly rain-fed and is vulnerable to low productivity thereby threatening the food security of millions of people, especially in sub-Saharan Africa. In addition, poor access to improved seeds and fertilisers, poor market development and low investment in research and extension services have worsened the situation. Africa imports 28% of its maize requirements from countries outside the continent (Mulungu & Ng'ombe, 2019). Mulungu and Ng'ombe, (2019) further noted that maize imports into the sub-Sahara Africa alone, account for thousands of metric tons annually in years of good crop harvests to far higher amounts than this after droughts. This altogether suggests that more still needs to be done by governments in Africa in terms of policy and programme interventions in order to mechanise agriculture and provide the much-needed support to their respective farmers.

2.3. Small-scale maize farmers in Namibia

Maize is the most important staple crop for 2.4 million Namibians, out of which over 70% are directly working for or indirectly dependent on the agricultural sector often as subsistence farmers (FAO, 2019). Namibia's climate varies from arid to semi-arid conditions with an annual rainfall range between 50 to 600 mm per annum (Namibia Statistic Agency, 2011). The country is characterised by hot and dry conditions with sparse and erratic rainfall, and the risk of agricultural production under rain-fed conditions is very high. In Namibia, most maize producers are small-scale, subsistence and very few commercial farmers, with an average crop field size of less than 4 hectares (Ministry of Agriculture, 2018). The subsistence farmers use their own traditional seed varieties, kept from previous season's harvest and the majority of these farms are rain fed and characterised by low input use and low yields (Agricultural Research Council (ARC), 2002). Although there are some emerging areas with limited maize production activities, most maize is produced in the north-east and north-central part of the Namibia (Agricultural Research Council (ARC), 2002). According to the Namibia Agronomic Board (2019), maize followed by wheat are the largest commercial grain crops grown in Namibia, produced both communally and commercially. Both the communal and commercial maize farming systems make up the total national maize production in Namibia (Ministry of Agriculture, 2018).

Dry-land white maize is produced mainly on the private commercially owned farms in the maize triangle (Otavi, Tsumeb and Grootfontein areas), while a significant amount of maize is also produced under rain-fed condition by subsistence farmers in the Zambezi, Kavango East, Kavango West, Otjozondjupa, Omaheke and Kunene regions (Namibia Agronomic Board, 2019). White maize production under irrigation is produced in the government green scheme projects, as well as on privately owned irrigation farms (Ministry of Agriculture, 2018). These green scheme projects were established by the Namibian government under the Ministry of Agriculture, Water and Land Reform. The aim of these projects is to increase food production in the country using irrigation systems thereby contributing toward the national agenda for food self-sufficiency, food security and job creation. These projects included the Hardap Irrigation Project near Mariental in the Hardap region and Haakiesdoorn at the Oranje River in the Karas region, both situated in the southern part of the country. In the north-central part, the Etunda Irrigation Project was established in the Omusati region. For the north-eastern part of the country, irrigation projects included Shadikongoro, Ndonga-Linena, Mashare, and Vungu-Vungu Irrigation Projects in the Kavango East region, as well as Sikondo, Shitemo and Muses in the Kavango West region (Ministry of Agriculture, 2018). Maize production as is the case with many other countries in southern Africa remains the most important staple crop to many communities in Namibia.

2.4. The concept of efficiency

The concept of efficiency was earlier studied by Debreu (1951) and Koopmans (1951). Debreu defined efficiency as the measure of resource utilization. Debreu evaluated the efficiency measure by subtracting the maximum relative reduction in all inputs that still holds the same level of production from one. For example, if the relative reduction in inputs equals 0.10, the efficiency measure would be 1-0.10 = 0.90 or 90%. Whereas Koopmans defined a producer's efficiency as a feasible input-output vector. He further explained that it is impossible to increase any output without increasing at least one input at the same time.

Other authors that followed such as Jakinda, Lionel and Eric (2012) defined efficiency as the relative performance of the processes used in transforming given input into output. Based on the work of Farrell (1957), he separated this concept into technical and allocative components. He defined technical efficiency as the ability of a producer to reach the maximum output possible from a given sets of inputs. Put simply, for a given output, the producer uses the minimum set of inputs possible. Allocative efficiency refers to the producer' s decision to use an optimal mix of inputs or outputs given their prices and technology in order to maximize profit (Kabwe, 2012). A firm is allocatively efficient if it uses the optimal combination of inputs with respect to their output. The economic efficiency of a firm is the combination of the technical and allocative efficiency (Farrell, 1957). Generally, it is expected that all farmers obtain the same production outputs, given the same conditions of production. However, the results vary from one farmer to another probably because the way different farmers manage their farm resources and general farm management is different from farmer to farmer. One farmer may produce more than the average while another farmer might produce below the average. This explains the farmer's efficiency. It is interesting for the less efficient farmer to compare with an efficient farmer so he can increase his production without using more inputs (Binam, Tonyè, Wandji, Nyambi, & Akoa, 2004).

2.5. Review of empirical studies on efficiency in Africa

Asogwa, Umeh and Penda (2011) used a parametric frontier approach to analyse the economic efficiency of Nigerian small-scale farmers. They made use of farm level data, collected from randomly selected small-scale farmers in Benue State, Nigeria. The results indicated that technical inefficiency was higher than allocative inefficiency. The average level of technical, allocative and economic efficiency was estimated at 30%, 12% and 36% respectively. The study also made conclusions that the low economic efficiency level could largely be explained by the low level of allocative efficiency relative to technical efficiency. Low level of technical efficiency was highly attributed to the unavailability of extension services and information about technical aspects of crop technologies. Thus, conclusions were made that efforts must be made to promote access of small-scale farmers to agricultural extension services in Nigeria as a basis for further improving their technical efficiency and hence overall economic efficiency.

Chiona (2011) studied the technical and allocative efficiency of smallholder maize farmers in Zambia by making use of the non-parametric method of efficiency estimation (the Data Envelopment Analysis). Similar to the study of Asogwa et al (2011), this study also found the technical and allocative efficiency levels to be very low among smallholder maize farmers. The average technical and allocative efficiency was estimated at 15% and 12% respectively, thereby concluding that these were both attributed to the fact that a high percentage of the farmers do not make use chemical fertiliser and hybrid seeds despite their positive influence on technical efficiency.

Oladimeji (2013) made use of the cobb Douglas functional form of the stochastic production frontier to make an analysis of technical efficiency and identify its determinants among small-scale rice farmers in Patigi local government area of Kwara State, Nigeria. In this study the result showed that rice farmers were about 65% technically efficient and that labour was the most limited resource for rice production in the study area, which was found to be statistically significant at 1%. This study also concluded that the most common determinants for technical efficiency were: household size, farming experience, level of education, labour, farm size and non-farm income. Furthermore, Gunda (2013) carried out a study on the productivity of small-scale maize farmers at Towkane–Ngundu Irrigation Scheme in Masvingo District in Zimbabwe. The findings of this study indicated a high mean technical efficiency score of 77%. The study noted that high technical efficiency is associated with increased formal education, farming experience, household size, English proficiency, arithmetic abilities, extension visit and compliance with best management practices.

Mukete et al. (2016) analysed technical efficiency of smallholder cocoa farmers in South West Cameroon. In this study, the authors made use of the stochastic production function to evaluate the level of farmer technical efficiency. The results showed that the technical efficiency ranged between 0.11 and 0.99, with a mean technical efficiency of 0.86. This study also concluded that farmers access to credit and farmers access to extension services has a significant influence on technical efficiency.

2.6. Measuring efficiency

Different methods for measuring technical efficiency have been developed and currently, there are two major approaches to measuring efficiency (Chirwa, 2007). These are the non-parametric programming approach and the parametric programming approach (Coelli, 1995; Thiam, Bravo-Ureta & Rivas, 2001). The difference between the two approaches is that the parametric approach specifies a particular functional form based on econometric techniques while the non-parametric is based on mathematical programming (Sarafidis, 2002). These approaches were used in the study of economic analysis of the factors influencing maize productivity efficiency among farmers in Gatsibo district, Rwanda (Ntabakirabose, 2017). The non-parametric approach is composed of the data envelopment analysis (DEA) while the parametric approach is composed of the stochastic frontier approach (SFA). According to Porcelli (2009), the main difference between the two approaches lies in their treatment of random noise and for flexibility in the structure of production technology. The stochastic frontier approach is preferred for assessing efficiency in agriculture because of the inherent stochasticity involved (Musaba & Bwacha, 2014). Distinctions between the two approaches of efficiency measurement are discussed in the following sub-sections.

2.6.1. Data Envelopment Analysis (DEA)

DEA is a non-parametric method of efficiency measurement adapted from multiple input-output production functions and is used in operational research and economics for the estimation of production frontiers. It is also used to empirically measure production efficiency of a decision-making unit (Porcelli, 2009). According to Peacock, Chris, Melvino and Johansen (2001), the DEA is also used to benchmark firms against the best producers and is characterised by an extreme point method that assumes that if a firm can produce a certain level of output utilising specific input levels, another firm of equal scale should be capable of doing the same. There are several advantages and disadvantages attached to the DEA as a method of efficiency measurement.

According to Jacobs (2001), the advantage of DEA is that this approach constructs a piecewise, linear, segmented efficiency frontier, based on the best practice and is capable of handling complex production data with multiple input and output technologies, such as production efficiency in agribusiness and research environments. The same author further stated that the DEA gives the benefit of the doubt to companies that do not have suitable companies that can be compared to them so that they are considered efficient by default. That is so because these companies do not have a benchmark that they can compare themselves with. Another advantage of the DEA method of efficiency estimation is that the model is free from specification bias because it does not require specification of a functional form (Charnes, Cooper, Lewin & Seiford, 1997). In addition, the model can accommodate efficiency estimation involving multiple outputs more easily and provides an indication of the scale of operation for individual DMUs in the sample (Sarafidis, 2002).

Based on the analysis made by Jacobs (2001), the DEA also have several disadvantages/ weaknesses that limit its suitability and appropriateness. One of these weaknesses are that the DEA does not take errors into consideration, thus making it more vulnerable to data error. Another weakness of DEA is that the model does not make provision for statistical noise and all deviations from the frontier are considered as inefficiency (Deme, 2015). As a result, efficiency estimates obtained by using DEA can be biased and unreliable in studies where the data has the influence of statistical noise. According to Sarafidis (2002), it is difficult to assess goodness of fit in the DEA model because as there is no proper definition of goodness of fit that enables model comparisons and the standard criteria cannot be used for assessment of the goodness of fit. The DEA does not also produce diagnostic tools that will enable judgment of the goodness of fit of the model specification created (Jacobs, 2001).

2.6.2. Stochastic Frontier Analysis (SFA)

Stochastic Frontier Analysis (SFA) is a parametric technique of efficiency measurement that is different from the DEA. Like the DEA model, the SFA has strengths and weaknesses. The main strength of the SFA is that this approach is based on econometric estimation and it take into considerations technical inefficiency and the fact that random shocks beyond producers' control may affect the yield (Sarafidis, 2002). This means that this technique makes provision for statistical noise and differentiate between inefficiencies of the producer and random shock through the introduction of a composed error term. The composed error term consists of a symmetric disturbance term (Vi) and a non-negative inefficiency term (Ui). This is an important property of SFA, especially when the data undertaken has the influence of random effects (Sarafidis, 2002). The SFA model permits hypothesis testing as to the functional form of the frontier and the significance of individual explanatory variables (Sarafidis, 2002).

The main weaknesses of SFA are the requirements of specification of the functional forms and formulation of distributional assumptions about the error terms (Henderson & Kingwel, 2002). In the literature, the stochastic frontier analysis has generally been preferred in many agricultural studies. This is because, first, the assumption that all deviations from the frontier arise from inefficiency, as assumed by data envelopment analysis (DEA) is difficult to accept, given the inherent variability of agricultural production due to factors that may not be under the control of the farmer such as weather, pests and diseases. Second, because many farms are small, family owned farm records are seldom kept. Consequently, available data on production are likely to be subject to measurement errors. The choice of the preferred technique mainly depended on certain circumstances. When random influences and statistical noises are perceived to influence the data and when the omitted variables may influence the final results, SFA is preferred. Moreover, when hypothesis testing is important and measurement of goodness of fit of the estimated model is required, SFA model is more appropriate (Sarafidis, 2002).

2.7. Factors affecting technical efficiency

A number of studies have been carried out to determine factors that influence efficiency of farmers (Farrell, 1957). Pioneer work on production efficiency that assumed constant returns to scale has been under going further improvements to increase the power of estimation (Battese & Coelli, 1995). Further modification of measurement went on to include other factors that were presumed to affect efficiency. According to Oladimeji and Abdulsalam (2013), the conventional inputs include labour intensity, fertilizer usage, tractor use intensity and stock of livestock. On the other hand, non-convectional inputs include land quality, irrigation, agricultural research, calorie availability, agricultural export and instability. In a study by Alene and Hassan (2003) and Baloyi (2011), they have identified fertilizer, cattle ownership, access to credit, supply of extension, human capital farmer's socio-economic characteristics (education, age, and gender of house head), and family size and as explanatory variables to efficiency. It is therefore very important to understand the fundamental factors that causes variations in the use of production inputs among farmers. The factors in this study are classified into demographic factors, production factors, socio-economic factors and support services (Institutional factors).

2.7.1. Demographic factors

Demographic factors are specific characteristics of every individual farmer. Many technical efficiency studies consider these as the most important factors in influencing the technical efficiency of the farmers. These include factors such as age, education, farming experience and gender. The inclusion of these variables in technical efficiency studies highlights the importance of the variables in determining efficiencies of decision makers. Age is among the factors that are said to have an influence on the production efficiency of a farmer. In a study by Mulinga (2013), younger farmers were found to be more efficient than older farmers. This can be explained by the fact that younger farmers are more energetic and tend to be more physically stronger than the older farmers. Younger farmers are also more likely to have attained a higher level of education and tend to be more innovative, hence are more efficient (Ndjodhi, 2016) . On the other hand, some authors have argued that older farmers are more efficient than younger farmers because farmers become more skilful as they grow older. This is evident in a study by Mignouna, Mutabazi and Senkondo (2010). They concluded that the older farmers who are more experienced are technically efficient.

Level of education among farmers is also one of the demographic factors that affect the technical efficiency of the farmers. According to a study done by Ogunyinka and Ajibefun (2003), education level of the farmers was found to be significant and showed signs to increase technical efficiency for Nigerian crop farmers. This is because high level of education helps the farmer in the use of production information that may increase the productivity potential and subsequently achieve increased yield. Ara Begum, Buysse, Alam and Van Huylenbroeck (2009) also concluded that the level of technical efficiency for commercial poultry producers may increase by improving training and education.

Among these many factors is also farming experience of the farmer. It is one of the most important factors with a positive impact on the technical efficiency of farmers. This means that the more farming experienced a farmer has, the more likely he/she is to be efficient. In a study done by Wollni (2007), o technical efficiency of coffee production in Costa Rica, he found that farm experience has the potential to improve technical efficiency, but an older farmer was found to be inefficient. In this case, this might mean that farming experience may be associated with the knowledge of the crop but the age of the farmer may not necessary imply the know how in crop production. In terms of gender, male farmers were found to be inefficient because of the argument that women are more likely to be members of a local group and therefore more knowledgeable than men in terms of credit procedures, pest management and new cultivation techniques. In a study by Simonyan, Umoren and Okoye (2011), they found that the technical efficiencies for male and female were 93% and 98%, respectively.

2.7.2. Production factors

Production factors of the farmers include factors that farmers make use of to produce a certain quantity of produces. These are input factors such as seeds, fertilisers, water, labour, etc. In a study conducted by Phofolo (2012), he measured the factors affecting technical efficiency of small-scale raisin producer. The results showed that the percentages of young vines were found to increase inefficiency because inputs were used on vines that are still unproductive. However, a prospering farmer was regarded as reinvesting in the land and is likely to show signs of inefficiency at the moment but in future the farmer is likely to be more efficient.

Soil fertility is another variable that is acknowledged to affect the technical efficiency of production. According to Nyemeck, Sylla, Diarra and Nyambi (2003) and Wollni (2007), the better the soil quality on which the farm is located, the more likely the farmer will be technical efficient. The impact of soil quality on farm efficiencies is due to differences in agro-ecological environment (Wollni, 2007). The quality of the soil and the application of appropriate chemicals in the soil are important factors that are likely to provide positive spin-off on technical efficiency. Labour is also one of the production factors that affect the technical efficiency of the farmers. The impact of labour on technical efficiency is understood through the economies of size (Wollni, 2007). Thus, technical inefficiency is realised when family labour is employed beyond optimal levels of production. That means with limited land, labour is sometimes employed beyond the size of what the land can accommodate, which decreases the productivity of labour. On the other hand, large farm area is likely to increase technical efficiency levels of decision makers compared to smaller farms as a result of economies of scale.

2.7.3. Socio-economic factors

Small-scale farmers are generally known to experience constraints in getting credit or off-farm income to meet day to day farming activities. Various studies have concluded credit to be important in explaining farm technical inefficiencies. Farmers with off-farm income are likely to be more able to afford sufficient appropriate inputs and services than those who are only dependent on farm income alone (Ndjodhi, 2016). This is mainly because these farmers have the ability to cater for day-to-day farming activities that in the end effect how much the farmer produces. The positive effect of off-farm income on farmer's technical efficiency is that, multiple sources of income may enable farmers to afford the necessary inputs and technology, thereby increasing their crop yields (Diiro, 2013). This is particularly the case when farmers do not have sufficient resources to afford basic inputs and services, causing farmers to compromise on the supply of essential inputs thereby adversely affecting the quality and quantity of the output. Wollni (2007), also argues that off-farm income contributes to improving farmer's technical efficiency because the farmers are more likely to have access to information and financial resources in order to overcome liquidity constraints and be able buy inputs on time.

2.7.4. Institutional factors (support services)

Support services include services such as extension services, cooperatives, etc. Co-operative membership is generally expected to provide members with relevant information and also allow farmers to reduce their transaction costs through affordable access to inputs (Ndjodhi, 2016). According to Binam et al. (2004), membership to a farmer association can affect the level of technical efficiency for farmers. The same authors further explained that this is so because the farmers benefit from sharing information on farming practices at association level, thereby increasing the farmers' awareness and knowledge. However, it can also be argued that improving the flow of information to a decision maker does not necessarily result in the decision maker acting on it. A financially constrained farmer may be familiar with improved cultivars, fertilisers and other necessary inputs but they are unable to access them (Phofolo, 2012).

Extension services also play more or less the same role as that of cooperatives to the farmers. These can equally affect the farmers' technical efficiency because extension service officers also provide farming information ant training to the farmers, thereby increasing the knowledge of the farmers and consequently the farmers' output. However, like cooperatives, extension service visits can also be found not to increase the farmers' technical efficiency. Hence, Dolisca and Jolly (2008) explained that extension services have little influence on farmers' decision making. This is because they address the problem of asymmetry of information without providing farmers the necessary resources such as finance.

2.8. Chapter Summary

This chapter presented the literature review of the study. It began by giving an overall overview of the maize production in Africa and specified it to the Namibian context. Literature also highlighted the main approaches used to measure the technical efficiency of the farmers, which include the non-parametric approach, composed of the data envelopment analysis (DEA) and the parametric approach composed of the stochastic frontier approach (SFA). The SFA approach has been criticised because some of its weaknesses include the imposition of explicit functional form and the distribution of the error term. The DEA two-stage semi-parametric approach has also been criticised, inter alia, for failing to explicate a coherent data gathering process. The advantage of DEA is that this approach constructs a piecewise, linear, segmented efficiency frontier, based on the best practice and is capable of handling complex production data with multiple input and output technologies, such as production efficiency in agribusiness and research environments. The main strength of the SFA is that this approach is based on econometric estimation and it take into considerations technical inefficiency and the fact that random shocks beyond producers' control may affect the yield. This study made use of the SFA approach mainly because the data was perceived to be influenced by statistical noises. This chapter finally discussed the factors affecting technical efficiency among small-scale farmers. These include demographic factors, production factors, socio-economic factors and Institutional factors). Based on the findings from the relevant studies, it is concluded that technical efficiency can be increased when improvements are made on the abovementioned factors which are hypothesised to have an influence on the technical efficiency of the small-scale farmers.

3. CHAPTER 3: METHODOLOGY

3.1. Introduction

This chapter presents and discusses the methodology and procedure followed to address the main objective and sub-objectives of this study. The chapter begins with the study area, where a description of the geographic location and the background of the different green scheme projects, as study areas is made. The second part presents and discusses the population and sampling procedures used, questionnaire design, the data collection and fieldwork procedure. The third and the last part of this chapter presents and discusses the analytical model used and the model specification.

3.2. Study area

Figure 1 is a map of the study area showing the different study sites.

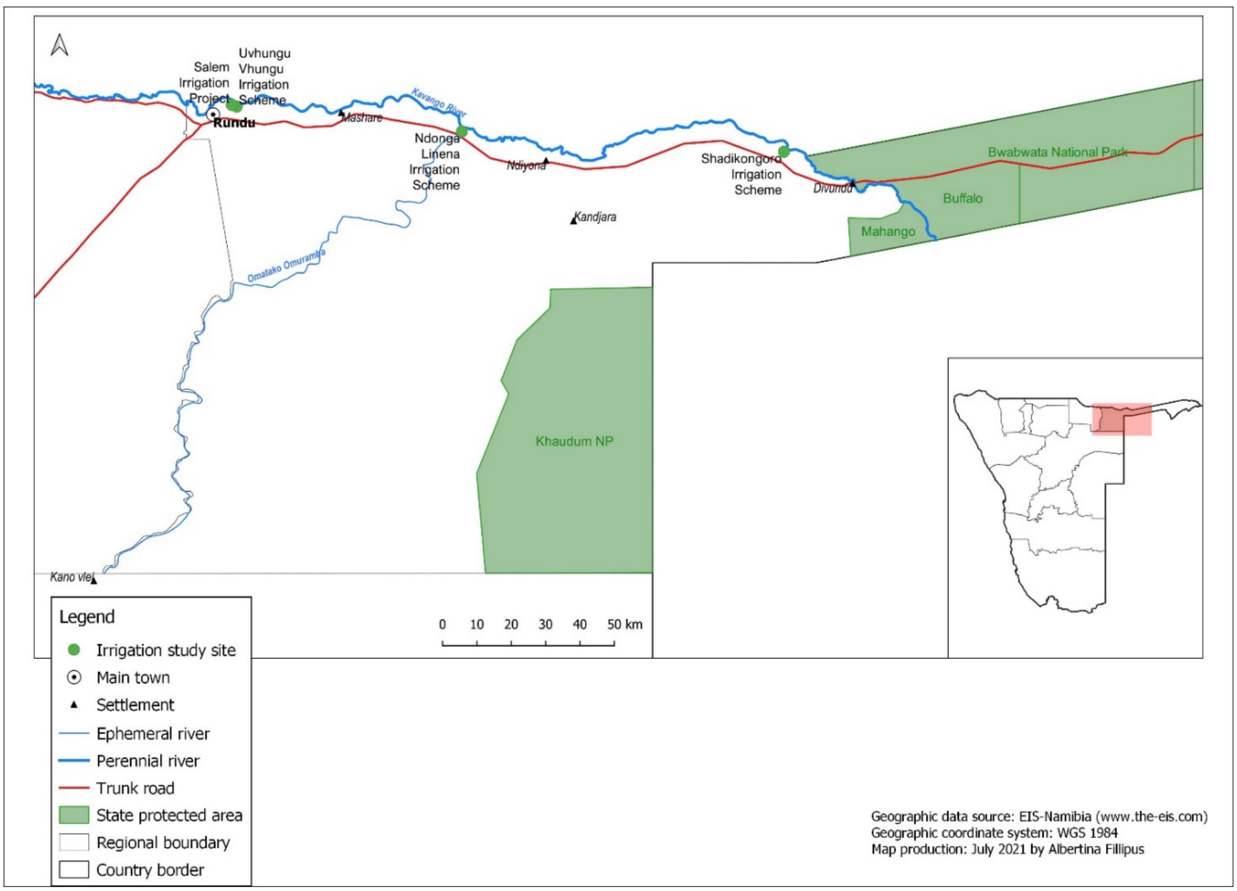

Figure 1: Location of the study sites in the Kavango East Region of Namibia
Source: (Fillipus, 2021)

This study was conducted in the Salem cooperative group of small-scale farmers and the 4 green schemes (Vhungu Vhungu, Shadikongoro and Ndonga-Linena) which are some of the government's Green Scheme Projects, situated in the Kavango East Region where most of the maize small-scale farmers are found.

3.2.1. Uvhungu Vhungu Irrigation Scheme Project

The Uvhungu Vhungu project is situated approximately 10km east of Rundu in Kavango East region. The farm has a total land surface of 825 hectares of which only 380 hectares are under full production. Commercial farming occupies 320 hectares and 60 hectares are occupied by ten (10) small-scale farmers. Maize is the main grain crop produced at the project with different types of vegetables such as, carrots, sweet potatoes, Onions, Butternuts, Watermelons, Sweet melons, Cabbage, Lettuce, Gem squash and Spinach. In terms of agro processing activities, the farm is mainly involved in the primary processing operations such as crop threshing, cleaning, grading, and packaging prior to storage, marketing or further processing. The project is directly managed through a contract agreement with the Ministry of Agriculture, Water and Land Reform and Agricultural Business Development Agency (AgriBusDev) as a service provider to the small-scale and commercial farming. In terms of marketing of the farm produce, AgriBusDev as a service provider also acts as a marketing agents for the small-scale farmers, by identifying the right customers for the farmers and facilitating the sale of the farmer's produce. A dairy farm is also currently being developed.

3.2.2. Shadikongoro Irrigation Scheme Project

The Shadikongoro project is situated 180 km east of Rundu in Kavango East region. The farm covers an area of 590 hectares of which 300 hectares are used for commercial farming and 90 hectares are occupied by small-scale farmers. Fourteen (14) small- scale farmers are part of the project of which 12 have 6 hectares each and 2 have 9 hectares each. The small-scale farmers and the commercial farming are mainly involved in the production of maize as their grain crop with cabbage as the only vegetable grown on the farm. In terms of agro processing activities, the farm is mainly involved in the primary processing operations such as crop threshing, cleaning, grading, and packaging prior to storage, marketing or further processing. The project is managed by the Agricultural Business Development Agency (AgriBusDev) through a profit-sharing agreement with the Ministry of Agriculture, Water and Land Reform. AgriBusDev as a service provider also acts as a marketing agents for the small-scale farmers, by identifying the right customers for the farmers and facilitating the sale of the farmer's produce.

3.2.3. Ndonga-Linena Irrigation Scheme Project

The Ndonga-Linena is situated 75km east of Rundu in Kavango East. The farm covers a total land area of 1000 hectares of which currently only 506 hectares are under commercial and small-scale production. A total of 332 hectares are utilised by commercial farming and 174 hectares are under small-scale farming. Twenty-nine (29) small-scale farmers are part of the project each occupying 6 hectares. The small-scale farmers and the commercial farming are mainly involved in the production of maize as their grain crop. Different vegetables such as carrots, sweet potatoes, Onions, Butternuts, Watermelons, Sweet melons, Cabbage and Lettuce are also produced at the farm. In terms of agro processing activities, the farm is mainly involved in the primary processing operations such as crop threshing, cleaning, grading, and packaging prior to storage, marketing or further processing. The project is managed by AgriBusDev through a profit-sharing agreement with the Ministry of Agriculture, Water and Land Reform. AgriBusDev as a service provider also acts as a marketing agents for the small-scale farmers, by identifying the right customers for the farmers and facilitating the sale of the farmer's produce. The Agricultural Bank of Namibia has provided loans to the small-scale farmers through a voucher system. This loan was provided mainly to the small-scale farmers who are just commencing business (first year of production). The loan is from the Ministry of Agriculture, water and Land Reform, administered by AGRIBANK. These vouchers are used by the farmers to purchase inputs and pay for services rendered.

3.2.4. The Salem Irrigation Project

The Salem irrigation project is situated at Uvhungu-Vhungu village in the Kavango East region, about seven kilometres east of Rundu and was started in August 1986 by a German church organisation. After independence, it was handed over to the Ministry of Agriculture, water and Land Reform. The Salem cooperative is a 34-hectare piece of land that has been divided among 43 small-scale farmers, each occupying a 1 ha piece of land. The piece of land was donated by the Sambyu Traditional Authority, to set up a cooperative, accommodating small-scale farmers. The small-scale farmers are mainly involved in the production of maize as their main grain crop with different types of vegetables, depending on the season.

3.3. Population and Sampling

The Kavango East Region is one of the northern regions of Namibia. It is an outcome of the split of Kavango Region into two Regions known as Kavango East and Kavango West. It is located in the North-eastern parts of Namibia. The Kavango East Region has a total population of 115 447 people, with 343 villages (excluding Rundu town and Divundu Village Council), and an area of 25 576 square Kilometres (Namibia Statistics Agency, 2011). The maximum temperature is higher than 30 °C for most of the year while average minimums of less than 10 °C are recorded in the winter months of June, July and August (Mwoombola, 2017) There is tropical climate with two distinct seasons; the rainy season (late October-April) and the dry season (May to September). The region has good potential for the production of maize, mahangu, sweet potatoes, sorghum, beans, groundnuts and vegetables. In the Kavango East Region, agriculture forms part of the main occupation of the people in this area. The selected region is well suited for this study because the small-scale farmers in these respective irrigation schemes derive their sustenance mainly from crop production, mainly maize. This study employed a census approach. There is a total number of 53 small-scale farmers in the 3 irrigation scheme projects altogether (Uvhungu Vhungu Irrigation Project, Ndonga-Linena Irrigation Project, Shadikongoro Irrigation Project). However, only a total number of 42 small-scale farmers was found available in the respective irrigation schemes at the time of the study. This number is relatively low to perform any kind of statistical analysis on the data, thus a total number of 30 small-scale farmers were added to the 42, totalling the population to 72 farmers. These small-scale farmers were obtained from the Salem irrigation Project, where more maize small-scale farmers are found. This number of maize small-scale farmers in the Kavango East region was relatively low, hence there was no need for sampling, and as such all the 72 farmers were interviewed.

3.4. Questionnaire design

The questionnaire was designed to collect information which would enable the analysis of technical efficiency of the small-scale maize farmers (specific objective 1) and exploration of the factors that determine technical efficiency (specific objective 2) of the farmers in the study area. The questionnaire consisted of three sections which were designated in alphabetical order (A to C). The first section (A) of the questionnaire covered the demographic factors that influence technical efficiency of the farmers, such as gender, marital status, age and highest education attained. Section B covered the production factors that affect technical efficiency of the farmers and section C covered the institutional factors that affect technical efficiency of the farmers.

3.5. Data collection and Fieldwork

Primary data was collected in a farm-level census using a well-structured questionnaire administered to the entire population of small-scale farmers in these irrigation schemes. This was administered to a total number of 72 small-scale farmers from these irrigation schemes. The questionnaire was structured in thematic areas including farmers' demographic information, maize production activities, input use and yield, labour, marketing, access to credit, extension contact and training. Data collection was set to take four weeks and started from 01 to 26 February 2021. Consultations with AgriBusDev was first made before commencing the data collection process to inform all the small-scale farmers of the research beforehand. One research assistant and one language translator were requested to assists to interview the small-scale farmers. Each small-scale farmer was interviewed individually in the comfort of their homes. Since data was obtained during the growing season, it was easy to get hold of the farmers because most of them were all present at the time, and those that were not present agreed to be interviewed telephonically. The interviews went smoothly since most of the farmers have been involved in surveys before and the purpose of the study was clearly explained to the farmers by both the researchers and the manager of that particular irrigation scheme project. Before the start of the survey, the researcher requested for permission and authorisation to conduct the survey in the respective irrigation schemes from AgriBusDev. This was also done in order for the AgriBusDev managing director to sensitise and inform all the small-scale maize farmers in the respective irrigation scheme projects about the planned survey. Upon arrival at each project, the researcher held a meeting with the Project Management to inform them of her arrival and to request the assistance of officials to direct the researcher to the small-scale farmers' houses. In the meeting, the researcher also gave a brief introduction of the research, including the research goals and objectives. The actual data collection survey was conducted from the 08th to the 26th February, 2021.

3.6. Analytical method

3.6.1. Justification of the Stochastic Frontier Model

In many technical efficiency studies, technical inefficiencies have been noted to be caused by many factors, some under the control of the producer (technical inefficiency) and some not (statistical noise). It is for this reason the Stochastic Frontier Analysis (SFA) model was developed nearly simultaneously by Aigner et al. (1977) and Meeusen and van den Broeck (1977). These authors were motivated by the idea that deviation from the production frontier might not entirely be under the control of the producer. The SFA model has the ability to separately identify the effects of statistical noise from that of technical inefficiency through a composed error term. A lot of literature has encouraged the use of SFA because of its consistency with theory, versatility and relative ease of estimation (Battese & Coelli, 1992; 1996). According to Sarafidis (2002), the application of the SFA model is mostly common in agricultural efficiency measurements, most especially in developing countries. This is because data in these countries are heavily influenced by statistical noise. After the introduction of the SFA, it could only be used to estimate technical efficiency, but was unable to analyse the sources of efficiency variations among the producers (Battesse & Coelli, 1993). It was then for that reason that a two stage approaches have been developed to explain technical inefficiency. Early studies adopted a two-stage approach where, efficiencies are estimated first and then the estimated efficiencies are regressed against a vector of explanatory variables in the second stage (Kumbhakar & Lovell, 2000). In recent studies, the two-stage approach is not preferred due to weaknesses associated with it. The two-stage approach suffers from inconsistency of assumptions regarding the independence of distribution of the inefficiency error terms (Nyemeck et al., 2003).

The inconsistency of assumptions implies that in the first step, SFA model estimates technical efficiency by assuming that the inefficiency error term is independent of the influence of the vector of farm specific explanatory variables. In the second step, the relationships between the inefficiency error term and the farm specific explanatory variables is assumed as if there is a linear relationship (Schmidt, 2011). Given the weaknesses of the two stages approach, a single stage approach was introduced and many recent studies (such as Reifschneider and Stevenson (1991) and Battesse and Coelli (1995)) made use of the single-stage approach. In a single-stage approach, technical efficiency estimation and the relationships of technical inefficiency error term and the vectors of explanatory variables are estimated in a single step (Battese & Coelli, 1995). Unlike the two-stage approach, the single-stage approach allows simultaneous estimation of the production frontier and the technical inefficiency model parameters (Battese & Coelli, 1995). By taking into consideration the weaknesses associated with a two-step estimation method, in the current study, a single-stage SFA model is used. The choice of the single-stage approach over the two-stage is due to the above-mentioned weaknesses of the two-stage approach.

3.6.2. Model specification

The first specific objective of this study is to analyse the technical efficiency of the small-scale maize farmers of Kavango East Region. A stochastic frontier model was chosen as the analysis model to analyse the technical efficiency of the Maize small-scale farmers. The model chosen in this study has gained preference in many efficiency studies as opposed to the data envelopment analysis. This is mainly because, SFA provides the relative frontier against which production performance is evaluated, assuming that producers are producing a single output using multiple inputs (Kumbhakar & Lovell, 2003). As opposed to the DEA, the Stochastic Production Frontier specification incorporates the difference of the technical inefficiency variable from that of the symmetric random variable that affect output (Bachwe, 2009). The assumption that all deviations from the frontier arise from inefficiency (as assumed by the data envelopment analysis approach) is difficult to accept, because of the variability of agricultural production, because of uncontrollable factors such as weather, pests and diseases. In addition to the above mentioned, another reason is also that many farms are small, family-owned enterprises, farm records are seldom kept. Thus the available data on production are likely to contain measurement errors (Mango, Makate, Hanyani-Mlambo, Siziba & Lundy, 2015a). In this study, a Cobb–Douglas functional form of the stochastic frontier production model with a log functional form was used to specify the stochastic production frontier. According to Binam et al., (2004), the Cobb-Douglas production function provides an adequate representation of the production technology. This study made use of the production data of maize production in the 2020 season by each of the 72 small-scale maze farmers of the different irrigation scheme projects. A stochastic production frontier given by Battese and Coelli (1995) for a cross-sectional data with a multiplicative disturbance term takes the form:

$$Y1 = \beta_0 + \beta_1 X_1 \ldots\ldots \beta_2 X_n + \varepsilon_i \quad (1)$$

Taking the natural logarithm of already specified Cobb–Douglas production function, we can reach the following linear production function which can be easily estimated:

$$\text{In}Y1 = \beta_0 + \beta_1 \text{In}X_1 + \beta_2 \text{In}X_2 + \beta_3 \text{In}X_3 + \beta_4 \text{In}X_4 + \varepsilon_i \ (Vi - Ui) \quad (2)$$

Where:

ln = natural logarithm
n = 1, 2, 3…,72
Y1 = quantity of maize produced (tons/ha)
X_1 = amount of seeds used (Kg/ha)
X_2 = Inorganic Fertiliser used (kg/ha)
X_3 = tractor use
X_4= Labour
β = a vector of unknown parameters to be estimated
εi = stochastic disturbance term consisting of two independent elements, *u* and *v*, where *u* is a one-sided inefficiency component and *v* accounts for random variation in output due to factors outside the farmer's control, such as weather, pest and diseases.

From the stochastic production frontier given by equation 2, the associated technical efficiency (TE) can be estimated. Technical efficiency measures the output of the farmer relative to the output that could be produced by a fully efficient farmer using the same vector of inputs (Mazvimavi, Ndlovu, An & Murendo, 2012) The farm-specific technical efficiency (TE_i) of the i^{th} farmer was estimated using the expectation of U_i conditional on the random variable ε_i. It follows that:

$$TE = \frac{Yi}{\exp(Xi\beta + Vi - Ui)} \quad (3)$$

where,

$Yi = \exp(Xi\beta + Vi - Ui)$= The actual output which is obtained in the presence of the technical inefficiency effects.

$\exp(Xi\beta + Vi)$= The frontier output under condition of random shocks.

Technical efficiency will be obtained by dividing the actual output by the frontier output. After cancelling the similar terms, the remaining value will be $\exp(-Ui)$ (Coelli, 1995). This represents technical efficiency. The value of TE ranges between zero and one ($0 \leq TE \leq 1$). According to Bachwe (2009), TE takes a value of one when the producers are technically efficient, becomes closer to zero when the producers are less technically efficient and becomes zero when producers are fully inefficient.

3.6.3. Factors influencing technical efficiency.

The second specific objective of this study is to identify factors influencing technical efficiency of Maize small-scale farmers of Kavango East Region. To achieve this objective, a single-stage estimation procedure was followed from the stochastic frontier production function. In single-stage estimation, inefficiency effects are defined as an explicit function of certain factors specific to the farm, and all the parameters are estimated in one-step using the maximum likelihood procedure. The technical efficiency of maize small-scale farmers of the Kavango East region depends on various demographic factors, farm production factors, institutional and marketing factors. These factors include age of the farmer, educational level attained by the farmer, extension service, farmer's access to credit facilities and farmer's access to training on maize production.

Below is a discussion of the expected hypothesized variables that affect technical efficiency.

Age of the farmer: The age of the farmer is expected to have appositive influence on technical efficiency of maize small-scale farmers of the Kavango East region. Older farmers are expected to more knowledgeable and have the relevant knowledge on productivity than younger farmers.

The level of education attained: This variable categorises farmers from those that have not attained any level of education to those that have attained tertiary level of education. The educational background of the farmers is also one of the important factors that influence the technical efficiency of the farmers. In this study, the level of education attained by the maize small-scale farmer is expected to have a positive influence on the technical efficiency of the farmer. This means that, more educated farmers are expected to have a wider understanding and be able to adopt new technologies and new ideas.

Extension service: Extension service is also one of the factors that is hypothesized to affect the technical efficiency of the maize farmers. Extension officials provide production information, advice and ideas to farmers. So farmers who have better extension service access are expected to be more efficient than others. This means that, the more extension service access the farmer has, the more the farmer will be well informed and knowledgeable in the latest technologies and farming trends. It is therefore assumed that farmers who have better extension service are more likely to be technically efficient due to the increased awareness (Dawit, 2012).

Access to credit: This variable categorises farmers to whether they have access to reliable sources of credit or not (1= yes and 0= no). It was used to capture the effect of credit on the technical efficiency of the maize farmers of Kavango East Region. The availability of credit will loosen the constraints of production, therefore facilitating the acquisition of inputs on a timely basis, and hence it is supposed to increase the level of efficiency of the farmers. Farmers who have access to a reliable source of credit were assumed to overcome liquidity constraints, purchase more production inputs or a new technological package such as high-yielding seeds since this can be regarded as access to funds (Bekele, 2013). Access to credit is therefore hypothesised to have a positive influence on technical efficiency of the maize small-scale farmers of Kavango East Region.

Access to maize production training: This variable categorises farmers to whether they have access to maize production training or not. (1= yes and 0= no). like level of education, access to training is also one of the factors that is hypothesized to positively influence technical efficiency. Training helps the farmers acquire the necessary skills and knowledge on maize production. The more knowledgeable the farmer is, the more the farmer will be able to efficiently utilize inputs which in turn increases the technical efficiency of maize production.

3.6.4. Relationships between socio-economic characteristics and technical efficiency

The third specific objective of this study is to examine the relationship between socio-economic characteristics of the Maize small-scale farmers of Kavango East Region and their farm technical efficiency. To achieve this objective, the predicted efficiencies obtained from the estimated stochastic frontier was regressed on a vector of farmer-specific factors (e.g. the age of the farmer, gender of the farmer, the farmer's level of education, Farm size, land ownership, access to formal sources of credit, seed type, weeding frequency extension office visit and access to training). According to studies done by Amaza and Olayemi (2002), Llewelyn and Williams (1996), and Narala and Zala (2010), they have investigated the determinants of technical efficiency among producers. These studies all showed a positive relationship between technical efficiency and socio-economic characteristics of the different producers.

In this study, it is expected that the farmers' access to extension services, access to training, weeding frequency and the farmers' years of farming experience would positively influence technical efficiency (negative relationship with technical inefficiency or a negative coefficient). This is so because several studies such as Battese and Coelli (1995), Narala and Zala (2010), and also Mango et al., (2015) have found a positive relationship between technical efficiency and socio-economic characteristics of the farmers. Farmers with frequent access to extension services were expected to be more productive and efficient, because they could obtain advice from the extension officers about new available technologies and other relevant information on production, thereby increasing or improving their productivity and efficiency. Another factor of efficiency among small-scale farmers is their access to credit. This will enable the small-scale farmers to purchase their inputs on time and improve their farm efficiency. Considering the importance of weed management in maize production, farmers with a higher weeding frequency are expected to be more technically efficient than those with very low weeding frequency.

3.7. Chapter summary

The chapter discussed the procedures used to achieve the objective of the study. The study employs a SFA model to estimate technical efficiency and to analyse the determinants of technical inefficiency. Evaluation to determine the best fit production function was carried out and a Cobb-Douglas production function is found to fit the data well and is chosen for the final SFA specification. In the production function estimated, the dependent variable is maize yield (ton/ha), and the explanatory variables are seeds used per ha, inorganic fertilizers per ha, tractor use and total labour used in maize production. In the technical inefficiency model, the farm specific explanatory variables are age, gender, education, farm size, land ownership, access to formal sources of credit, seed type and weeding frequency. SFA was used to test the two hypotheses, were the first one is the test for the presence of technical inefficiency effects in the estimated model and the other is the test to see if socio-economic characteristics (age, gender, educational level, experience of farmers, farm size etc.) significantly influence the farmer's technical efficiency. The hypotheses tests confirmed the presence of technical inefficiency effects and a number of socio-economic characteristics of the farmers (Age, Education, Access to formal sources of credit and Extension office visit) does have an influence on the farmers' technical efficiency.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. Introduction

This chapter presents the results of the study and give a discussion of the results. It starts with an overview and descriptive characteristics of the respondents. The second part gives an analysis on the technical efficiency scores, followed by a discussion on the factors affecting the technical efficiency of the maize small-scale farmers of Kavango East Region.

4.2. Characteristics of the respondents

4.2.1. Socio-economic characteristics

4.2.1.1. Gender and age

Table 1 presents an overview of the maize small-scale farmers of Kavango East Region by different study sites, gender and age in years (mean, minimum and maximum). As shown in Table 1, the highest number of farmers were sampled in the Salem Irrigation Project, followed by the Ndonga-Linena Irrigation Project and the least number of farmers were found in the Uvhungu Vhungu Irrigation project.

Table 1: Distribution of farmers by gender and age (N = 72)

Study site	**No. of farmers**	**Gender (Percentages)**		**Age (Years)**		
		Male	Female	Mean	Minimum	Maximum
Uvhungu Vhungu	6	3	3	38 (3.847)	32	42
Ndonga-Linena	26	17	9	37 (4.221)	24	45
Shadikongoro	10	4	6	43 (4.962)	39	54
Salem	30	8	22	47 (6.409)	39	61
Average	**18**	**8**	**10**	**41**		

Note: Figures in parenthesis are standard deviations

In terms of gender, the results show that the overall study consisted of more females (40) than males (32). In terms of the farmers' ages, the results indicate that the oldest farmer (61 years old) was found in the Salem Irrigation Project whereas the youngest farmer (24 years old) was found in the Ndonga-Linena Irrigation Project. The results also indicate that the mean age of the total sample is 41 years.

4.2.1.2. Gender

The distribution of the small-scale farmers based on gender is represented in Figure 2. The gender distribution revealed that 44.44% of the small-scale farmers are male, while 55.56% are female farmers. The results further indicated that at the time of the study, most of the small-scale maize farmers in the study area females. In other words, the studied population of small-scale farmers had 32 male farmers and 40 female farmers.

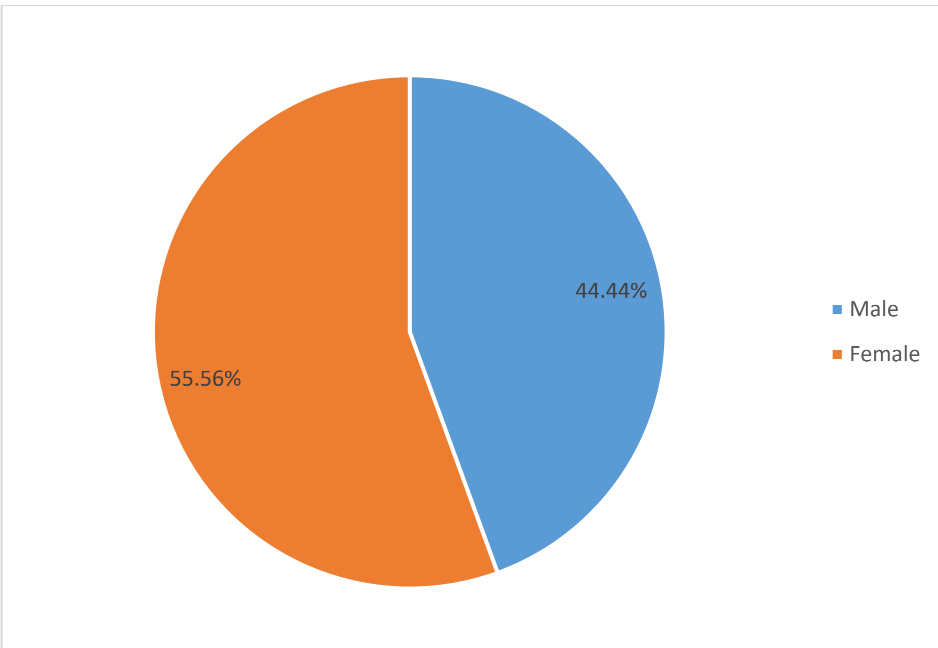

Figure 2: Distribution of the small-scale farmers by gender (N = 72)

According to Bachwe (2009), the gender of the farmer is a very important factor in determining causes of inefficiency among farmers. Female farmers can be inefficient relative to male farmers because male farmers are generally known to be physically stronger than female farmers. This allows them to handle farm activities more easily than females.

4.2.1.3. Gender and age group

The distribution of the small-scale farmers based on gender and age is represented in Figure 2. The gender distribution revealed that female farmers represented a high percentage in the first two age groups (youth and adult), constituting of about 58% of the small-scale farmers, whereas the male farmers only constituted of about 39%.

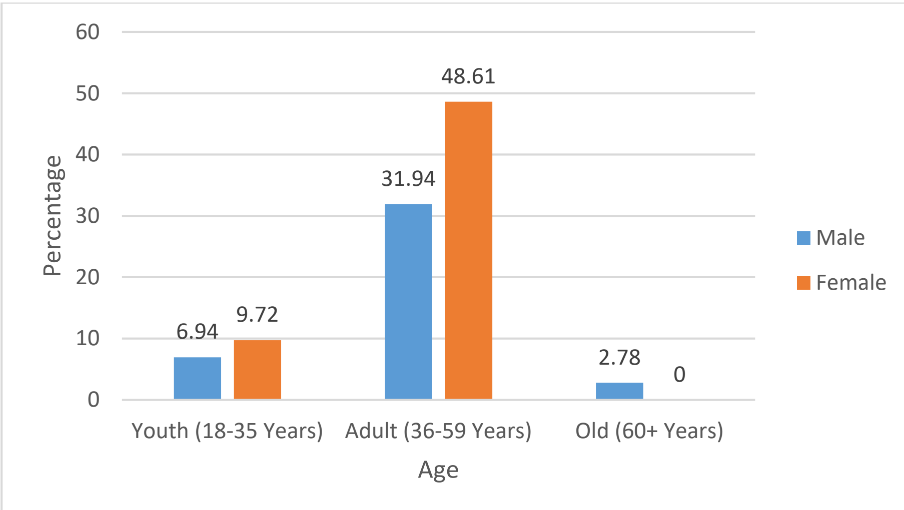

Figure 3: Distribution of the small-scale farmers by gender and age group (N = 72)

This clearly indicates that young males are reluctant to participate in the farming activities in this region. Moreover, the results further indicated that small-scale farmers in the elderly category (60+) are male only. This indicates that, many male farmers are found in the elderly age categories as opposed to female farmers that are found mostly in the younger age categories.

4.2.1.4. Marital status

Figure 4 shows the marital status of the studied small-scale farmers. The marital status is represented by four designations, namely, single, married, divorced and widowed. The results indicated that most of the respondents (55.56%) are married, followed by the single (41.67%) category and a very few small-scale farmers that are, divorced (1.39%) or widowed (1.39%). This expected because marriage is one of the requirements of a farmer to be able to live with their family members on the farm.

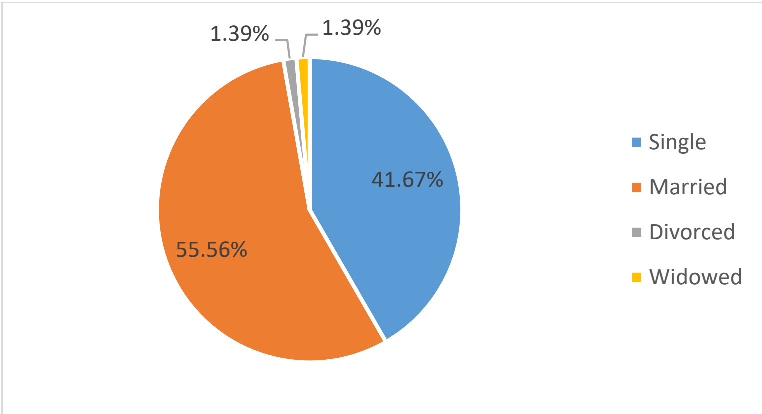

Figure 4: Distribution of the small-scale farmers by marital status (N = 72)

A high percentage of married small-scale farmers could have an impact on technical efficiency of the farmers. This is because, farmers that are married are permitted to live with their families on the farmland, as opposed to that are not married, and as such they will be able to use these family members as part of the labour force on the farm.

4.2.1.5. Education

This category is based on the idea that small-scale farmers that have attained at least secondary education could develop basic knowledge that is required to handle the agricultural decision makings better than the farmers that have not attained any education at all.

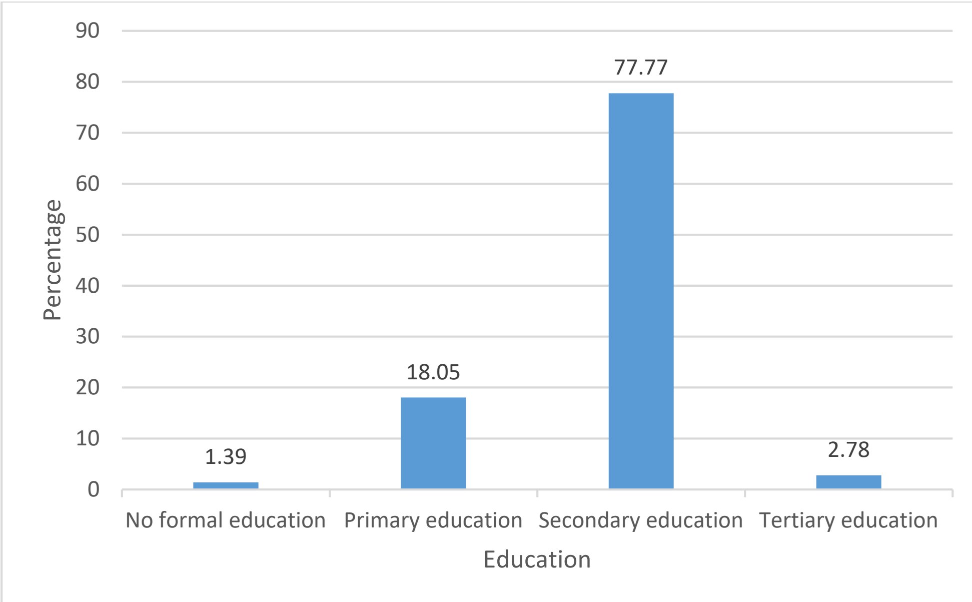

Figure 5: Distribution of the small-scale farmers by highest education attained (N = 72)

Figure 5 indicates that about 78% of the farmers have attained at least secondary education level. This was followed by the primary education category with 18 % of the small-scale farmers. Moreover, the results also indicated that only 2 (2.78%) out of the total of 72 (100%) studied small-scale maize farmers in Kavango East region have undergone tertiary education. The results obtained shows that a high number of the small-scale farmers have undergone at least secondary education and only a very small percent (1.39%) have not attained any form of education.

4.2.1.6. Tenure (Land ownership)

Tenure refers to the form of farm land ownership of the small-scale farmers. The farmers were asked whether or not they own the land they are faming on. Figure 3 provides the distribution of small-scale farmers based on land ownership.

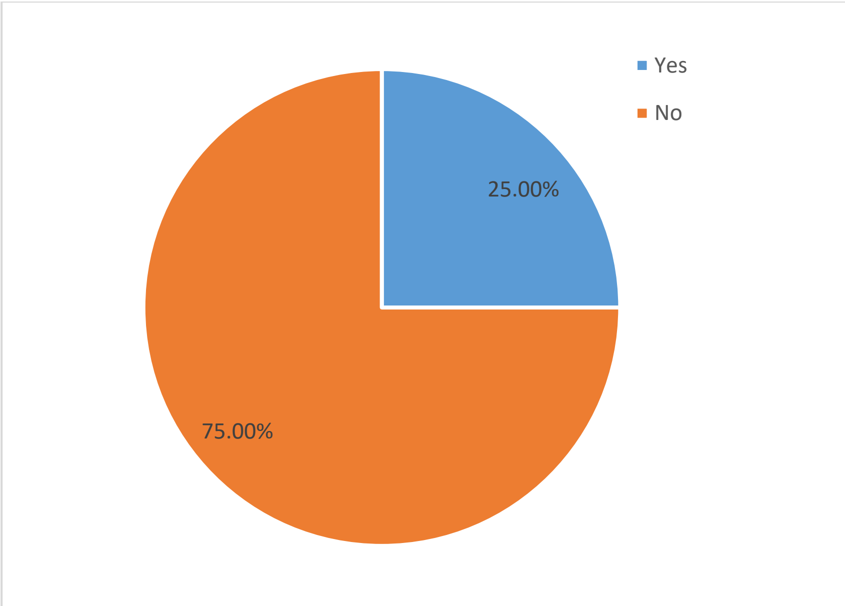

Figure 6: Distribution land ownership by small-scale farmers (N = 72)

Land tenure distribution of the small-scale farmers is based on the idea that if farmers own the land that they are farming on, it gives the farmers greater incentives for practising conservation and investing more in the farm and in turn produce more. As indicated in Figure 6, 75% of the small-scale farmers do not own the land they farm on and are operating on rented land. From the interviews held with the farmers, it was noted that these farmers are leasing the land from the government, while others are renting from fellow farmers. Only 25% of the farmers own the land they are farming on.

4.2.1.7. Access to credit

Access to credit is an important socio-economic variable that can influence small-scale farmers' ability to purchase inputs and can also improve the livelihood of the farmers. Figure 7 above provides the distribution of the farmers with regard to credit access. As indicated in Figure 5, only about 45.83% of the farmers have access to formal sources of credit while the remaining 54.17% do not have access to credit. The sources of finance for most of the small-scale farmers in Namibia are mostly state and private owned banks, the Ministry of Agriculture Water and Land Reform and informal money lenders that include neighbours, friends and family.

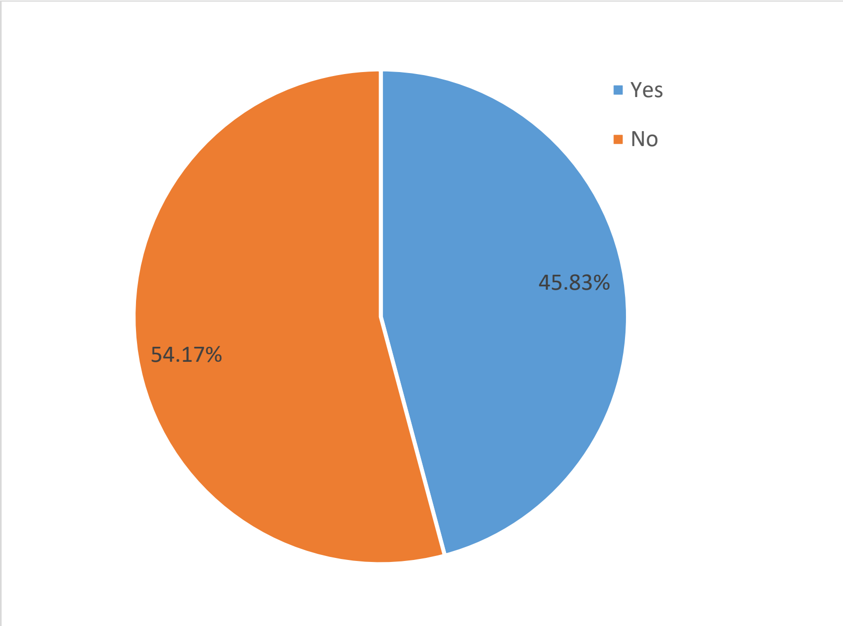

Figure 7: Access to credit by small-scale farmers (N = 72)

The Agricultural Bank of Namibia has provided loans to the small-scale farmers in the different irrigation scheme projects through a voucher system. This loan was provided mainly to the small-scale farmers who are just commencing business (first year of production). The loan is from the Ministry of Agriculture, water and Land Reform, administered by AGRIBANK. These vouchers are used by the farmers to purchase inputs and pay for services rendered. This is however different from the Salem farmers who are not part of any irrigation scheme project. They have noted that they find it very difficult to access these type of loans as they do not have the required collaterals. In addition, the banks set high interest rates which limits credit to mainly large land owners and most of these small-scale farmers are excluded from credit services provided by banks.

4.2.2. Farm management practices

4.2.2.1. Irrigation

According to Hordofa, Menkir, Bekele, and Erkossa (2008), irrigation is referred to as a means of supplying enough water to the plants for better crop production. irrigation is important because it helps farmers improve crop production and intensification, thereby sustaining and improving their livelihood and food security. The distribution of the small-scale farmers based on the use of irrigation is represented in Figure 8.

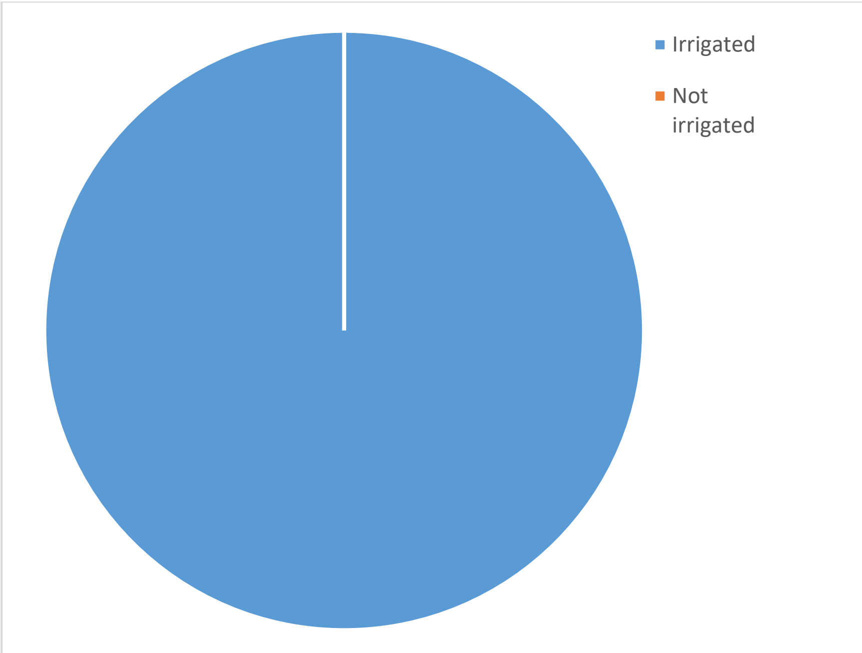

Figure 8: Distribution of the small-scale farmers based on irrigation use (N = 72)

Figure 8 shows the distribution was based on the irrigation use by the small-scale farmers. From Figure 6, it is observed that 100% (72) small-scale farmers all make use of irrigation for their maize production. This means that the use of irrigation in the small-scale farmers that were studied is dominant and that the availability of water for production in the Kavango East region is not a cause for concern for the small-scale farmers. These results are explained by the fact that all the small-scale farmers studied are based in the irrigation scheme projects of the country where irrigation methods are made available to them.

4.2.2.2. Access to extension services

Extension service refers to the advice and training provided by agricultural extension officers regarding better farm management. Figure 9 provides the distribution of the small-scale farmers studied with respect to extension. The small-scale farmers were asked whether or not they received extension office visits on their farms. The chart indicates that about 92% of the small-scale farmers have no access to extension services whereas only 8% of them have access to extension services.

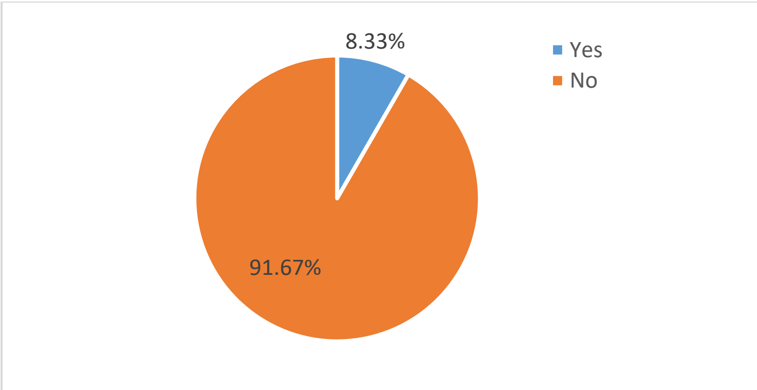

Figure 9: Distribution of access to extension service by small-scale farmers (N = 72)

The service provider (AgriBusDev) had made available a number of extension officers to the small-scale farmers on a monthly basis. According to some small-scale farmers, they would rather consult their fellow farmers for advice than make use of the extension officials who are seldom available or not available at all. They also indicated that the extension officials do not bring any new knowledge to them.

4.2.2.3. Farm size and labour

In this research, farm size refers to the size of the land in which the farmers grow maize, measured in hectares (ha). Similarly, labour (seasonal and full time) refers to the number of people that worked on the farm during the entire maize production season.

Table 2 presents a summary of farm size and labour use by the maize small-scale farmers of Kavango East Region. From Table 2, the mean farm size of the small-scale farmers was found to be 3.93 ha with a standard deviation 2.613 ha. The minimum farm size was 1 ha and maximum farm sizes was 9 ha. One of the many common characteristics among small-scale farmers in many developing countries is that they tend to have relatively small land sizes.

Table 2: Summary statistics of farm size and labour use by small-scale maize farmers (N = 72)

Variable		**Descriptive statistics**		
		Minimum	**Maximum**	**Mean**
Farm size (ha)		1	9	3.93 (2.613)
Labour	Full time	0	2	0.90 (0.937)
	Seasonal	4	24	8.93 (4.784)

Note: Figures in parenthesis are std. deviations

Though the scale on which they farm is small, the small-scale farmers of the Kavango East still manage to produce enough for their livelihood, and also for the market. Labour was divided into full time and seasonal labour. The small-scale farmers mostly make use of seasonal labour and very less of full time labour. The results in Table 2 shows that the minimum and maximum full time labour used was 0 and 2 people respectively, with an average of 1 person recruited as a full time labourer and a standard deviation of 1. For seasonal labour, the minimum and maximum was 4 and 24 people, respectively, with a mean of 9 people and a standard deviation of 5.

4.2.2.4. Seed and fertiliser

For many small-scale farmers, seeds and fertiliser are the primary inputs in crop production. Table 3 is a representation of the total amount of seed, fertiliser (inorganic and organic) and pesticides used by the farmers. Table 3 shows a summary of farm seed and fertiliser use by the maize small-scale farmers of Kavango East Region. From Table 3, the average quantity of total seed used/ha in maize production for the small-scale farmers was 15.45 kg whereby 3 kg/ha was the lowest and 43 kg/ha was the highest and a standard deviation of 9.093 kg/ha. It is observed that some of the farmers used improved seed while others used traditional seed in maize production. Improved seeds where mostly used by the small-scale farmers that are part of the irrigation scheme projects whereas traditional maize seeds were used by the Salem small-scale farmers. of the inorganic fertilisers used, 24166.67 kg/ha was the maximum and 175 kg/ha was the minimum.

Table 3: Summary statistics of farm seed and fertiliser use by small-scale maize farmers (N = 72)

Variable	**Quantity**		
	Minimum	**Maximum**	**Mean**
Seeds (kg)	3	43	15.45 (9.093)
Inorganic Fertiliser (Kg/ha)	175	24166.67	2019.23 (4105.349)
Organic Fertiliser (kg)	0	16000	2145.83 (2823.689)
Pesticide (litres/ha)	1	14.78	4.64 (2.395)

Note: Figures in parenthesis are std. deviations

The average quantity of inorganic fertiliser used was 2019.23 kg/ha with a standard deviation of 4105.349 kg/ha. The standard deviation indicates a very wide variation in the quantity of inorganic fertiliser use among the small-scale farmers. Furthermore, on average, farmers used 2145.83 kg of organic fertilisers, whereby 0 kg/ha was the lowest and 16000 kg the highest. The average amount of pesticide used was 4.64 litres/ha, with 1 litre/ha being the minimum and 14.78 litres/ha being the highest and a standard deviation of 2.395 litters/ha. In terms of pesticides, there is also a high standard deviation, indicating a wide variation in the quantity of pesticides use among small-scale farmers.

Another analysis is in terms of seed type used by the small-scale farmers. Figure 6 shows the distribution of the small-scale farmers based on seed type used.

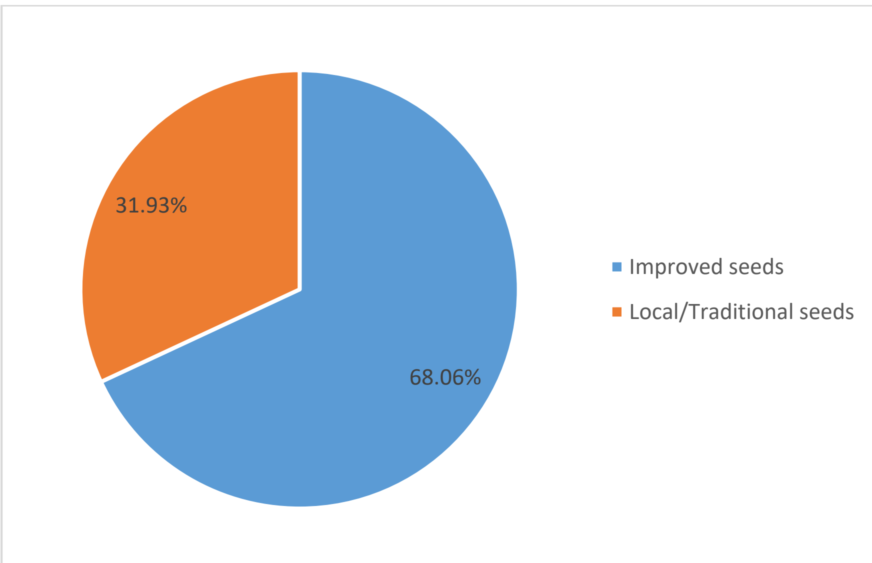

Figure 10: Distribution of the small-scale farmers based on type of seed used (N = 72)

Figure 10 indicates that most of the small-scale farmers in the study area (68.06%) made use of improved seeds while only 31.93% used local/traditional seeds. This indicates that the use of improved seeds is high compared to traditional seeds. Based on the type of seed used, there is a yield difference among the small-scale farmers studied. According to the small-scale farmers, more improved seed is used because it is made available to them for use by their service providers and they do not have to source for their seeds elsewhere. However, the 31.93% of the farmers that uses local/traditional seeds is explained by the Salem small-scale farmers who do not get their seeds from service providers but rather source for their seeds on their own. local/traditional seeds in this context means the maize seed variety which originates within the country and exists within the country, whereas improved variety means any maize seed variety that has been bred using formal plant breeding methods, usually imported into the country (Fransiska, Rahajeng, Dewi, & Gonzaléz, 2015).

4.2.2.5. Maize yield

Maize yield is the quantity of maize produced in tons per hectare. Table 4 shows a summary of descriptive statistics for maize yield produced during the 2019/2020 cropping season of by the small-scale farmers of Kavango East Region.

Table 4: Maize yield of the small-scale farmers (N = 72)

Variable	Descriptive statistics		
	Minimum	**Maximum**	**Mean**
Maize yield (tons/ha)	1	10.16	5.07 (2.078)

Note: Figures in parenthesis are std. deviations

The results show that the average maize yield is 5.07 ton/ha. The yield level was highly variable among the farmers with minimum and maximum yields of 1 and 10.16 ton/ha respectively, and a standard deviation of 2.13 ton/ha. This was achieved after having applied all the necessary inputs as indicated in Table 3 (inorganic fertilizers, organic fertilizer and pesticides).

4.3. Estimation of technical efficiency

Table 5 shows a summary of descriptive statistics for the variables used in the stochastic frontier model.

Table 5: Descriptive Statistics of the production variables in the model (n=72)

Variables	Descriptive statistics			
	Minimum	**Maximum**	**Mean**	**Std. Deviation**
Maize yield (tons/ha)	1	10.16	5.07	2.078
Inorganic fertilizers (Kg/ha)	175	24166.67	2019.23	4105.349

Total Labour (no. of workers)	4	24	10.05	4.417
Seeds used (Kg/ha)	3	43	15.48	9.093
Pesticides used (l/ha)	1	14.78	4.64	2.395
Farming experience (years)	1	20	10	4.680

The results show that maize small-scale farmers of Kavango East Region produced 5.07 tons/ha of maize on average, with 10.16 tons/ha being the maximum yield reached and 1 ton/ha as the minimum yield the farmers have produced during the 2019/2020 cropping season. The farmers use on average 15.48 kg of maize seed per hectare, with 2019.23 kg of inorganic fertilizer applied per hectare. An average of about 4.64 litres of pesticides were applied by the small-scale farmers per hectare.

Table 6 shows the results of the estimates of the stochastic production frontier model. The estimated coefficients of the production frontier parameters are positive for seeds used, inorganic fertilisers used and labour, but negative for tractor use and the farmer's farming experience. The positive coefficients of seeds used, inorganic fertilisers used and labour indicate that increasing the amount of these inputs increases maize production. The increasing effect of these inputs on maize production is as expected because production of maize is dependent on the quantities of these inputs used. These results concur with the findings of Alene and Hassan (2003) Geta, Bogale, Union, Belay and Elias (2013) in which application of fertiliser increases production significantly.

Table 6: Estimates of the stochastic production frontier model

Variables	**Coefficient**	**Std. error**	**Z-test**	**Significance**
Constant	0.43412	0.1395372	3.11	0.002***
lnSeeds used per ha	0.0998909	0.0467354	2.14	0.033**
lnInorganic fertilizers per ha	0.1610625	0.0522148	3.08	0.002***
Tractor use	0.16872548	0.0356535	-1.91	0.056

lnTotal Labour (no. of workers)	0.1810365	0.0511168	3.54	0.000***
Mu parameters:				
lnFarming experience (years)	-0.2219874	0.0640062	-3.47	0.001***
Variance parameters:				
Sigma u (δ_u)	0.392857	0.0510908	7.69	0.000***
Sigma v (δ_v)	4.06e-08	4.45e-06	0.01	0.993
Sigma squared (δ^2)	0.154337	0.00261	59.1362	
Lambda (λ)	9668659	0.0510908	1.9e+08	0.000***
Gamma (γ)	0.999998	1		
LR test	8.716			
Mean Technical Efficiency	0.58			
Log likelihood = -17.4951 Prob Chi-square = 0.000				

*** and ** refer to 1% and 5% levels of significance

As indicated in Table 6, the amount of seeds used per ha had a coefficient of 0.0998, implying that, a 10% increase in the amount of seeds used would lead to the increase of 0.99% in maize output. The amount of inorganic fertilizer applied had a coefficient of 0.161, implying that, a 10% increase in fertilizer use would lead to 1.61% increase in maize output. Tractor use had a coefficient of 0.168, implying that, a 10% increase in the use of tractors for different farm activities such as weeding, ploughing and harvesting, would lead to a 1.68% increase in the maize output. Labour had a coefficient of 0.181, implying that, a 10% increase in agrochemical usage would lead to 1.81% increase in maize output. An indication in this study is that major contributors to the increase in maize output are increase in seed usage, increase in the amount of inorganic fertilizer usage, increase in the usage of tractors for farm activities and an increase in labour input. All these inputs of production (amount of seeds used, inorganic fertiliser used, tractor use and labour) are statistically significant. This indicates that, an increase in any of these inputs will lead to an increase in the maize output for the farmers.

In terms of the technical inefficiency model, the farming experience was used as the independent variable with technical inefficiency being the dependent variable, to determine how the farming experience of each farmer correlates with his/her technical efficiency levels. The results show that the coefficient is negative (-0.2219874) and is significant (p=0.001) at 1% level. This shows that there is a negative relationship between the farming experience of the farmers and technical inefficiency. This means that more experienced farmers are more technically efficient than those that are not experienced. This means that, an additional year of experience for each farmer is associated with a reduction in technical inefficiency of 0.22 units. The negative coefficient implies a reduction in technical inefficiency because the dependent variable in this case is technical inefficiency.

The variance parameters for the sigma square (δ^2), lambda (λ) and gamma (γ) are also presented in Table 6. The sigma square (δ^2) refers to the total model variance, which is obtained by adding the variance due to random effects(δ_v) to the variance due to technical inefficiency effects (δ_u) (Battese & Coelli, 1995). It gives the correctness of fit and the distributional form assumed for the composite error term (Mango, Makate, Hanyani-Mlambo, Siziba, & Lundy, 2015). The coefficient of the δ^2 is 0.154. These estimates of variance parameter are then used to identify the gamma (γ) parameter which represents the proportion of total model variance that accounts for technical inefficiency. It is obtained by dividing the variance due to technical inefficiency effects by total model variance. According to Oke and Baruwa (2012), the value of γ ranges between zero and one. Zero value indicates that technical inefficiency effects are absent in the estimated SFA model and all variation from the frontier is due to random noise and when the value is closer to one, the model indicates that most of the variation of output from the frontier is accounted for by technical inefficiency, which suggests the presence of technical inefficiency in the model and confirms appropriateness of SFA technique (Oke & Baruwa, 2012). The gamma (γ) estimate for the study is has a coefficient of 0.999998 or 99.9% which means that, most of the variation of output from the frontier is accounted for by technical inefficiency, with the statistical noise contributing only 0.1%.

4.3.1. Technical efficiency estimations

As indicated in Table 6, the estimated mean technical efficiency score for the sample is 0.58 or 58%. This indicates that on average, the studied small-scale maize farmers are able to obtain only 58.4% of potential output from the given mix of production inputs. The finding suggests the presence of considerable level of technical inefficiency of about 41.6% among the studied small-scale farmers. The mean technical efficiency estimated provides an indication that the studied small-scale maize farmers of Kavango East region have a potential of increasing their output by about 41.6% by using the existing resources and technology more efficiently or without increasing the available inputs. The 58.4% mean technical efficiency of this study is closely comparable to other technical efficiencies obtained in previous studies such as Kongolo (2021) Mango et al., (2015) Southavilay, Teruaki, and Shigeyoshi (2012) that obtained mean technical efficiencies of 65%, 63% and 65%, respectively.

Table 7: Technical efficiency of the studied farmers

Te Range	**Frequency**	**Percentage (%)**
0.10-0.90	1	1.39
0.20-0.29	1	1.39
0.30-0.39	9	12.5
0.40-0.49	16	22.22
0.50-0.59	11	15.28
0.60-0.69	11	15.28
0.70-0.79	11	15.28
0.80-0.89	5	6.94
0.90-1	7	9.72
Min	0.17	
Max	1	
Mean	0.58	
S.D	0.203	
No. of observations	72	

The results in Table 7 is a summary of the technical efficiencies of the studied farmers, summarized in terms of the technical efficiency rage, the number of farmers (Frequency) in the respective ranges and the respective percentage. The results show that average technical efficiency of the maize small-scale farmers was 0.58 with a low of 0.17 and a high of 1.0 indicating that farmers operate at low level of efficiency. This is also indicated by the fact that majority of the maize small-scale farmers (52.78%) are operating at less than 0.60 and only 28.94% of the farmers having technical efficiency more than 0.7.

4.4. Hypothesis testing

For hypothesis testing, the Generalised Likelihood Ratio (LR) test of the one side error of γ was used following a Chi-square (χ^2) distribution and was used to test the null hypothesis ($H_0 = \delta_0 = \ldots \delta_n = 0 = \gamma$), which implies that technical inefficiency effects are absent from the SFA model. The generalised likelihood ratio is expressed as:

$$\lambda = -2[L(H_0) - L(H_1)]$$

Where [L (H_0)] and [L (H_1)] are the values of the Log Likelihood function for the frontier model under the null hypothesis and alternative hypothesis, respectively (Battese & Coelli, 1995).

The test statistic was performed to estimate the value of LR. The calculated value of is 8.716. It is greater than the values in the Chi-square distribution at 1% level with 1 degree of freedom. Therefore, the null hypothesis of no technical inefficiency effect among small-scale maize producers of Kavango East Region was rejected in favour of the alternative hypothesis which is supporting the presence of technical inefficiency that exists among small-scale maize producers in the study area.

4.5. Factors influencing technical efficiency

Table 7 shows results of the estimates of the inefficiency effects model run to identify factors that are affecting the technical efficiency of maize small-scale farmers of Kavango East Region. The technical efficiency of the farmer can be affected by a range of factors, including socio-economic characteristics, demographic factors and environmental factors. This is evident in a number of studies (Abdul-Kareem & Isgin, 2016; Baloyi, 2011; Battese, G.; Coelli, 1995; Binam et al., 2004; John K. M. Kuwornu, Emmanuel Amoah, 2013; Kumbhakar, Ghosh, & McGuckin, 1991; Nchare, 2007; Thiam et al., 2001). These studies have investigated and analysed technical efficiency and its determinants among a variety of producers. An analysis of the factors that influence the farm technical efficiency is a particularly valuable exercise for policy formulation. The list of socio-economic variables selected for this objective include both dummy variables and continuous variables such as the gender of the farmer, highest education attained, farm size, land ownership, extension, access to formal sources of credit, seed type, weeding frequency and training. From the hypothesis testing, it was confirmed that technical inefficiency effects are present in the SFA model. Results for the inefficiency model are presented in Table 7.

Table 9: Estimates of the inefficiency effects model

Variables	Description	Coefficient	Std. error	Z-test	Significance
Constant		0.8549406	0.307069	2.78	0.005***
Gender	Gender (1 = female; 0 = male)	0.0158271	0.0494162	0.32	0.749
Age	Age of the farmer (years)	-0.0023576	0.0043512	2.59	0.010**
Education (dummy var)	(1 = at least secondary education 0 = otherwise)	-0.0338 51	0.0662369	-0.51	0.041**
Farm size	Size of the farm (ha)	0.0881216	0.0183657	4.80	0.400
Land ownership	(1 = yes 0 = no)	0.0502282	0.0703587	0.71	0.475
Access to formal sources of credit	Credit access (1 = yes; 0 = No)	-0.0515004	0.0472497	-1.09	0.042**
Seed type	(1 = improved 0 = Local)	-0.05863	0.0800165	-0.73	0.464
Weeding frequency (dummy var)	(1 = at least 2 times 0 = otherwise)	-0.0453567	0.0507387	-0.54	0.0593
Extension office visit	(1 = yes 0 = no)	-0.2123636	0.1055393	-0.89	0.044**
Training	(1 = yes 0 = no)	-0.0309201	0.0577822	0.69	0.491

*** and ** refer to 1% and 5% levels of significance

In the technical inefficiency model, the technical inefficiency variable was treated as the dependent variable and the independent variables are the farm specific socio-economic and farm management variables. Variables with positive coefficients will have an increasing effect on farm technical inefficiency and those with negative coefficients will have a decreasing effect on technical inefficiency. The implication is that the variable that has an increasing effect on technical inefficiency will have a decreasing effect on technical efficiency and vice versa. Below is a discussion of the statistically significant socio-economic variables (Age, Education, Access to formal sources of credit and Extension office visit) affecting technical efficiency of the small-scale farmers of Kavango East Region.

From Table 7, the results show that the coefficient of the age of farmer has negative sign (positive relationship with technical efficiency) and it is significant at 5%. This implies that the technical inefficiency tends to decrease as the age of farmers increases. This is because older farmer has more experiences than younger farmer (younger farmer tend to more inefficient). These findings are in line with the finding of Southavilay et al., (2012), who did an analysis of technical efficiency of maize farmers in the northern province of Laos, and also a in a study by Abubakar and Sule (2019), who also looked at the technical efficiency of maize production in Rijau Local Government Area of Niger State, Nigeria. According to their work, age of the farmers had a negative impact on the inefficiency model, suggesting that an increase in the farmers' age led to an increase in technical inefficiency of farmers.

The estimated coefficient of the education variable has a negative sign and it is significant at 5% level of significance. This implies that there is a positive relationship between the farmers' level of education attained and their farm technical efficiency. It is hypothesized that educated farmers would be able to have higher technical efficiency than those that are not educated. This is because education can increase their information acquisition and adjustment abilities, thereby- increasing their decision making capacity (Asefa, 2011). From the results of this study, most of the farmers (78%) have attained at least secondary education level, hence the positive effect on technical efficiency. Additionally, education can also help them to adopt modern agricultural technologies and be able to produce higher output using the existing recourses more efficiently. Moreover, with higher levels of education, farmers are able to organize themselves into farmer groups or associations, thereby enabling them to source funding from lending institutions, especially from non-government organizations (NGOs) engaged in micro credit delivery (Narcisse, Antoine, & Chrysostome, 2019).

From Table 7, the results show that the coefficient of the farmer's access to formal sources of credit has a negative sign and it is significant at 5% level of significance. This means that there is a positive relationship between the farmer's access to credit and their farm technical efficiency. It is hypothesised that farmers who have access to formal sources of credit are more efficient than those that do not have access. This is mainly because credit availability shifts the cash constraint outwards and thus enables farmers to make timely purchases of inputs that they cannot afford otherwise from their own resources and enhances the use of agricultural inputs that leads to higher efficiency (Asefa, 2011). These findings are in line with the other empirical works Dawson, Lingard and Woodford (1991), and also Dolisca and Jolly (2008).

Extension office visit is one of the variables that was hypothesised to influence technical inefficiency of the maize small-scale farmers negatively. This variable was treated as a dummy variable (1=yes 0= no) to determine if or not the farmers receive extension service visit on their farms. For some of the studied maize small-scale farmers, extension services are provided to them by their service providers while others visit the extension office on their own accord. The empirical result indicates that extension has a negative and coefficient and it is significant at 5% level of significance. This means that extension decreases technical inefficiency. This might be due to the fact that farmers who obtained extension services can have better information about farm management practises and better agricultural technologies. These findings are supported by Bachwe (2009). Despite the fact that most of the farmers studied (91.67%) do not receive extension services, the study revealed that extension services are an important determinant of technical inefficiency. According to most of the studied farmers, even though the extension service is made available to them by their service providers, the extension officers rarely visit them.

4.6. Chapter Summary

This chapter presented the empirical results and the discussions thereto. The chapter started with an overview and descriptive characteristics of the respondents. This chapter also include a presentation and discussion of the estimated parameters of production function, the estimated results of the technical efficiency and the technical inefficiency model parameters in the Kavango East Region small-scale maize production. The inputs defining the production frontier in the study are used per ha, inorganic fertilizer per ha and total labour. The estimated coefficients of the production frontier parameters are positive for seeds used, inorganic fertilisers used and labour, but negative for tractor use and the farmer's farming experience. The positive coefficients of seeds used, inorganic fertilisers used and labour indicate that increasing the amount of these inputs increases maize production. Along with the stochastic production frontier parameters, variance parameters of the model are also estimated.

The coefficient of the δ^2 is 0.154and is highly significant, confirming the correctness of the specified distributional assumptions of the error terms. The other variance parameter estimated is gamma (δ^2), which shows the proportion of the total variance that is attributed to technical inefficiency in the model. The gamma (γ) estimate for the study is has a coefficient of 0.999998 or 99.9% which means that, most of the variation of output from the frontier is accounted for by technical inefficiency, with the statistical noise contributing only 0.1%.

The estimated results of the technical efficiency indicate that estimated mean technical efficiency score for the sample is 0.584 or 58.4%. This implies that on average, the studied small-scale maize farmers are able to obtain only 58.4% of potential output from the given mix of production inputs. Among the technical inefficiency model explanatory variables involved in the study, the estimated coefficients of age, education, access to formal sources of credit, seed type and weeding frequency are negative and statistically significant. The variables were found having decreasing effects on technical inefficiency hence increasing effects on technical efficiency of the maize farmers.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

This Chapter provides the conclusion to the study regarding achievement of the objectives, provides recommendations for possible policy implications made based on the results of the study as well as the recommendations for further research.

5.2. Summary and Conclusions

Despite the various government efforts to improve food security in the country, food insecurity remains a challenge in Namibia. This situation is highly explained by low and stagnating agricultural productivity, particularly in the crop sector where major crops such as maize is predominantly produced by small-scale farmers. Due to this low production of food crops, the country is unable to supply the growing food demand for its growing population. Although the local production of maize has shown a gradual increase during the past good rainy seasons (2016/2018), Namibia remains a net grain importer. In the face of all these facts and the various efforts by the Namibian government, there is still little knowledge in Namibia on sources of technical inefficiency of small-scale maize farmers. In addition to this, little is known about the sources of inefficiencies among the Namibian maize small-scale producers. This means that there is little/no information available to guide the efforts to reduce technical inefficiency of maize small-scale farmers of Namibia. It is therefore for this reason that this study was carried out in an attempt to investigate the problems causing low maize productivity of the maize small-scale farmers in Namibia.

The potential factors affecting the technical efficiency of the farmers were analysed by studying the population of small-scale farmers in the Kavango East Region. This region was selected for the study because it is one of the most maize producing regions of the country. A total number of 72 small-scale maize farmers located in the four (4) different irrigation schemes in the Kavango East Region (Uvhungu Vhungu Irrigation Scheme Project, Ndonga-Linena Irrigation Scheme Project, Shadikongoro Irrigation Scheme Project and Salem Irrigation Project). This number of maize small-scale farmers in the Kavango East region was relatively low, hence there was no need for sampling, and as such all the 72 farmers were all interviewed. Data was collected through structured questionnaire in a formal interview manner. The study made use of both descriptive and econometric methods in order to analyse the data. A Cobb-

Douglas functional form of the stochastic frontier model was used. Stochastic Frontier Analysis technique was as an analytic method for analysing technical efficiency of the farmers and its determinants.

From the empirical estimation, it is found that inorganic fertilisers are an important input that can increase maize productivity significantly. Seed and labour inputs are found statistically insignificant in explaining maize production. The estimated value of γ, which is a parameter used to indicate the proportion of total variance that is attributed to technical inefficiency is 0.99 and significant. This means that 99% of the random variation in output of maize production is attributed to the technical inefficiency component which indicates the importance of examining technical inefficiencies in maize production. The estimated mean technical efficiency score of the sample is 0.584 or 58.4%. This indicates that on average, the studied small-scale maize farmers are able to obtain only 58.4% of potential output from the given mix of production inputs. The finding suggests the presence of considerable level of technical inefficiency of about 41.6% among the studied small-scale farmers. The technical inefficiency factors model revealed that the efficiency of the maize small-scale farmers of the Kavango East Region was positively and significantly influenced by socio-economic and institutional factors such as, age, highest education attained, access to formal sources of credit and extension office visit.

The results show that most of the variation in maize production is due to technical inefficiency and not due to random shock that are beyond the farmers' control. The results furthermore indicated that it is possible to improve the current productivity by increasing technical efficiency of the farmers. The current level of low production efficiency can be addressed through the formulation and implementation of policies that motivate and mobilize the youth to part take in agricultural activities. It can also be addressed by improving the farmers' access to formal sources of credit, extension services visit to the farmers and improving the farmers' education through the provision of continuous trainings in the region. The constant term in both models is statistically significant at 10% level of significance. This means that all variables used in the model are important factors in explaining the factors influencing the technical efficiency of maize small-scale farmers of Kavango East Region. All the various factors that can influence the technical efficiency of the maize small-scale farmers were not fully explored due to data limitations. Therefore, there is a need for further studies that can incorporate all the possible factors in the production frontier and the technical inefficiency model.

5.3. Recommendations

Based on the findings of this study, the following recommendations are made for the improvement of maize productivity and technical efficiency of farmers in the study area.

- Policies that motivate and mobilise the youth to part take in agricultural activities should be put in place. This will encourage the youth to part take in agricultural activities and in turn make the younger farmers more efficient.
- Extension service visits to the small-scale farmers needs to be more enforced so that all small-scale farmers are up to date with the current, relevant and important farming information. The agricultural extension officers must provide support, guidance and encouragement to the farmers to help them better adopt pre and post-harvesting agricultural technologies.
- Improving the farmers' education through the provision of continuous training programs to the farmers as well as follow up on the application of improved farming and farm management practices. The level of education might influence the farmer's ability to use available technology. Additionally, education will enhance the farmers' knowledge thereby enhancing the farmers' technical efficiency.
- As indicated in Table 7, access to formal sources of credit is also shown to significantly affect the farmers' technical efficiency (negative coefficient). It is on this basis that it is recommended that credit access should be enhanced. The Namibian government can help in this regard by influencing the borrowing rates on credit and loans for agricultural development as these rates are still high.
- From the results in Table 7, the use of improved seeds is also shown to affect the farmers' technical efficiency (negative coefficient), although it is not significant. It is therefore recommended for awareness creation about the improved seed use. This can be done through training provision by any of the concerned stakeholder such as the Ministry of Agriculture, Water and Land Reform, AgriBusDev, Agribank, the regional or local government and any training institutions.

5.4. Recommendations for further research

- This study only explored the technical efficiency of the farmers, excluding the contributions of economic and allocative efficiency. Therefore, there is potential for further research to be undertaken to determine economic and allocative efficiency of the maize small-scale farmers in Namibia.

- All the various factors that can influence the technical efficiency of the maize small-scale farmers were not fully explored due to data limitations. Therefore, there is a need for further studies that can incorporate all the possible factors in the production frontier and the technical inefficiency model.
- Different variable combinations, for example combinations of improved seed with inorganic fertilisers or improved seeds with only organic fertilisers were not accounted for. Therefore, future studies can assess the contribution of combining different variables to the technical efficiency of the maize small-scale farmers.
- Variables relating to the management of maize production such as timely applications of fertilisers, timely irrigation, weeds and pest control were not assessed in this study. Therefore, further studies should explore these variables and their respective contributions to technical efficiency of the maize small-scale farmers.
- A value chain analysis study is also recommended to identify the external factors that would indirectly affect maize production among the small-scale farmers in Namibia. The future research should analyse the maize value chain to shed the light on possible gaps in the whole process of maize production.

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APPENDIX: A QUESTIONNAIRE

Analysis of factors influencing the technical efficiency of Maize small-scale farmers of Kavango East Region

Instruction:
- **The questionnaire will be completed by the researcher on behalf of the small-scale farmer in the respective study site**
- **For selection questions, please tick as appropriate.**

A. FACTORS INFLUENCING TECHNICAL EFFECIENCY: DEMOGRAPHIC FACTORS

A01. Farm Identification

____

A02. Name of the green scheme

____

A03. Name of the farm owner

____

A04. Name of Main Respondent (if different from the farm owner)

____

A06. Gender of the Respondent male female

○

○

A07. Age of the Respondent/year of birth

____

A08. Marital status of the Respondent

○ single

○ married

○ divorced

○ separated

○ widowed

A09. Highest education attained

- ◯ no formal education
- ◯ primary education
- ◯ secondary education
- ◯ tertiary education

A10. Number of farming years

____

A11. How long have you been farming maize?

____

B. FACTORS INFLUENCING TECHNICAL EFFECIENCY: PRODUCTION FACTORS

B01. Farm size (ha)

____

B02. Size occupied by maize (ha)

____

B03. Is it your own land?

- ◯ yes
- ◯ no

B3.1. If yes, is it inherited or transferred from previous owner?

- ◯ inherited
- ◯ transferred from previous owner

Other (Specify)

____

B3.2. If no, is it rented or is it borrowed

- ◯ rented
- ◯ borrowed

Other (Specify)

B04. Indicate which of the following situations negatively affected your yield during the past season.

- ☐ none
- ☐ drought
- ☐ flood
- ☐ lack of resources

Other (Specify)

B05. What is the main source of water for your Maize production?

- ○ rain fed
- ○ irrigation

B06. If B05=2, please indicate what type of irrigation technology you use for your Maize production

- ○ flood irrigation
- ○ centre pivot irrigation system
- ○ drip irrigation system

Other (Specify)

B07. What method of weed control do you use for your maize production?

B08. How many times do you weed per production period?

B09. What method of fertilizer application do you use for your maize production?

B10. How many times do you apply fertilizers to your maize crops?

B11. In case of pest infestation, how do you control pest

B12. In case of disease infestation, how do you control diseases?

» B13. Please indicate whether you use manual or mechanic labour when performing the following activities

Ploughing

____

Weeding

____

Irrigating

____

Fertiliser application

____

Pest control

____

Harvesting

____

B14. What variety(ies) of maize did you grow last season?

- ◯ improved
- ◯ local

B15. If improved, which variety did you plant?

____

B16. How many kilograms of seed did you plant?

____

B17. Where did you get the seed that you planted from?

- ◯ own
- ◯ neighbour
- ◯ agribusdev assistance

Other (Specify)

____

» B18. Please estimate the amount of the respective inputs you've used for your 2019/2020 maize crop

Inorganic Fertilizer (Kg)

____

Organic Fertilizer (kg)

____

Pesticide (liters)

____

Water (liters)

____

Labour: Full time

____

Labour: Seasonal

____

Fuel (liters)

____

» B19. Please estimate the amount of money you've spent on the respective production inputs

Inorganic Fertilizer (N$/Kg)

____

Organic Fertilizer (N$/kg)

____

Pesticide (N$/liters)

____

Water (N$/liters)

____

Labour: Full time

____

Labour: Seasonal

____

Fuel (N$/liters)

____

B20. In terms of output, please estimate the quantity (tonnes per ha) you obtained in your 2019/2020 maize production

____

B21. In terms of output, please estimate the quantity (total tonnes) you obtained in your 2019/2020 maize production

____

B22. In terms of output, please estimate the amount of income you have generated (per ha) in your 2019/2020 maize production.

____

B23. In terms of output, please estimate the amount of income you have generated (total income) in your 2019/2020 maize production.

____

B24. In your opinion, did you apply a sufficient amount of inputs to obtain an optimal yield?

- ○ yes
- ○ no

B25. If not…

- ☐ Input costs are too high
- ☐ I do not have enough money at the time I need the input
- ☐ Inputs are not easily accessible

FACTORS INFLUENCING TECHNICAL EFFECIENCY: INSTITUTIONAL FACTORS

C01. Do you have access to formal (formal lending institutions) sources of credit?

- ○ yes
- ○ no

» C02. If NO, please indicate on a scale from 1 to 5(1=strongly disagree,2=disagree, 3=undecided, 4=agree, 5=strongly agree) the level to which the following factors prevent you from having access to credit

I do not have title deeds of my land and thus I do not have the required collateral

○——○——○——○——○

strongly disagree disagree undecided agree strongly agree

I do not have a credit record at credit providers

strongly disagree disagree undecided agree strongly agree

The credit facilities are too distant for my reach

strongly disagree disagree undecided agree strongly agree

Other (Specify)

____

C03. Do you have access to informal (i.e Family and friends) sources of credit?

- yes
- no

» C04. If NO, please indicate on a scale from 1 to 5(1=strongly disagree,2=disagree, 3=undecided, 4=agree, 5=strongly agree) the level to which the following factors prevent you from having access to credit

I do not have family members with sufficient surplus money to fund me

strongly disagree disagree undecided agree strongly agree

Family members and friends are not willing to take the risks

strongly disagree disagree undecided agree strongly agree

Other (Specify)

____

C05. Do you have access to reliable markets for maize?

- yes
- no

» C06. If NO, please indicate on a scale from 1 to 5(1=strongly disagree,2=disagree, 3=undecided, 4=agree, 5=strongly agree) the level to which the following factors prevent you from having access to a reliable market

The market is too far

○ strongly disagree ○ disagree ○ undecided ○ agree ○ strongly agree ○

lack of transportation to the markets from the farm

○ strongly disagree ○ disagree ○ undecided ○ agree ○ strongly agree ○

Poor physical infrastructure such as poor roads

○ strongly disagree ○ disagree ○ undecided ○ agree ○ strongly agree ○

Market information is often not available or are available too late

○ strongly disagree ○ disagree ○ undecided ○ agree ○ strongly agree ○

Other (Specify)

____

C07. If yes, which marketing channel best describes the channel within which you participate?

○ Farmer --- Consumer

○ Farmer --- Processor --- Retail --- Consumer

○ Farmer --- Transporter (middle man) --- Processor --- Retail --- Consumer

Other (Specify)

____

C08. Do you receive extension office visit and/or advice about maize production?

○ yes

○ no

C09. If Yes, How many times in a month

____

C10. If No, how do you acquire extension information?

____

C11. Apart from extension office visit, what are other ways in which you receive extension advice and/or information

____

C12. Indicate which of the following actors in the value chain normally provide you with advice and/or assistance with regard to Maize production

select only as applicable

- ☐ Input suppliers
- ☐ Buyers
- ☐ Government
- ☐ Other farmers
- ☐ Cooperative
- ☐ Research institutes
- ☐ Private consultants

C13. Do you receive any kind of training with regards to maize production?

- ○ yes
- ○ no

C14. If yes, who provides you with that kind of training?

____

» C15. If you have received assistance/training, indicate on a scale from 1 to 5(1=strongly disagree,2=disagree, 3=undecided, 4=agree, 5=strongly agree) the level to which you agree with the following statements:

I attend all of the training sessions that are held in the region.

○———○———○———○———○

strongly disagree   disagree   undecided   agree   strongly agree

I fully understand the advice and/or training I receive from the above organisations.

○———○———○———○———○

strongly disagree   disagree   undecided   agree   strongly agree

I implement all the advice I receive from the above organisations

○———○———○———○———○

strongly disagree   disagree   undecided   agree   strongly agree

APPENDIX B: Request for permission for Ms. S. Kristof to conduct research at green scheme projects in Kavango East Region.

REG. 21/2011/0704
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Namibia

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Filling The Basket

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Email: info@greenscheme.org.na

Enquiries: Rosalia Andreas
Tel: 061-424 822

08 February 2021

Dr. Thinah Moyo
Research Supervisor/Coordinator: Master of Agribusiness Management
Namibia University of Science and Technology
Private Bang 13388
Windhoek

Dear Dr. Moyo

This letter serves to inform you that approval has been granted for Ms. Saija Kristof to proceed with her academic research: '*Analysis of factors influencing the technical efficiency of maize small scale farmers in the Kavango Region'*, at Uvhungu-Vhungu, Ndonga-Linena and Shadikongoro green scheme irrigation projects, commencing Wednesday, the 10th February 2021. Farm Managers will be informed accordingly.

Furthermore, please note that the Shitemo green scheme project is not under the management of AGRIBUSDEV. It falls under the management of the Namibia Industrial Development Agency (NIDA). Please contact NIDA at +264 61 2062111 to make an arrangement to visit the farm.

Lastly, any information obtained through this exercise shall be used exclusively for academic purposes.

Should you require further support, please do not hesitate to contact the undersigned.

Yours Sincerely,

AGRIBUSDEV
0 J FEB 2021
MANAGING DIRECTOR
REPUBLIC OF NAMIBIA

Berfine N. Antindi
ACTING MANAGING DIRECTOR

All official correspondence must be addressed to the Managing Director