TECHNICAL RESOURCE USE EFFICIENCY OF SMALL-SCALE MAIZE FARMERS IN THE ETUNDA IRRIGATION PROJECT, OMUSATI REGION IN NAMIBIA

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Thesis submitted in partial fulfilment of the requirements for the degree of Master of Agribusiness Management at the Namibia University of Science and Technology

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DECLARATION

I, Tshupo Kitso Baitshoki, affirm that I alone am the author of this dissertation titled "Technical Resource Use Efficiency of Small-scale Maize Farmers in Etunda Irrigation Project, Omusati Region in Namibia." I acknowledge all references to other people's work that have been properly cited. I confirm that this research work was conducted entirely by me, and that it has not been submitted in entirely or in part for any degree at this university or any other institution.

ktbaitshoki **29 September 2023**

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Tshupo Kitso Baitshoki Date

DEDICATION

"Intellectual growth should commence at birth and only cease at death"- Albert Einstein

This work is devoted to my father

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AMTA	Agro Marketing and Trade Agency
Agribusdev	Agribusiness Development Agency
CES	Constant Elasticity of Substitution
DCPP	Dry Land Crop Production Program
DEA	Data Envelopment Analysis
EGSIP	Etunda Green Scheme Irrigation Project
FAO	Food Agriculture Organization
FPBH	Fresh Produce Business Hubs
GDP	Gross Domestic Product
GMA	Gross Margin Analysis
Ha	Hectare
ICT	Information Communication and Technology
IPM	Integrated Pest Management
MAWF	Ministry of Agriculture Water and Forestry
MFC	Marginal Factor Cost
MSP	Market Share Promotion
MT	Metric Ton
MVP	Marginal Value Product
NAB	Namibia Agronomic Board
NDP	National Development Plan
pH	Potential of Hydrogen
SFA	Stochastic Frontier Analysis
SFPF	Stochastic Frontier Production Function
SSA	Sub-Saharan Africa
TC	Total Cost
TVC	Total Variable Cost
TE	Technical Efficiency
UNIPAF	United Progressive Africa Foundation

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ABSTRACT

Namibia has identified agriculture, among other sectors, as a strategic development area to achieve its vision of economic growth through industrialisation. Maize production is a vital contributor to Namibia's socio-economic development, with an average per capita consumption of 44kg per year, higher than other cereals such as pearl millet. This study aims to investigate the technical resource utilisation efficiency of small-scale maize farmers at the Etunda Green Scheme Irrigation project in the Omusati Region of Namibia.

A total of 47 small-scale farmers at the Etunda Irrigation Scheme were surveyed using a census sampling method and a structured questionnaire to capture data. A Cobb-Douglas function for production under the Stochastic Frontier Model was used to estimate the technical efficiency of producers, whereas an enterprise budget was used to evaluate their profitability. The average technical efficiency of this study is 90%, which means the farmers are using the available resources efficiently. The study reveals that producers' technical efficiency is influenced by tractor power, seeds and fertilisers. Tractor power, seeds and fertiliser elasticities are 0.761, 0.087 and 0.442, respectively. Farm specific socio-economic factors were modelled to estimate farmer's technical inefficiency. The results reveal that gender and extension services had a significant and negative impact on the technical efficiency of producers. The results also show that the majority of producers (81%) operated at a loss, with fertiliser accounting for 51% of total production costs.

The study recommends that policymakers incentivise local fertiliser production through availing of funds to citizens and non-citizens who wish to do fertiliser production business or remove taxes on imported fertilisers which will significantly drop production costs. There is a need to provide farmers with comprehensive technical training and robust extension services, ensuring they utilise technical resources to their fullest potential, thereby maximising profitability. It is highly recommended that farmers have intensified access to technical training and effective extension services to enhance their efficient use of technical resources to enhance profitability.

Keywords: *Technical Efficiency, Stochastic Frontier, Enterprise Budget*

CHAPTER 1: INTRODUCTION

1.1 Background to the Study

The majority of Namibia's land is devoted to agricultural production, which makes it an essential component of the country's agrarian economy. Agriculture, as stated in the National Development Plan Strategy, is one means by which the government can attain its economic growth goals. However, since the 1970s, the significance of the agricultural sector to the national economy has declined steadily. The agricultural sector's contribution to the Gross Domestic Product (GDP) decreased from 16.1% in 1976 to 8.7% in 1981 (Harrison, 1983) and to 4.2% in 2012 (FAO, 2012). Despite this decline, agriculture remains vital to Namibia for the following reasons: (i) it makes up 4% of the nation's GDP and 27% of employment; (ii) approximately 70% of the Namibian population relies on agriculture as a source of living; and (iii) primary agriculture and related activities form the basis of nearly all productive and social activities in rural areas (Teweldemedhin, 2012).

The Namibian economy is significantly reliant on exports of minerals, tourism, and fisheries, while the value of agriculture has diminished over time (FAO, 2012). Nonetheless, enhancing agricultural productivity is essential for enhancing household food security and decreasing rural poverty in Namibia (Foeken, 2000). Namibia still confronts challenges associated with food insecurity and malnutrition (UNIPAF, 2014), despite making significant strides through accomplishing the Millennium Development Goal of ending poverty and hunger. To address these problems, it is essential to enhance production efficiency, avail land to the poor, improve soil fertility, and to implement technical innovations that promote technological change (UNIPAF, 2014). Focusing on agronomic production, primarily wheat and maize to boost the agricultural sector's input to the country's GDP, the Namibian government adopted the Green Scheme Policy to reduce reliance on imported food and alleviate rural poverty. The initiative seeks to encourage skill transfer, job creation, productivity and human development in the irrigation sub-sector (MAWF, 2008).

The Namibian government has implemented the green scheme program to encourage collaborative ventures between commercial farming enterprises and small-scale farming units for the purpose of enhancing the local production and marketing management capacity. As part of this program, small-scale farmers observe commercial farmers, and the latter provide farm equipment, transport, and marketing services at cost to the former. Initiated by the Ministry of Agriculture, Water, and Forestry, this program has expanded from its initial two irrigation projects, which are Orange River and Etunda Green Scheme, to include additional installations in Kavango East, Kavango West, and Hardap.

The Green Scheme projects aim to increase the irrigation land to over 27,000 hectares, with N$2.1 billion already spent on the scheme(Agribusdev, 2015). The Agricultural Bank of Namibia (Agribank) provides production loans to small-scale farmers who are beneficiaries of the project(Agribank, 2018). Currently, the Green Scheme projects are operating on an estimated 11,000 hectares, which is below the target (MAWF, 2016). The projects produce various vegetables, maize, and wheat, which reduces the need for imports and improves national food self-sufficiency. This initiative has created employment opportunities and entrepreneurship by recruiting small-scale farmers in the projects and improved livelihoods. Within the green scheme project maize has been selected as the main crop for the small-scale farmers while wheat is done by the commercial farmers (Mutero, 2018). Of the 3ha allocated to each small-scale farmer a minimum 2.2Ha is fully dedicated to maize production hence the focus of this study on maize.

The selection of maize for this study is based on the following reasons: (a) it is a staple food for Namibians, accounting for 33% of overall cereal consumption, (b) it is simple to cultivate and adaptable to harsh climates, and (c) produces good yield and a great source of energy. Alongside wheat, maize is one of the primary commodities promoted by the Green Scheme Policy. Due to its significance to Namibians, the Namibia Agronomic Board (NAB) has also designated maize as a special regulated crop (NAB, 2016), which helps protect and promote the production and competitiveness of local farmers. Shifiona (2016), stated that the average maize annual consumption per capita is greater than any other locally produced cereal. According to Mutero (2018), small-scale farmers in the Etunda Irrigation Scheme devote roughly 70% of their allocated land to maize production annually. However, the maize production efficiency of these producers is unclear and requires further investigation.

The evaluation of farm productivity is a crucial area of research in developing as well as developed countries (Kareem et al., 2008). Despite government efforts to increase food production, local production falls short of meeting the majority of food needs, showing that policy initiatives should focus on production efficiency. According to a 2016 report by the Agro Marketing and Trade

Agency (AMTA), between 2013 and 2016, Namibia imported approximately 60 percent of its total maize consumption via the formal market, highlighting the need for increased production efficiency. Enhancing production efficiency is a viable option in resource-scarce developing nations, according to Kibaara and Kavoi (2012), who argued that it is a crucial factor for productivity growth.

The Green Scheme Policy is a testament to the Namibian government's dedication to elevating food production and fostering agribusiness within its borders. Recognising agriculture's pivotal role in fortifying food security, alleviating rural poverty, and championing self-reliance, the government embarked on a mission to optimise the nation's agricultural potential. This involved significant investments in irrigation infrastructure and inviting private sector participation in traditionally underserved regions. The overarching goal was to cultivate local expertise in production, marketing, and management, thereby catalysing comprehensive development in these regions.

This policy, a beacon of the government's commitment, was designed to bolster agricultural output and rectify existing gaps in the production continuum, thereby enhancing self-sufficiency and diminishing rural impoverishment (Government Republic of Namibia, 2008). Seamlessly aligning with the National Development Plan (NDP) III and the Vision 2030 strategy, the Green Scheme Policy harnesses both governmental resources and collaborative efforts from various stakeholders to realise its vision. A significant focus of this initiative is to exploit irrigation prospects within the maize triangle, encompassing regions like Grootfontein, Tsumeb, and Otavi. Moreover, it emphasises the establishment of irrigation systems adjacent to rivers in areas such as Zambezi, Kavango, North Central, and Northeastern. The policy also champions agro- endeavors in the southern regions, leveraging resources like the Orange River and reservoirs including Naute and Hardap.

The Green Scheme Policy, as delineated by the Government Republic of Namibia (2008), is anchored in several pivotal objectives. Foremost among these is the ambition to harness the irrigation potential within strategic regions. This includes the maize triangle and areas adjacent to rivers. Concurrently, the policy champions agro-initiatives in the southern regions, leveraging vital resources such as the Orange River and significant dams. The policy also underscores the importance of identifying areas ripe for agricultural irrigation and spearheading agro-projects in these designated regions. A cornerstone of this initiative is the establishment of sturdy storage facilities and marketing frameworks. In a bid to realise these goals, the policy seeks to galvanise both public and private financial backing. Furthermore, there's a pronounced emphasis on enhancing local expertise to ensure both productivity and a competitive stance in the market. This is complemented by a commitment to drive research, embrace technological innovations, and implement adaptive strategies. Upholding Good Agricultural Practices is also paramount, as is the advocacy for the prudent use of agricultural land and water resources. The policy also promotes crop diversification and a focus on boosting exports.

Namibia's agricultural sector plays a significant role in the country's economic development, and the government has implemented various initiatives to promote food security. These include the Green Scheme project, the development of national Fresh Produce Business Hubs (FPBH), the Market Share Promotion Scheme (MSP), and the Dry Land Crop Production Programme (DCPP). The Green Scheme Project is the first and most significant initiative aimed at expanding the land under irrigation to over 27,000 hectares by 2015, with the government spending approximately N$360 million. Additionally, 138 small-scale farmers have been resettled as beneficiaries of this project and have been granted provisional production loans by the Agricultural Bank of Namibia (MAWF, 2011).

Green Scheme projects are currently operational on approximately 11,000 hectares of land in several regions of Namibia, including Kavango, Omusati, Hardap, and the Orange River irrigation project in Karas (MAWF, 2016). These projects produce various crops such as vegetables, maize, and wheat (Agribusdev, 2016). The Green Scheme initiative has contributed significantly to ensuring a consistent supply of produce to both local and foreign markets, reducing the need for imports and improving national food self-sufficiency. Additionally, it has created employment opportunities and entrepreneurship by involving small-scale farmers in the project (Iita, 2012).

The Etunda Irrigation Project is one of the longest-running projects with the greatest number of small-scale agricultural units, making it an investigation-worthy subject. Consequently, the focus of this study is on the Etunda Green Scheme Project in the Omusati region. Since its inception in 1998, the Etunda Irrigation project is one of the oldest and largest of all irrigation initiatives. Even though it has the greatest number of small-scale producers, it is one of the least efficient irrigation systems. The Ministry of Agriculture, Water, and Forestry (MAWF) provides the Etunda small-scale producers with approximately N$3 million to purchase inputs via a voucher system facilitated by Agribank (2018). This does not appear to be the case for the small-scale maize producers in Etunda, despite the fact that a number of studies suggest that more experienced farmers are more effective at utilizing their inputs. The subpar performance persists despite the government's annual investment of millions of dollars into the Green Scheme to provide inputs and machinery to small-scale producers via the service provider Agribusdev. Idealistically, the Green Schemes would be self-sufficient if producers produced the minimum standard yield per hectare, which is nine tonnes per hectare (t/ha). The purpose of the research is to assess the resource utilization efficiency of farmers in order to evaluate their business status and identify key procedures that can assist in achieving the Green Scheme's goals.

1.2 Problem Statement

According to NAB's (2016) report, despite having the greatest maize plantations in Namibia, the Green Scheme has the lowest yield. The report indicates that Green Scheme farmers contributed 24% of the nation's maize production, with 3,006Ha of maize planted and 17,829MT harvested, equating to an average yield of 5.95MT/Ha for all green schemes. According to Agribusdev (2017), the average harvest of Etunda during the 2016/17 planting period was around 4.2 tonnes per hectare. According to Agribusdev (2017), the desired production of maize per hectare is 9MT. It is notable that the irrigation scheme accounts for 68% of the total irrigated area in Namibia during the 2013/14 season, but only47.9% was utilised in 2014/2015 cropping year. According to Agribusdev (2017), the Green initiatives produced 37.1% of the total local maize grain production, while the Etunda irrigation project only contributed 5%.

According to Andreas (2016), irrigation scheme farmers confront obstacles such as delayed planting, low water pressure for irrigation, and high prices for services provided by Agribusdev. There are numerous factors contributing to the current poor performance of the scheme's producers. Although it is evident that the small-scale farmers participating in the irrigation program are inefficient, it is uncertain to what extent. It has not yet been scientifically determined which key factors contribute to the irrigation scheme's poor performance. There have been no prior attempts to investigate the technical efficiency of small-scale irrigation producers in the study area. In order to identify and implement appropriate solutions for the issue of inefficiency, it is necessary to collect additional information about its scope.

The investigation of these issues is crucial to this study and can aid in the development of policies aimed at enhancing the resource utilisation efficiency of small-scale farmers. The research issue, therefore, can be stated in this manner:

1. What is the maize production process at the Etunda Irrigation Scheme?
2. Are small-scale irrigation farmers in the study area maximising their potential, given their available resources and other constraints, in order to boost their revenue and meet national food security goals?
3. Are small-scale producers using available resources effectively?
4. What factors determine small-scale maize producers' technical efficiency or inefficiency?
5. What are the reasons why small-scale maize farmers are not reaching their yield goals?

1.3 Research objectives

The objective of the study was to examine the resource use efficiency of small-scale maize producers participating in the Etunda Irrigation project. These were the specific objectives:

i. Determine the technical efficiency of small-scale maize producers participating in the Etunda Irrigation project.

ii. Determine the social and institutional factors or household characteristics that influence the technical efficiency of small-scale maize producers at the Etunda Irrigation Project.

iii. Determine the financial viability of the maize business.

1.4 Research Hypotheses

H_0: There is no statistically significant difference in the level of technical efficiency among small-scale maize farmers at the Etunda Irrigation Scheme.

H_0: There is no significant relationship between the socio-economic characteristics of small-scale maize farmers and their resource use efficiency in the Etunda Irrigation Scheme.

H_0: Small-scale maize farmers at the Etunda Irrigation Scheme are not operating profitably.

1.5 Significance of the study

Maize production is an important contributor to the socio-economic development of Namibia. It is crucial to identify and address technical efficiency challenges faced by small-scale irrigation farmers to enhance their productivity. Although there are some studies done in the research area, this study did not only cover technical efficiency but also estimated the profitability of the Etunda small-scale farmers. This study's findings can provide insights to policymakers and green scheme management on effective mitigation strategies. Academic institutions can also benefit from the results of this research for educational purposes. Moreover, the recommendations from this study can assist farmers in improving their resource use efficiency and farmers profitability.

CHAPTER 2: BACKGROUND OF THE AGRONOMIC AND HORTICULTURAL INDUSTRY

2.1 Introduction

This chapter gives a general overview of Namibia's agronomic and horticulture industry, including production, supporting policy framework, and contribution to national food security. Additionally, this chapter discusses the significance of small-scale irrigation and provides an overview of common challenges encountered by small-scale irrigation farmers in Sub-Saharan Africa.

2.2 Namibia agricultural development initiatives

Namibia has prioritized its agricultural sector as a cornerstone for economic growth, launching multiple programs to bolster food security. Among these, the Green Scheme initiative stands out as a pioneering effort, targeting the expansion of irrigated land to surpass 27,000 hectares by 2015. This ambitious project saw an investment of around N$360 million from the government. Furthermore, it has facilitated the resettlement of 138 small-scale farmers, who have subsequently received provisional production loans from the Agricultural Bank of Namibia (MAWF, 2011).

Currently, lands spanning roughly 11,000 hectares across regions like Kavango, Omusati, Hardap, and the Orange River in Karas are under the Green Scheme projects (MAWF, 2016). These lands are fertile grounds for a variety of crops, including but not limited to vegetables, maize, and wheat (Agribusdev, 2016). The initiative has not only reduced dependency on imports by ensuring a steady flow of produce to both domestic and international markets but has also enhanced Namibia's self-reliance in food. Moreover, the project has been instrumental in job creation and fostering entrepreneurship, especially by integrating small-scale farmers into its framework (Iita, 2012).

Another initiative aimed at strengthening the marketing system of the grain industry is the development of two national Fresh Produce Business Hubs in Ongwediva and Rundu. The total estimated cost of these facilities is N$217 million, and they are managed by 12 marketing agents who oversee the operations at each site (MAWF, 2010). These two hubs are designed to support the needs of producers, processors, traders and consumers alike (Amagola, 2010).

The Namibian government introduced the Namibian Horticulture Market Share Promotion (MSP) scheme in 2004 to promote local production of food and vegetables through import substitution. The scheme facilitates improved market access for local horticultural producers. The import control permit mechanism requires local wholesalers and retailers of fruit and vegetables to purchase a minimum percentage of produce locally before issuing an import permit for horticultural food items. This percentage is gradually increased as Namibia's ability to produce more locally improves and is currently at 41%. (Price Waterhouse Coopers, 2008; AMTA, 2016).

The fourth initiative implemented by the Namibian government was the Dry Land Crop Production Programme (DCPP) which aims to increase crop production under a rain-fed system. Communal farmers are aided by the government through subsidized tractor ploughing services, improved seeds, fertilisers, and weeding services under the Youth Empowerment scheme. The programme's goal is to enhance productivity per household and create employment opportunities. This information was sourced from MAWF (2010).

Finally, the Namibian government introduced the National Strategic Food Reserves program to ensure food security at both national and household levels during times of scarcity. This initiative involves the procurement of grain from local producers, which provides a guaranteed market for local crop growers and storage facilities. These silos are situated in cropping areas in regions such as Kavango, Northcentral regions, and the Zambezi, with a total storage capacity of 14,000 metric tonnes as of 2012.

2.2.1 Green Scheme Policy

The Green Scheme Policy represented a significant step in the Namibian government's efforts to boost food production and agribusiness in the country. Recognizing the crucial role of agriculture in improving food security, reducing poverty in rural areas, and promoting self-sufficiency, the government sought to enhance the productivity of the country's agricultural resources. By investing in irrigation and bringing the private sector to underserved regions, the government aimed to build local capacity in production, marketing, and management, leading to overall development of these areas.

The Green Scheme Policy represents a significant step towards the government's commitment to improving food production and agribusiness in Namibia. It aims to increase agricultural productivity and address the identified shortcomings in the production chain to enhance food self-sufficiency and reduce rural poverty (Government Republic of Namibia, 2008). This policy aligns with the National Development Plan (NDP) III and Vision 2030 strategy, and it leverages government resources and other stakeholders to achieve its objectives. The Green Scheme focuses on maximizing irrigation opportunities in the maize triangle, including Grootfontein, Tsumeb, and Otavi, as well as setting up irrigation systems along rivers in the Zambezi, Kavango, North Central, and North Eastern regions. Additionally, the policy promotes agro projects in the South, using Orange River and dams like Naute and Hardap.

The objectives of the Green Scheme Policy are as follows:

• Maximizing irrigation opportunities in the maize triangle (Grootfontein, Tsumeb, and Otavi) and other regions along the rivers, including Kavango, North Central, North Eastern, and Zambezi, as well as promoting agro-projects in the south using Orange River and dams such as Naute and Hardap;

- Identifying potential areas for agricultural irrigation.
- Developing agro-projects at identified areas for irrigation;
- Developing storage facilities and marketing infrastructure.
- Mobilizing public and private capital.
- Building capacity to ensure productivity and competitiveness.
- Conducting research and development, technology transfer and adaptation.
- Implementing Good Agricultural Practices;
- Promoting the efficient utilisation of agricultural land and water resources and diversification of crops and export promotion (Government Republic of Namibia, 2008).

2.3 Food production in the irrigation projects

The Green Scheme irrigation project aims to increase food production with a focus on maize and wheat as the main crops (Government Republic of Namibia, 2008). In recent years, the projects have expanded to include the production of various vegetables such as potatoes, onions, butternut, cabbage, and others (Agribusdev, 2016). According to Agribusdev (2016), there are 11 irrigation projects located throughout the country, including Etunda, Musese, Kalimbeza, VhunguVhungu, Sikondo, Shadikongoro, NdongaLinena, Hardap Irrigation, Orange River

Irrigation, Shitemo, and Mashare. These projects collectively support 134 small-scale farmers and 28 medium-scale farmers. The total fenced-off area for all Green Scheme farms is 8,477 hectares, with 5,312 hectares fitted with irrigation.

2.3.1 Wheat production

In 2014/2015, Namibia consumed 114,635 MT of wheat, with only about 11,600 MT being produced locally and the rest being imports, which accounts for 89.8% of the national consumption (Agribusdev, 2016). However, despite the low local production of wheat, the Green Schemes played a significant role in wheat production, with 77% of the total hectares planted nationally being from these schemes. The Green Schemes harvested 5,447 MT of wheat, accounting for 46.9% of the national production (Agribusdev, 2016).

2.3.2 Maize production

According to Agribusdev's(2016) annual report, it was stated that Namibia consumed 151,960MT of maize during 2014/15. Out of the total national consumption, 71,305MT was produced locally, and 82,527MT was imported. Of the total national production, 36,244MT was produced under rainfed conditions, and 37,213MT was produced under irrigation, including the Green Scheme farms. The report estimated that a total of 12,628Ha were planted in the year 2014/15, with 8,209Ha planted under rainfed conditions and 4,419Ha under irrigation.

The Green Scheme farms contributed about 24% of the national maize production, producing a total yield of 17,829MT on 3,006Ha of land planted with maize. However, it was noted that most of the farms did not meet the internal standard for maize production, which is set above 9MT per hectare, due to various factors such as climate, weather and power shortages(Agribusdev, 2016).

2.3.3 Vegetable production

The Green Schemes' primary focus is on producing significant crops such as wheat and maize, with vegetable production being done on a small to medium scale. However, Agribusdev's 2016 annual report indicates an increase in overall vegetable production in the Green Schemes.

2.4 Challenges in small-scale irrigation farming

The agriculture industry in Namibia faces several challenges, as stated in both the Namibian Agronomic Board's 2006 annual report and the Agribusdev 2016 annual report. These challenges include power shortages, high input costs such as fertiliser, pesticides, fuel, and electricity, as well as climatic conditions such as floods and droughts that make the country dependent on imports. Pest and disease infestation also affects production, and farmers still rely on low-yielding local crop varieties. Low soil fertility and the predominance of fragile ecosystems also pose challenges. Conflicting land use, with tourism promoted by the government, limits farmers' ability to expand their fields, while wildlife damage affects subsistence farmers, particularly in Caprivi and Kavango(Subasubani, 2012). Therefore, it is necessary to promote and intensify local production to reduce dependence on imports and mitigate the impact of global food prices and unpredictable weather conditions on the economy.

2.5 Opportunities in small-scale irrigation farming in Namibia

The Namibian government has implemented policies, such as Market Share Promotion and controlled crops, to provide local farmers with access to competitive markets. Additionally, there is a growing demand for production and processing capacities within Namibia. Agribusdev is considering more sites for future irrigation projects, and there is still more land available for irrigation in the Green Scheme (Agribusdev, 2016).

Small-scale irrigation needs to be given emphasis and support, and small-scale farmers require production, marketing, and training support to succeed. Fresh produce and grain production are opportunities within the industry, as the majority of these commodities are currently imported, for example, maize from Zambia and South Africa (Namibia Agronomic Board, 2014). There is also the possibility of small-scale irrigation expansion along the rivers in Kavango and Zambezi regions, and the potential for market expansion in the region puts farmers in a competitive position. The government has introduced the Fresh Produce Business Hubs (FPBH) under the Agro Marketing and Trade Agency (AMTA) to provide a local market for local producers, influencing mass production (MAWF, 2013). The high population growth and urbanization within Namibia also presents potential opportunities for industry development (Teweldemedhin, 2012).

Despite Namibia's substantial staple food production, the country still relies on food imports to address its food insecurity. However, Namibia has sufficient land and water resources to become an independent food producer for its people and potentially export surplus.

2.6 Importance of small-scale irrigation

The need for small-scale irrigation has increased due to population pressure and the exhaustion of fertile arable land suitable for rain-fed cultivation in many countries, according to the FAO (2006). Millions of subsistence farmers are forced to farm on land with marginal potential, which is compounded by harsh climatic conditions with scarce rainfall and pronounced seasonality. To address this challenge, surface and groundwater resources are utilized for agricultural production, and a range of technical concepts has been developed to suit different physical and socio-economic situations to stabilize or increase the income of respective users and contribute to the economy of Sub-Saharan African countries (Makombe et al., 2011).

Small-scale irrigation is a vital tool to stimulate sustainable economic growth, poverty reduction, and rural development, according to Hagos et al. (2007) and Purcell(2019). It can contribute to employment creation, increased yield per hectare, household income, and food security. Irrigation reduces the risk of crop failure due to drought and enables off-season production. Small-scale farmers can adopt a more diversified cropping pattern and switch from traditional low-value crops to high-value cash crops. Lastly, irrigation allows for scheduled crop rotation, which helps soil conservation.

2.7 Constraints/ problems of irrigation

Small-scale irrigation has been identified as a key solution to achieving food security and self-sufficiency in the developing world. However, there are challenges facing small-scale irrigation farmers. Harrison and Mdee (2017), and Ogunjimi and Adekalu (2007) listed some of these challenges, which include:

- Inadequate startup capital for farmers
- High input costs
- Lack of operation and maintenance skills
- Limited knowledge of plant water requirements
- Conflicting water uses for human consumption, livestock, and crop production
- Inadequate skills in irrigation scheduling, which can lead to over- or under-irrigation and wastage of water
- Poor irrigation management leading to waterlogging and nutrient leaching
- Stringent water rights
- Frequent droughts in many Sub-Saharan African countries.

These constraints must be addressed to ensure that small-scale irrigation is a sustainable and effective solution to food insecurity in the developing world.

2.8 Chapter summary

Ensuring food security remains a major challenge for Namibia and other Sub-Saharan African nations, but irrigation agriculture holds potential to improve the situation. Namibia's agriculture industry has a promising future given the current policy regime, but it is essential to address the challenges hindering progress. Sub-Saharan Africa has realized significant yield benefits under different irrigation management systems. Successful implementation of these systems requires addressing the observed challenges in a participatory process with farmers to find appropriate solutions that consider local conditions and adapt irrigation systems accordingly.

CHAPTER 3: LITERATURE REVIEW ON EFFICIENCY MODELING AND ITS APPLICATION IN SUB-SAHARAN AFRICA

3.1 Introduction

This chapter examines the fundamental principles of efficiency and presents empirical evidence regarding the technical efficiency of small-scale producers in Sub-Saharan Africa (SSA). In addition, the models used to analyse efficiency, and the model selected for this investigation are examined.

3.2 The concept of efficiency

In economic theory, the concept of efficiency, which relates to the relative efficacy of transforming inputs into outputs, is discussed. There are two distinct categories of efficiency: allocative and technical. One of the pioneers of efficiency studies, Farrell, utilised the frontier production function to differentiate between the two (Murrillo-Zamorano, 2004). According to Ellis (1988), the theory of production in economics is concerned with optimisation, and optimisation implies efficiency. Thus, business decision-makers seek to maximise certain performance indicators, such as profit or efficiency. According to Murrillo-Zamrano (2004), efficiency analysis typically concentrates on producing a certain level of output at the lowest possible cost or producing an optimal level of output with minimal inputs/resources. According to Battese and Coelli (1995), efficiency measurements are beneficial for formulating and analysing agricultural policy because they indicate the potential for improved performance.

3.2.1 Technical efficiency

The concept of economic efficiency, which consists of two components, technical efficiency and allocative efficiency, is used to analyse a firm's performance. Technical efficiency refers to the maximum possible level of output that can be obtained from a given set of inputs, given a range of alternative technologies available. According to Ellis (1988), a firm is technically efficient when it produces a given output with the minimum possible quantity of inputs. Koopmans (1951) defines a production process as technically efficient when it cannot increase one output without decreasing another or increasing at least one input. In contrast, Farrell (1957) stated that a production unit is efficient as long as it operates on the production frontier. If a production unit operated on the part of the production frontier parallel to an output axis, it would increase the output associated with the axis without decreasing any other output. This efficiency analysis is essential in formulating and analysing agricultural policies (Battese and Coelli, 1995).

A firm that is technically efficient produces on the production possibility frontier, while a technically inefficient firm operates either inside or outside the production possibility frontier. According to several researchers including Ellis (1988), Battese and Coelli (1995), and Murillo-Zamorano (2004), technical inefficiency has a negative impact on allocative efficiency, and this, in turn, reduces the economic efficiency of the firm.

3.2.2 Allocative efficiency

According to Farrell (1957), allocating efficiency is the capacity to select appropriate levels of input for given factor prices. According to Ellis (1988), it is the adjustment of inputs and outputs to reflect relative prices (price efficiency) within a given technology. According to Murrillo-Zamorano (2004), allocative efficiency is the willingness and capacity of an economic unit to match its particular marginal value product. Allocative efficiency refers to the concept that decision-makers are concerned with how output is produced, as well as what output and balance of output is produced. In competitive output market conditions, production is considered efficient when the Marginal Value Product (MVP) and the Marginal Factor Cost (MFC) are equal (Chiona, 2011). To evaluate production efficiency, a ratio of the MVP to the MFC is computed, with a ratio of one indicating efficient utilization of a factor. As stated by Ellis (1988), Coelli and Battese (1995), and Murillo-Zamorano (2004), technical inefficiency has a negative impact on allocative efficiency, which has a negative impact on economic efficiency.

Since Schultz's (1964) "poor but efficient" hypothesis, there has been a great deal of interest in evaluating the efficiency of agriculture in developing nations. (Murrillo-Zamorano, 2004) Several scholars have pointed out that resource allocation is a means of attaining maximum efficiency. When it becomes difficult to reallocate resources without first reducing the total value of production, it is said that allocating efficiency has been attained (Chiona, 2011). Labour and capital are considered essential movable resources because they can be reallocated between land resources in the form of farms (Battese, 1992).

Researchers and policymakers acknowledge that quantifying resource use efficacy is necessary for boosting agricultural output. Ellis (1988) identified three distinct methods for measuring farm efficiency: the cost frontier method, the profit method, and the production function method. This investigation will employ a production function methodology. Several estimation techniques for frontier functions have been devised, including parametric and non-parametric Data Envelopment Analysis (DEA) and stochastic frontier analysis (SFA). The model selection is dependent on the data type. Using the SFA model, researchers in Sub-Saharan Africa have analysed the technical efficiency of small-scale maize producers. These investigations include Kibaara (2005) Masuku, Dlamini, and Rugambisa (2012), Baha, et al., (2013) and Musaba and Bwacha (2014).

3.3 Empirical studies on technical efficiency of small-scale maize farmers in sub-Saharan Africa

Agriculture plays a crucial role in the economic development of Sub-Saharan Africa (SSA) countries, and improving farm output and income through the adoption of new technologies is a priority. Technology's efficiency is a critical component of output growth. The technical efficiency of small-scale farmers has been widely studied in Africa, with similarities and differences observed in the various studies. Household demographics, socio-economic factors, access to credit, extension services, and management practices have been identified as determinants of efficiency by different authors (Geta et al., 2013; Baloyi, 2011; Mignouna et al., 2012; Diiro, 2013; Bempomaa and Acqua, 2014).

In east Africa using Stochastic Frontier Production Function Analysis (SFPF), Hassan and Alene (2003) determined that farm size, education, accessibility to credit, and timely availability of contemporary inputs are crucial determinants of technical efficiency between maize producers in Ethiopia. The research revealed that the average technical efficiency of farmers was 76%. Using Data Envelopment Analysis (DEA), Geta et al., (2013) found that enhanced seed types, location, group membership, education level, and occupation had a positive and significant effect on the technical efficiency of small-scale producers. However, factors such as size of farm, gender, market, and drought had a negative impact on technical efficacy. Similar research undertaken in Kenya and Uganda by Kibaara (2012), Mignouna, Mutabazi, Senkondo, and Mayongo (2012), Diiro (2013), and Kibirige (2013) using SFPF discovered that improved maize seed variety, group membership, farming experience, location, household size, tractor use, and education level positively influenced the technical efficiency of small-scale maize farmers.

In the past, studies on the technical efficiency of small-scale maize farmers in Tanzania have yielded mixed results. Studies by Msuya, Hisano, and Nariu (2009) and Baha et al. (2013) used the SPFP model to estimate technical efficiency, with mean values of 61% and 62%, respectively.

Msuya et al. (2009) found that hand hoe usage had a positive influence on technical efficiency, while Baha et al. (2013) found the opposite. In addition, there were conflicting findings on the use of insecticides, with one study showing a positive impact on technical efficiency.

The relationship between technical efficiency and factors such as off-farm income, household size, credit access, and distance from production sites was found to be inverse in one study but positively correlated in the other. Factors such as education level, capital availability, inputs, and extension services were found to have a negative impact on technical efficiency, contrary to popular belief, according to Baha et al. (2013) and Msuya et al. (2009). However, Kibirige, et al., (2014) found that the negative relationship between these factors and technical efficiency could be attributed to poor extension information dissemination, farmers opting for formal jobs over farming, more capital invested in other enterprises than maize, and improper use of inputs.

From West Africa studies conducted in Ghana by Bempomaa and Acqua(2014) and Abdulai et al. (2013), using the SFPF model, found that land, Labour, and fertiliser positively influenced technical efficiency, while agrochemicals and seeds had a negative effect. They also found that age, gender, and off-farm income were significant determinants of technical inefficiencies in production. The maximum likelihood estimate of the frontier model showed that, on average, farmers were sixty seven (67%) and seventy four (74%) percent technically efficient, implying that 33% and 26% of maize yield was not realized, respectively. Research by Aye and Mungatana (2010) and Nsikak-Abasi and Onkon (2013) in Nigeria revealed that factors such as Labour, improved maize seed variety, artificial fertilisers, access to credit, education, age, and group membership had a positive influence on the technical efficiency level.

Studies conducted in Malawi by Chirwa (2003) and Tchale (2009) using the SFPF model indicate that factors such as access to credit, inorganic fertilisers, group membership, off-farm income, farming experience, and access to inputs positively and significantly influenced the technical efficiency of small-scale farmers. Similar results within the Southern African region were found in other studies by Baloyi (2011), Masuku, Dlamini, and Rugambisa (2012), and Kibirige (2013), which also utilized the SFPF model. Other factors identified to have a positive and significant impact on small-scale maize farmers' technical efficiency include hired Labour and intercropping, while crop rotation practice and distance to the market had a negative and significant influence.

3.4 Production functional forms

Several functional forms have been used in production efficiency modelling studies, according to research by Griffin, Montgomery, and Rister (1987). The most commonly used functional forms are the quadratic, translog, semilog, and Cobb-Douglas models.

In an article by Pavelescu (2011), it was suggested that the translog and quadratic production functions are better suited to deal with the strong homogeneity of constant elasticity of substitution (CES) and Cobb-Douglas production functions. The translog production function is particularly useful as it can account for several production inputs or factors (Christensen, et al., 1973). Bahta and Baker's (2015) research showed that the translog and quadratic production functions offer greater flexibility with supplementary parameters for estimation, but they may violate econometric assumptions such as multicollinearity. In contrast, the Cobb-Douglas production function can be used to solve the multicollinearity problem.

The advantages of the Cobb-Douglas production function were summarized by Bhanumurthy (2004) as follows: 1) it can effectively address econometric estimation issues such as heteroscedasticity, serial correlation, and multicollinearity; 2) it does not introduce its own distortions in the presence of market imperfections; and 3) it can accommodate different production scales. Thus, the Cobb-Douglas production function will be used in this study due to its favourable properties.

3.5 Farm profitability estimation

Farm profitability is the level at which the total value of production exceeds the total cost of production, according to Kibirige (2014b) and Nixon and Dunford (1972). Farm profitability is a critical metric for assessing the financial health and sustainability of agricultural operations. It serves as an indicator of the farm's ability to generate a positive return on investment. In the context of Sub-Saharan Africa, where many farmers operate on thin margins, understanding and optimizing profitability is crucial. Factors such as fluctuating commodity prices, variable input costs, and unpredictable weather patterns can significantly impact profitability. Efficient resource management, adoption of modern farming practices, and access to market information are essential for enhancing farm profitability in the region. Moreover, government policies, subsidies, and training programs can play a pivotal role in supporting farmers and ensuring that they achieve sustainable profitability. Lastly, farm profitability is not just about monetary gains; it also reflects the overall well-being and quality of life of the farming community.

3.6 Enterprise budget

Farm managers must make decisions regarding farm profitability on a seasonal and yearly basis (Saiz-Rubio & Rovira-Más, 2020). One method of selecting the most profitable farming enterprise and practices is through the use of an enterprise budget. An enterprise budget outlines all of the costs and revenue associated with producing a specific product and can be used to create complete, partial, and cash flow budgets. It is a useful tool for estimating total costs and returns for an existing or prospective enterprise and can help inform farm planning decisions such as potential income, required farm size, and projected cash flow (Sahs & Bir, 2020). An enterprise budget allows farm managers to make informed decisions before committing resources to a project. Gross margins can be derived from an enterprise budget and are a crucial component of farm profitability estimation, according to Kibirige(2014a).

3.7 Gross margin analysis

Gross margin analysis is a commonly used technique for farm profitability estimation, which involves subtracting total production cost from total revenue. Gross margin analysis is suitable when information on fixed costs is unknown or limited, as fixed costs or production overheads are ignored in the estimation. Gross margins consider factors of production such as fertiliser, tractor power, seeds, pesticides, herbicide, labour, and other inputs, making it a simple yet realistic farm performance measurement, according to Kibirige (2014b) and Nixon and Dunford (1972). Gross margin analysis is effective in measuring and comparing enterprises and for planning purposes and it can also be used as a starting point for constructing cash flow budgets and assessing overall farm profitability. Additionally, it can assist in evaluating the opportunity to develop new farm enterprises. According to Choumbou et al. (2015), Gross Margin Analysis (GMA) is a reliable and straightforward method to assess the financial performance of an enterprise. The GMA helps farmers calculate farm productivity and compare the performance of different practices and technologies applied, leading to better management of farms. Gross margins are evaluated by identifying and quantifying the projected Total Variable Cost (TVC) and the total revenue (Trust, 2021). Total variable costs (TVC) represent the sum of the production costs, whether projected or incurred by the farmer for a particular enterprise. Total revenue (TR) is calculated by multiplying the projected yield with the current or potential market price (i.e. TR = Yield * Unit Price). The difference between total revenue and total variable costs gives the gross margin. Therefore, the formula for gross margin is:

$$GM = TR - TVC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

3.8 Break-Even analysis

After completing an enterprise budget, it is important to determine or estimate the minimum price and quantity to produce. Break-even analysis is an important financial assessment that compares the cost of producing a new product to the unit selling price, determining the point at which the farmer will break even, neither making a profit nor a loss (Sahs & Bir, 2020). Break-even price helps farmers to explore alternative production combinations and markets. The breakeven price can be calculated as follows:

$$Break - even\ price\ = \frac{estimated\ total\ cost}{expected\ yield} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (2)$$

The breakeven quantity or yield is the minimum yield required to cover all projected costs at an expected unit selling price. This calculation helps with target yield estimation to cover all projected costs. It also helps analyse alternative production options and decide if the enterprise is worth pursuing. The breakeven quantity is computed as follows:

$$Breakeven\ Yield\ = \frac{estimated\ total\ cost}{expected\ price} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (3)$$

3.9 Conceptual framework

According to Pather and Chetty (2016), a Conceptual framework is a visual presentation of critical variables, factors and their relationship with each other, which have been or have to be studied. In agriculture, the process of producing crops involves converting inputs such as seeds, land, labour, and fertiliser into outputs such as maize or other crops. However, the successful transformation of inputs into outputs is not only dependent on the inputs used but also on the management practices employed by the farmers to combine these inputs.

Management practices encompass the knowledge and skills that the farmer possesses or gains over time, as well as the characteristics of the farm. The quantity and quality of output are jointly determined by the technical inputs and the management practices. The role of Agribusdev as a service provider for technical inputs and advisor on correct management practices is also critical to the output produced.

CONCEPTUAL FRAMEWORK FOR MAIZE PRODUCTION IN A GREEN SCHEME

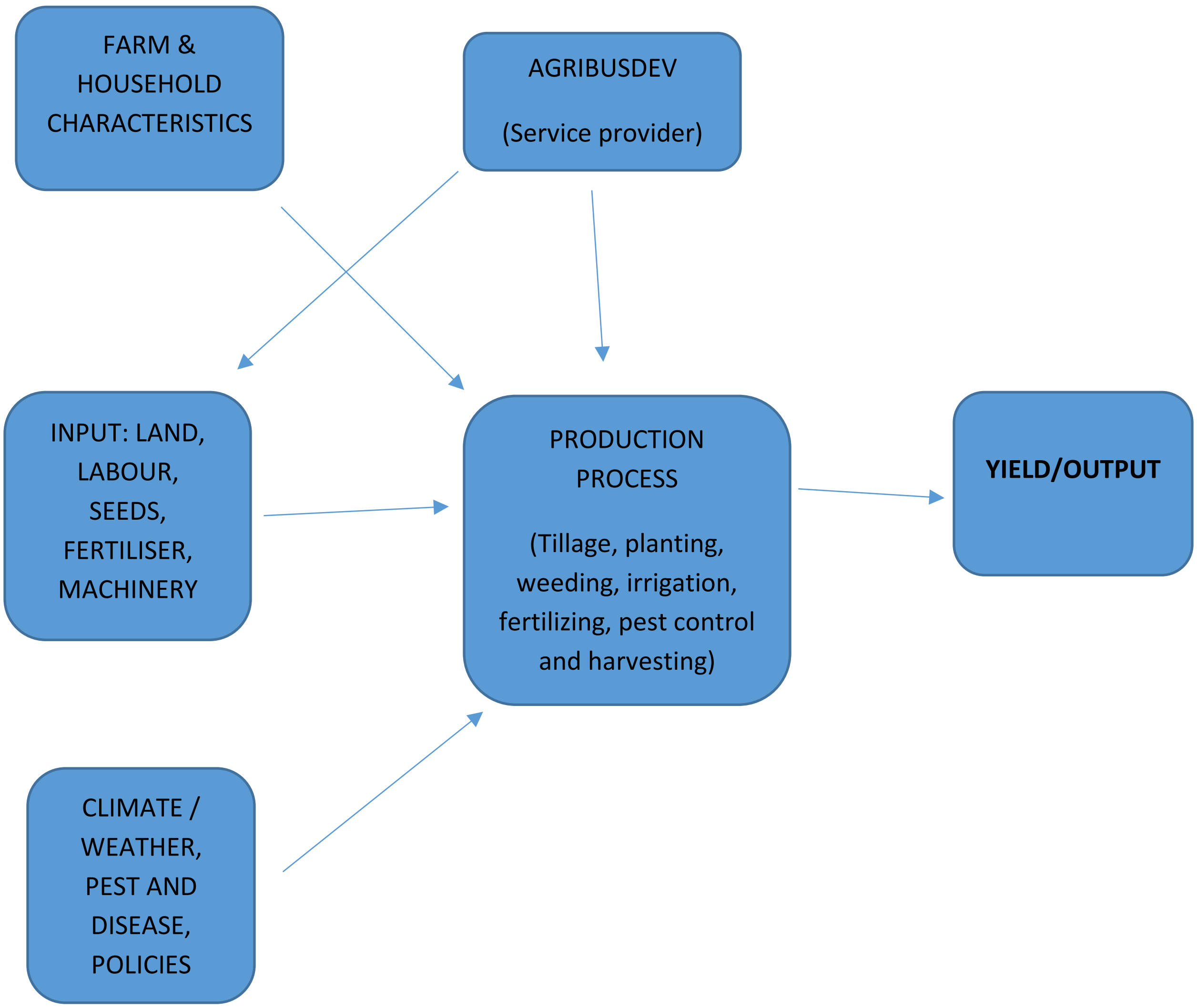

Figure 2.1 Conceptual Framework for Maize Production in a Green Scheme

(Source: Baitshoki, 2023)

Figure 2.1 presents a conceptual framework for maize production in a green scheme. The framework visualizes the critical variables, factors, and their relationships that impact the process of maize production. The framework highlights the importance of inputs such as seeds, land, labor, and fertiliser and their transformation into outputs such as maize. Management practices, which include the knowledge, skills, and characteristics of the farmer and the farm, are also depicted as critical factors in the transformation process. Additionally, the role of Agribusdev as a service provider for technical inputs and advisor on correct management practices is highlighted in the framework. The conceptual framework serves as a guide for understanding the complexities of maize production in a green scheme and can be used as a basis for further research and analysis.

3.9 Chapter summary

The topic of farm resource use efficiency is a crucial area of research in both developed and developing countries and it is particularly relevant to study in Sub-Saharan Africa due to the scarcity of resources in the region. The Cobb-Douglas production function model is appropriate for this research, given the above literature review around technical resource use efficiency. The efficiency of small-scale maize irrigation farmers will be analysed using a Stochastic Frontier Production Function (SFPF), specifically the Cobb-Douglas production function. This study adopts enterprise budget, gross margin and breakeven analysis to estimate farmers' profitability.

CHAPTER 4: METHODOLOGY

4.1 Introduction

The chapter presents a comprehensive outline of the methodology employed in the study, covering the study area overview, population and sampling techniques, data collection methods and ethical considerations. Additionally, the chapter explains the selection of the efficiency model, specifically the justification for the adoption of the Cobb-Douglas production function, and the independent and dependent variables included in the model

4.2 Overview of the study area

The research was carried out at the Etunda Irrigation project located in the Omusati region of north-central Namibia, specifically in the Ruacana constituency. The project has been in existence for a long time and is home to a significant number of small-scale farmers, currently numbering around 72 (MAWF, 2016; Andreas, 2016). The farm spans approximately 600 hectares, with half of the land designated for commercial farming and the other half for small-scale farming. The primary crops grown on the farm are maize and wheat, while small-scale farmers cultivate various vegetable varieties such as potatoes, cabbage, onion, melons and tomatoes seasonally throughout the year on a minor portion of the land. Each small-scale farmer is allocated 3 hectares to produce crops and vegetables under irrigation (Andreas, 2016). The region receives relatively high annual rainfall of between 400 and 550 mm during normal years and is characterized by sandy and loamy soils, extensive flood plains, and open woodland and shrub land (Mendelsohn , 2006; Le Roux and Muller, 2009).

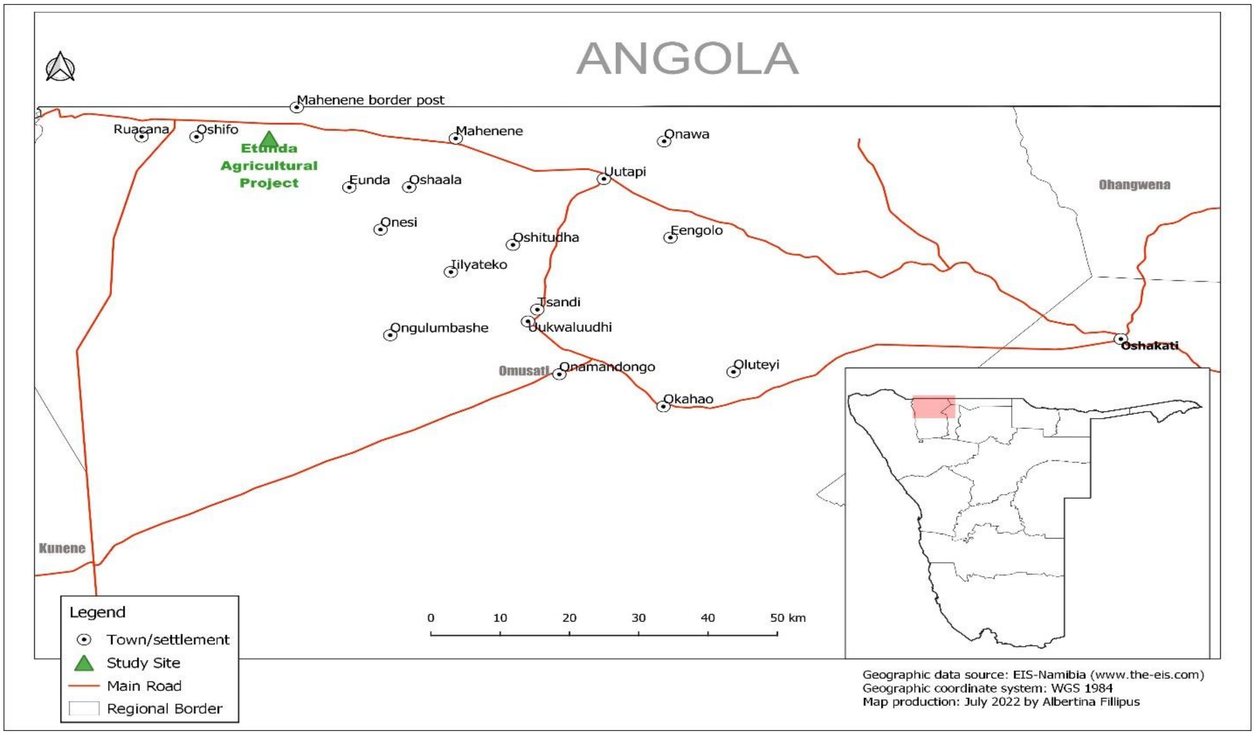

Figure 2 Map of the Study area

Source: (EIS-Namibia, 2022)

4.3 Population and sampling

There are 72 small-scale farming units in the scheme with 52 active producers. The study population for this research comprised of household heads who were involved in decision-making on food production at the Etunda Irrigation Project. A census sampling technique was used, meaning that the entire population was selected for the study. A non-probability sampling technique has been adopted in this study because the population is small.

4.4 Data Collection

A survey questionnaire was used to gather information from farmers who were actively engaged in the production of maize at Etunda Irrigation. Respondents were questioned on-site at their farming operations. Prior to taking the survey, the respondents were informed of the study's goal. The researcher engaged a translator to make sure that the questionnaire was understood by the respondents.

4.5 Efficiency Model Choice and Justification

Numerous research studies have endeavoured to evaluate the efficiency of small-scale agricultural production (Xu and Jeffrey, 1998; Khem et al., 1999). Jeffrey and Xu (1998) highlight that various modelling approaches, such as deterministic versus stochastic, parametric versus non-parametric, and programming methods versus statistical methods, have been utilised in empirical studies of production efficiency. These techniques can be broadly classified into two types: stochastic frontier production approaches and non-parametric mathematical programming approaches (Khem, et al., 1999).

The analysis of production frontiers has generally followed two main approaches: the full frontier and the stochastic frontier. Meller(1976) noted that the full frontier can be estimated using either non-parametric or parametric techniques. In the parametric approach, a functional form is imposed on the production function, and the parameters of the production function are estimated using programming or statistical techniques. In this case, all deviations from the frontier are attributed to inefficiency. In contrast, stochastic frontiers decompose the deviation into random components, which reflect measurement error, statistical noise, and a component that reflects inefficiency.

Battese and Coelli (1995) examined the advantages and disadvantages of the full and stochastic frontier methods for estimating production frontiers. The stochastic frontier technique is advantageous because it deals with factors beyond the researcher's control, such as stochastic noise, and permits statistical testing of production structure and inefficiency-related hypotheses. Nonetheless, this method's limitations include the requirement to impose an explicit functional form for the technology that underlies distributional assumptions for the inefficiency term. In contrast, the non-parametric approach, particularly Data Envelopment Analysis (DEA), avoids parametric technology specification and distributional assumptions of inefficiency. DEA is susceptible to measurement errors and other errors in the dataset due to its deterministic character, attribution of all deviations from the frontier to inefficiencies. As with the Farrel (1957) technique, the approach is also susceptible to outliers, which can significantly distort the estimated frontier and efficiency measures.

The full frontier model has an advantage over the stochastic frontier model when estimating the efficiency index of firms (Jondrow et al., 1982). However, the stochastic frontier approach is generally regarded as superior because it takes into account the effects of unmeasured variables and measurement mistakes regarding the dependent variable, as well as the effects of random breakdowns in input supply channels that are not correlated with the regression error (Jondrow et al., 1982). Therefore, the stochastic frontier model suggested by Jondrow et al. (1982) will be utilized in this investigation.

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4.6 Production Frontier Input Factors

The previous chapter's studies on efficiency modelling in SSA indicate that various factors, such as fertiliser, seeds, labour, land size, and land preparation, influence the production frontier.

4.6.1 Labour

Agricultural production relies heavily on labour, which is defined as the (physical or mental) effort exerted by individuals during the production process. It can be measured by the number of workers or hours spent producing products (Nasirzadeh and Nojedeh, 2013). In labour-intensive traditional agricultural systems, such as those in Sub-Saharan Africa, labour is crucial (Okurwa et al., 2006). It is required for a variety of tasks, including land preparation, weeding, and harvesting. There are two categories of agricultural labour: contracted labour (including temporary and permanent labour) and family labour. In rural areas, the demand for contracted labour has increased due to rural-urban migration, which has diminished the availability of family labour.

In the literature, the function of labour in agricultural production and technology adoption is well-established (Bempomaa & Acquah, 2014). According to the findings of Kibaara's (2012) study, the estimated coefficient for labour was positive and statistically significant, indicating that increased labour input results in higher output levels. This indicates that larger families can provide more labour for agricultural endeavours. Nonetheless, Tchale and Sauer (2007) discovered a negative labour coefficient, indicating that labour is over utilised under these conditions, resulting in decreased output. This study measures labour as the total number of man-days required to execute farming tasks such as weeding, irrigation, and harvesting. It consists of both paid and unpaid labour.

4.6.2 Land (farm size)

Land is a crucial resource for maize production and is measured in hectares. Agricultural land is heterogeneous due to factors such as soil type, size, and productivity-related characteristics. At EGSIP, farmers were allocated 3 hectares of land each, but not all farmers utilized the entire allocated space. The majority of studies examined in chapter 3 found that land has a significant positive influence on production, based on its estimated coefficient.

Studies by Tchale(2009) and Nsikaka-Abasi and Onkon(2013) found that the estimated coefficient of land is positive and significant, indicating the positive influence of land on agricultural production. The results also suggest that economies of scale dominate the plot size distribution.

However, studies conducted in Tanzania and Ethiopia by Baha(2013) and Alene and Hassan (2003) found the estimated coefficient of land to be negative and significant, suggesting that farmers who produce on larger plots are technically inefficient, possibly due to the high cost of production on bigger plots, which they cannot afford. For the purpose of this study, land refers to the total hectares of land used by each respondent for maize production.

4.6.3 Seeds

Seeds are an important aspect of crop production because they form the foundation of production, upon which the level of production depends. Compared to vegetative propagation, seeds are the most effective method of plant propagation, according to Delouche and Potts (1983). The two varieties of seeds available to farmers are open-pollinated and hybrid. In general, open-pollinated seeds produce lower yields than hybrid seed varieties. Seed selection is crucial for producers because it affects plant population per hectare, management, and yield. Previous research in Chapter 3 indicates that seeds have a statistically significant positive effect on the technical efficiency of small-scale maize producers.

Mignouna et al. (2012) and Geta et al. (2013) concluded that the improved seed variety has a positive and significant effect on technical efficacy in Kenya and Ethiopia, respectively. Therefore, producers who utilize improved seeds (pest- and disease-resistant, drought-tolerant, and high-yielding) are technically competent. According to research cited in Chapter 3, seeds have a positive and substantial effect on the technical efficiency of small-scale maize producers. Chirwa (2003) and Musaba and Bwacha (2014), however, discovered a negative coefficient for seed input, indicating a decline in technical efficacy. This may be a result of sowing too many seeds or poor germination, implying that as the quantity of seeds sown increases, so does the yield reduction. The EGSIP measured the quantity of seed used per hectare in kilograms (kg).

4.6.4 Fertiliser

Fertiliser is any naturally (organic fertiliser) or synthetic (artificial fertiliser) substance that can be used to provide essential nutrients to plants (Savoy, 2015). Rewritten: Fertility of the soil refers to its capacity to support plant growth by supplying essential nutrients. Farmers can apply organic and/or synthetic fertilisers when the soil lacks enough nutrients for optimal plant growth. The chemical and physical properties of the soil are crucial to the absorption of nutrients by plants. It is essential for farmers to understand the soil fertility and fertiliser requirements for each crop they cultivate. Once a farmer understands the soil fertility and crop fertiliser requirements, it is simple for them to implement a crop-specific fertilisation program.

According to research conducted in Tanzania (Baha, 2013) and Malawi (Tchala& Sauer, 2007), the use of artificial and organic fertilisers is positively correlated with crop yields and technical efficacy. Therefore, producers in fertile regions produce greater yields than those in less fertile regions. For optimal plant performance, farmers must comprehend the fertility status of their farms' soils and add any deficient nutrients. Fertiliser is a crucial production factor; this study examines how the quantity (in kilograms) distributed per hectare affects the overall yield.

4.6.5 Tractor Power

Tractor power is effective in crop production because it can plough and plant timeously compared to manual labour and animal draught power. With the use of tractors farmers can work on mass land easily which may be impossible or difficult to attain manually. Secondly, it is also versatile in the number of farm implement it can be used with e.g.disc harrow, ripping, row planter, boom sprayer, ploughs and combined harvester. Thirdly, tractor usage brings about precision in land preparation, planting, spraying and harvesting. Tractor precision plays a big role in attaining desired plant population, even spacing, fertiliser application which in turn influences the output (yield). Furthermore, tractor power helps farmers save in production cost because it takes less time to work hence saving on labour cost.

A study in Kenya by Kibaara(2012) and in Namibia by Montle(2016) found that farmers who use tractor power for land preparation increase technical efficiency. At the EGSIP tractors and all implements are provided by Agribusdev to all small-scale farmers at cost. The method used to calculate fuel cost in this study is to charge fuel use per hectare and then convert it to a monetary value by multiplying the amount of fuel used (in litres) by the price per litre. The amount of fuel (in litres) used per hectare was used in estimating technical efficiency, while the cost (in monetary terms) was used in estimating profitability.

4.7 Socio-economic factors and efficiency

Several studies show that socio-economic variables influencing technical inefficiency level are; farming experience, off-farm income, extension service, gender, farm credit, cooperative membership, household head age, education level and family size. According to studies, agricultural experience has a substantial effect on technical efficacy. For example, Sieno et al. (2013) discovered that the coefficient for farming experience was negative and statistically significant, suggesting that farming experience reduces technical inefficiency. The negative coefficient for farming expertise may imply that experienced farmers have superior managerial skills and can implement new farming techniques and technologies with relative ease. In addition, according to a study by Tijani (2006), the negative coefficient for age and agricultural experience indicates that older and more knowledgeable farmers are more productive than their younger counterparts. This suggests that as farmers' age and gain more agricultural experience, their inefficiency increases. However, contradictory findings by Chirwa (2003) indicate that farming experience influences technical inefficiency positively and substantially. The inefficiency of seasoned farmers may be attributable to their refusal to implement new technologies or alter their management style.

According to Masuku et al. (2012), off-farm income has a positive and significant effect on technical inefficiency. Farmers with multiple sources of income have a tendency to divide their attention and prioritize where they earn the most money, neglecting their properties. Contrary to the above result, Msuya et al. (2009) report that the coefficient for non-farm income is negative and statistically significant. Therefore, farmers with income from outside the property are more technically efficient. With a higher income, producers can purchase machinery and other inputs that enhance production, thereby becoming technically proficient. According to studies conducted by Tchale and Sauer (2007), household income has a negative coefficient, indicating that it reduces or increases technical inefficiency. In addition, Kibaara (2012) found that the estimated coefficient for the level of education was negative, indicating that an increase in the number of years spent in school reduces technical inefficiency. Therefore, farmers with a high level of education tend to be more technically efficient in agricultural production because they can use modern farming techniques with greater ease, comprehend extension messages more thoroughly, and have greater access to information communication and technology (ICT) services.

According to Sieno et al. (2013), the coefficient for extension services is negative and significant, meaning that an increase in extension visits/training decreases the inefficiency level of farmers. However, a study in Nigeria by Aye and Mungatama (2010) found the opposite result with a positive and significant coefficient for extension services or technical assistance. This negative relationship between access to extension services and technical efficiency could result from poor extension services or farmers' reluctance to practice what they are taught. It is generally expected that farmers gain skills, become more technically aware of the production process, and adopt new technologies with every extension visit/training.

Studies have shown mixed results on the relationship between family size and technical efficiency in agriculture. Masuku et al. (2012) found a positive coefficient for family size, indicating that larger family sizes lead to increased technical inefficiency. However, Mushunje et al. (2005) found a positive and statistically significant coefficient for family size, suggesting that larger family sizes improve technical efficiency. It is worth noting that the impact of family size on technical efficiency may depend on the level of involvement of family members in farming activities.

4.8 Stochastic Frontier Analysis (SFA)

Stochastic Frontier Analysis (SFA) is a statistical method that accounts for measurement errors and noise in the production function specification. A stochastic frontier model can be expressed as:

$Yi = f(Xi;B) \exp(Vi - Ui)$ where $i = 1,2,\ldots,n$ …………………… (4)

Where:

Y_i= Farm yield

X_i = Maize production Input quantities used

B = Estimated Parameters

V_i- U_i = Composite Error term/random error.

V_i- The variable Vi in the stochastic frontier model represents random errors that are not under the control of farmers, assumed to be independently and identically distributed as $N(0, \sigma^2\mu)$, while U represents the non-negative random variable associated with technical inefficiency. U is assumed to be independently distributed as a truncated normal distribution, with truncations at zero, as proposed by Battese and Coelli (1995).

Ui is given as:

μi = δ0 + δiZij ………………………………… (5)

Where Zi represents the vector of farm-specific variables that may influence the efficiency of the farm and are the parameters to be estimated.

In agricultural production, the technical efficiency (TE) of a farm is defined as the ratio of the observed output (Yi) to the corresponding frontier output (Y*), conditioned on the level of inputs used by the farm. Mathematically, this equation is expressed as:

TEi = Yi / Y*i

$$TE = \frac{f(X_i: B)\exp(V_i - U_i)}{f(V_i: B)\exp(V_i)} \dots\dots\dots \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (6)$$

The use of a likelihood function for two variance parameters, has been recommended by Aigner et al. (1977) in the stochastic frontier production function. It has been emphasised that values of lambda (λ) should be between zero and one, with values of 0 indicating deviation from the frontier and values of 1 indicating that all deviations are due to technical inefficiency.

4.8.1 Production function frontier model

The research modelled the production frontier and technical inefficiency using STATA version 13.1. As stated by Hassan and Alene (2003), the production frontier represents the maximum output that can be achieved with a given set of inputs and existing production procedures. Inability to achieve the frontier output indicates technical inefficiency. Battese and Coelli (1995) devised the specification for the stochastic frontier model. The authors developed a stochastic frontier paradigm that expresses technical inefficiencies as a function of variables that explain and a random error. The Cobb-Douglas stochastic frontier production function was specified as follows:

$$LnY_i = \beta_{0i} + \beta_1 LnX_{1i} + \beta_2 LnX_{2i} + \beta_3 LnX_{3i} + \beta_4 LnX_{4i} + V_i + U_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (7)$$

Where;

Y is the yield of maize in Tonnes (Ton) per hectare;

X1 is the area of maize planted in hectares (ha);

X2 is the quantity of fertiliser in kilograms (kg);

X3 is the quantity of seed in kilograms (kg);

$X4$ is the total labour (man-days);

$X5$ is the quantity of pesticide (kg);

$X6$ is the tractor power measured in litres (i.e. fuel used);

Vi denotes the random error term, assumed to be independently and identically distributed as $N(0, \sigma v^2)$;

Ui denotes the technical inefficiency term, assumed to be independently and identically distributed as truncated normal distribution $N+(\mu i, \sigma u^2)$.

4.8.2 Technical inefficiency model

The technical inefficiency model will be utilised to determine the factors that affect the efficiency of small-scale irrigation farmers in the study area, and the model will be estimated using the following equation:

$$U_i = \delta + \sum_{n=1}^{N} \delta_n Z_i + \omega_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where;

Zi = Vector of explanatory variables associated with technical inefficiency effects.

δ = Vector of unknown parameters to be estimated.

ωi = Unobservable random variables which are assumed to be identically distributed. They are obtained by truncating the normal distribution with mean zero and unknown variance $\delta 2$, such that Ui is non-negative. The inefficiency of production Ui was modelled in terms of the factors assumed to affect farmers' technical efficiency. Empirically, the inefficiency model based on Battese and Coelli (1995) was specified as follows:

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_{2i} Z_{2i} + \delta_{ni} Z_{ni} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Whereby;

Empirically, the inefficiency model based on Battese and Coelli (1995) can be specified as follows:

$Z1$ = farm experience measured in number of years

Z2 = education level measured as the highest grade attained by respondents.

Z3 = extension services – measured as dummy variable (1=yes and 0 = No)

Z4 = off-farm income - measured dummy variable (1=yes and 0 = No)

Z5 = cooperative membership– measured as dummy variable (1=yes and 0 = No)

Z6 = household size measured as number of people per household

Z7 = gender- dummy variable (1=Male and 0 = Female)

Z8 = farm credit (loan). Dummy variable (1=yes and 0 = No)

4.9 Ethical considerations

To ensure ethical considerations, the confidentiality of the information collected during the survey was strictly maintained to protect the privacy of the participating farmers. The respondents were not coerced or forced to answer the questionnaire and had the option to withdraw from the interview at any time. No personal information was required on the questionnaire to preserve the anonymity of the participants. Additionally, the main objective of the investigation was clearly communicated to the respondents before administering the questionnaire.

4.10 Chapter summary

This chapter offers an in-depth look into the research methodology employed in this study. The chapter begins with an introduction, highlighting the various components of the research methodology, from the study area to the data collection methods and the reasoning behind the chosen efficiency model. Furthermore, it gives insights of the production frontier input factors. These factors include labour, measured in man-days and essential for tasks like weeding and harvesting; land size, gauged in hectares and its influence on maize production; seeds and their variety's impact on production efficiency; fertilisers and their effect on yield based on quantity used; and tractor power, which looks at the advantages of tractor use in crop production.

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CHAPTER 5 RESULTS AND DISCUSSION

5.1 Introduction

This section discusses descriptive statistics, an overview of farm practices, stochastic frontier analysis and gross margins. Discussions are centred on the production frontier, technical inefficiency, and its determinants. The last part of this chapter deals with an analysis of small-scale farmers' profitability. Notable is the fact that of the 72 farmers, only 47 farmers got interviewed; the remaining 25 were not available for an interview because of several reasons ranging from suspensions, deaths and diversion from maize production.

5.2 Descriptive statistics

Table 1 presents descriptive statistics of the production and socio-economic factors, including technical efficiency and inefficiency variables. The findings indicate that average age of farmers is 48.23 years, suggesting that most farmers are older. Farmer's age comes with years of experience, so it is not surprising that the average years of experience at the EGSIP is 16.91. It is noteworthy that experienced farmers tend to resist adopting new technology or farming methods, which can affect their technical efficiency. Labour is a crucial factor of production, particularly in small-scale production.

Labour is needed to carry out production activities such as planting, weeding and harvesting. The average labour is 82.39 man-days; it comprises full-time hired, family and casual labour. There is ample family labour given the household size, which is averaged at 5.8 persons per household. The Etunda Green Scheme Irrigation project is surrounded by rural villages where unemployment is prevalent, which results in excess labour availability. The average land cultivated for maize production is 1.97 Ha which is below the Green Scheme set standard of 3Ha; therefore, farmers utilise about 1Ha to produce other products besides maize.

Table 1 Descriptive Statistics of the Etunda Irrigation Project Respondents

Variable	Unit	Min	Max	Mean	Std Dev
Age	Years	31	70	48.23	8.2573
HH Size	Number	1	20	5.8	4.0734
Farming Experience	Years	3	27	16.91	6.1779
Labour	Man Days/Ha	42	157	82.39	27.2408
Land	Ha	1.25	3	1.97	0.4564
Tractor Power	ltrs	48.29	115.9	76.49	17.6349
Fertiliser	kg	1200	3600	1901.17	540.4046
Seeds	kg	23.37	56.25	36.37	8.252
Yield	Ton/ha	3	9	4.41	1.4814

5.3 Education Level

Education is an integral part of modern farming and has a huge potential to influence the adoption of new farming systems, thus improving technical efficiency. Of the 47 interviewed farmers, 43 of them have formal education. Most of the farmers have either obtained secondary school or better, meaning most are highly educated. About 89.47% of the male respondents had a secondary education or above while 85.71% of the female respondents had secondary education or above. The number of respondents is shown on the Y-axis, while the level of education attained is depicted on the x-axis in Figure 3.

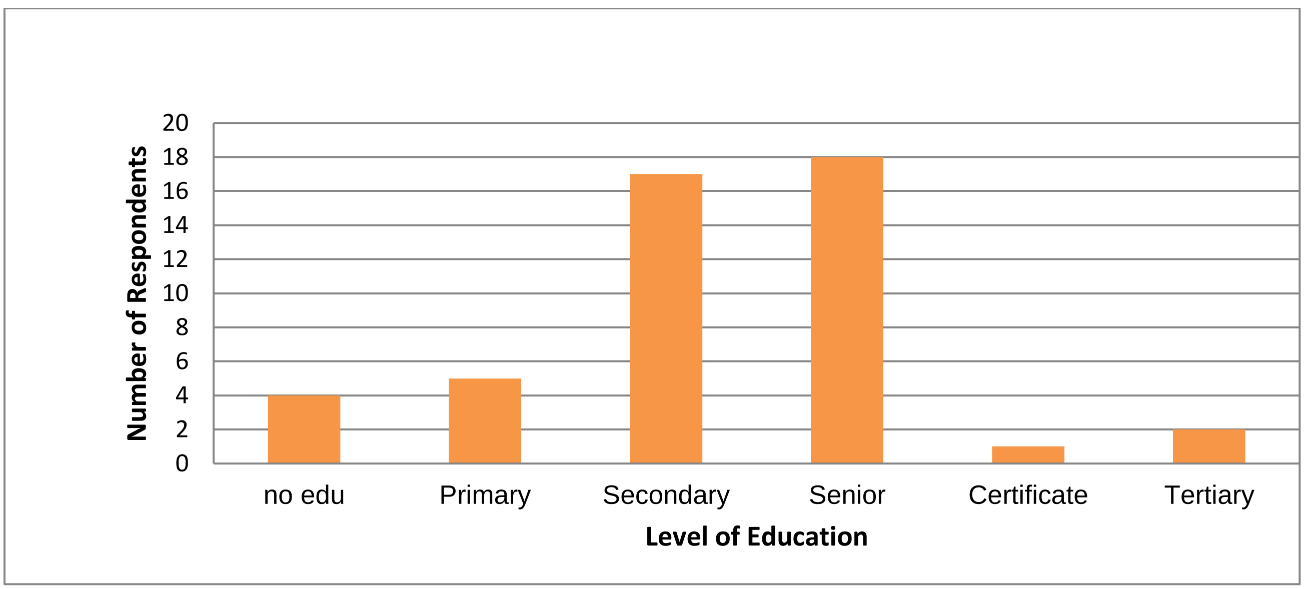

Figure 3 Farmers Level of Education

5.4 Gender of household head

It is common in Africa that more females are involved in agricultural production than their male counterparts, who tend to move to cities for formal employment. Most of the households at Etunda Irrigation Scheme are female-headed. The result below shows that 60% of the small-scale farmers at Etunda Irrigation are women.

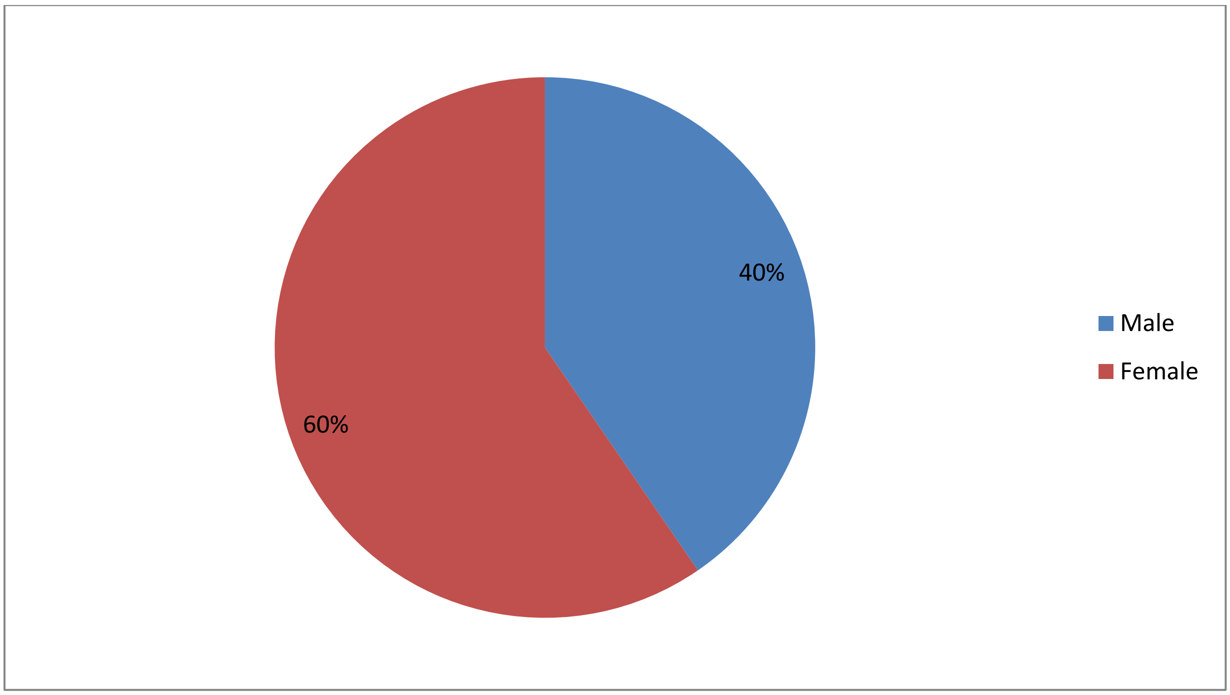

Figure 4: Gender of Household Head

5.5 Farm situational analysis

The success of any farming enterprise is determined by the process or practices adopted during production. Several factors, such as soil and water testing, pest control availability of irrigation water, electricity, machinery and timely planting, influence the overall performance of farmers. All the respondents at the EGSIP did not do any soil fertility tests before planting maize for the past five years. Therefore, the fertilising program they followed was more subjective hence the general below-par performance. The respondents cited that there is no local soil and water testing centre in the northern region of Namibia, and it is expensive to do soil tests hence why they do not do soil tests. For plants to take up the applied nutrients in the right quantity, they need the right soil potential hydrogen (pH). Respondents at the Etunda irrigation scheme did not do any pH tests or lime their soil which affects the performance of crops.

Pest control is an important production factor in maize production; if done properly, farmers may realise improved yield. Prevalent fall armyworm attacks are a major challenge to maize producers at the Etunda Irrigation Scheme, resulting in increased expenditure on pest control. Respondents had no pest control or prevention plan in place; therefore, they only acted when the need for pest control arose. Availability of electricity and irrigation water is the lifeblood of the irrigation scheme hence why it is vital to have an adequate supply of these production factors throughout the season. Low water pressure and frequent power cuts were prevalent changes that farmers faced at the EGSIP. The low water pressure resulted in uneven germination for most of the interviewed farmers, which led to a reduced plant population per hectare. A low plant population per hectare is a setback in achieving the desirable tonnage/ha. Irrigating at a low pressure means a farmer must spend more hours irrigating, increasing electricity usage for water pumping and increasing the monthly electricity bill. Lastly, low irrigation affects daily moisture supply and foliar feeding or fertigation of the plants because the sprinklers do not cover the desired space in a hectare leading to a drop in plant performance.

Machinery or farm tech plays a critical role in the overall performance of modern-day commercial farming. Farm machinery, such as precision planters, ploughs, harrows, combined harvesters, tractors, and boom sprayers, can improve farm efficiency if availed and used correctly. The respondents had access to modern farming machinery from Agribusdev; however, there were delays and limited access to implements such as combined harvesters and boom sprayers. Farmers were then forced to use manual labour to harvest and for weed control, which may be slow and inefficient. During the survey, there were farmers with maize in their fields waiting to be harvested for more than three months. This kind of delay paralyses farmers' cash flow which may result in farmers being unable to buy all inputs for the next cropping season. The small-scale maize farmers at the Etunda Irrigation Scheme need to work together with service providers to improve their overall productivity.

5.6 Estimation of technical efficiency

Table 2 describes the variables employed with regard to of their elasticity coefficients, standard errors, and significance.

Table 2 Estimation of the Stochastic Production Frontier Model

Variables	Coefficient	Std. error	Z-test	Significance
logTractorpower	0.7610917	0.2215238	3.44	0.001***
logLabour	-0.0134781	0.0503602	-0.27	0.789
log10Seeds	0.0870694	0.3770404	0.23	0.817
LogLand	0.0706368	0.3344318	0.21	0.833
log10Fertiliser	0.4421973	0.2874558	1.54	0.124
Constant	1.87442	0.5848677	3.20	0.001***
Mu parameters:				
log10farmngYrs	0.6003648	0.3823004	1.57	0.116
Variance parameters:				
Sigma u (δ_u)	0.104071	0.0914658	1.14	0.010
Sigma v (δ_v)	0.1285879	0.0137582	9.35	0.000
Sigma squared (δ^2)	0.1326589	0.105224	10.49	
Lambda (λ)	0.8093372	0.0931902	8.68	0.000
Gamma (γ)	0.784500701			
Mean Technical Efficiency	0.97			
Log likelihood = 29.1540 Prob Chi-square = 0.0026				

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

The elasticity for tractor power was 0.7610917, indicating that a 1% increase in the use of tractors for weeding, ploughing, and harvesting would result in a 0.76 percent increase in maize yield. Montle (2016) found tractor power to be a significant factor in explaining technical efficiency among farmers. However, labour was found to be statistically insignificant, with a negative elasticity of -0.013 indicating that an increase in labour results in a decline in farm output. These results are consistent with findings in Zambia by Musaba et al. (2014) and in Namibia by Montle (2016). . The elasticities of both labour and tractor power imply that a 1% increase in any of the factor will result in less than 1% increase in output.

Labour supply at Etunda Irrigation Scheme exceeds the demand hence the negative relationship with the output. Hall (1991) stated that when there is an oversupply of labour in the market, firms are willing to employ more people because a high labour supply comes cheap. However, additional personnel decrease the worker's marginal productivity if the output does not increase with additional personnel (Hall, 1991).

The elasticity of seeds is 0.087, it demonstrates that an increase in the quantity of seeds used would result in an increase in maize yield. Though positive, the elasticity is less than one meaning that it has inelastic effect on the output of maize. This result is consistent with studies conducted by Kibaara (2012) in Kenya and Sieno et al. (2013) in Nigeria. The elasticity for land size or total planted hectares was 0.071, indicating that an increase in planted area would lead to a rise in yield. The elasticity is less than one (i.e. inelastic) meaning a 1% increase in land size will result in less than 1% increase in maize yield. This finding is consistent with Geta et al.'s (2010) research in Ethiopia. In accordance with Nsikak-Abasi &Onkon's (2013) study in Nigeria's western region and Baha's (2013) study in Tanzania, fertiliser use had an elasticity of 0.442, indicating that an increase in fertiliser use would contribute to an increase in maize production. The value shows that fertilizer application is inelastic i.e., its application will not increase the maize yield at a commensurate amount.

In this study, an increase in the use of agricultural tractors and seed and fertiliser was found to have a positive effect on maize production. These production inputs, such as the quantity of seeds, fertiliser, and tractor horsepower, have been shown to have a positive correlation with the technical efficiencies of producers. Any increase in these inputs will not result in an equivalent increase in output because their elasticities are all less than one. Additionally, the study used farming experience as the independent variable and technical inefficiency as the dependent variable to assess the correlation between each farmer's farming experience and their technical efficiency levels. The results indicate a correlation of 0.600 between the producers' farming experience and their technical inefficiency. These findings align with prior research by Montle (2016) and Mango et al. (2015).

In the study's Table 2, variance parameters for the sigma square (2), lambda (λ), and gamma (y) are presented. The sigma square (2) is the total model variance, which is calculated by adding the variance due to random effects (v) to the variance due to technical inefficiency effects (u)

(Battese & Coelli, 1995). It indicates the goodness of fit and the presumed distributional form for the error term (Mango et al., 2015). 2 has a coefficient of 0.133. Gamma (y) represents the proportion of the total model variance attributable to technical inefficiency. It is calculated by dividing the variance attributable to technical inefficiency factors by the total model variance. According to Oke and Baruwa (2012), ranges from 0 to 1, with 0 signifying the absence of technical inefficiency effects in the estimated SFA model and 1 indicating that all variation from the frontier is due to random noise. A value closer to one indicates that the majority of output variation from the frontier is attributable to technical inefficiency, validating the SFA technique (Oke &Baruwa, 2012). Gamma is estimated to have a coefficient of 0.784, or 78.4%, indicating that the majority of output variation from the frontier is attributable to technical inefficiency, while statistical noise contributes only 21.6%.

Table 3: Technical Efficiency Estimation of Etunda Maize Farmers

Te Range	Frequency	Percentage (%)
0.80-0.89	14	29.79
0.90-1	33	70.21
Min	0.87	
Max	0.93	
Mean	0.90	
S.D	0.162	
No. of observations	47	

Table 3 presents a summary of the small-scale maize farmers' technical efficiencies, laid out in terms of the range of technical efficiency, the total number of farmers (Frequency) in each range, and the corresponding percentage. The results indicate that the average technical efficiency of the farmers is 0.90, with a minimum of 0.87 and a maximum of 0.93, indicating that the farmers operate with a high degree of efficiency. Moreover, all small-scale maize farmers operate at a technical efficiency level between 0.87 and 0.93.

5.6.1Hypothesis Testing

Based on the estimate of gamma (γ) at 0.785 or 78.5%, it can be inferred that technical inefficiency is a major contributor to the variation of output from the frontier. Furthermore, the Log likelihood test coefficient is greater than the critical chi-square (x^2) value. Thus, the null hypothesis (H_0) of no significant difference in the level of technical efficiency among small-scale farmers is rejected, as the results suggest that there is indeed a significant difference in their technical efficiencies. These findings confirm the importance of running an inefficiency estimation model.

5.7 Factors influencing technical efficiency.

Table 4 displays the results of the inefficiency effects model that was used to determine the factors affecting the technical efficiency of small-scale maize producers in the Etunda Green Scheme Irrigation Project. A multitude of factors, such as socioeconomic, demographic, and environmental factors, can affect technical efficiency. Several studies, such as Abdul-Kareem and Isgin(2016), Baloyi (2011), Binam, et al., (2004), Kuwornu, et al., (2013), Nchare (2007), and Thiam et al. (2001), have investigated and analysed the technical efficacy and its determinants among various producers. Analysing the factors that influence the technical efficiency of a farm is particularly essential for the development of policies. This study examined socioeconomic variables including the farmer's gender, education level, cooperative membership, extension office visits, and maize production training as continuous variables. Table 4 displays the model's results concerning inefficiency. Due to the multicollinearity effect, other variables, such as off-farm income, access to credit, age, and household size, were eliminated from the model.

Table 4: Estimates of the Inefficiency Effects Model

Variables	Description	Coefficient	Std. error	Z-test	Significance
Gender	Gender (1 = female; 0 = male)	0.0909471	0.0457181	1.99	0.047**
Education	education attained (1= no edu etc)	-.0154847	0.0213418	-0.73	0.468
Cooperative member	(1 = yes 0 = no)	-.0217362	0.0478188	-0.45	0.649
Access to Extension Service	(1 = yes 0 = no)	.0279566	0.1503617	0.19	0.044**
Access Training	(1 = yes 0 = no)	-.0374136	0.1022332	-0.37	0.714
Constant		9.106597	0.2229959	40.84	0.000***

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

The technical inefficiency was the dependent variable, while the socioeconomic characteristics of the producers were the independent variables. The coefficients of the independent variables represent their influence on technical inefficiency. Positive coefficients indicate a rise in technical inefficiency, whereas negative coefficients indicate a fall. Consequently, a variable that increases technical inefficiency will also reduce technical efficiency, and vice versa.

The coefficient of gender (0.0909471) is positive, indicating a negative influence on technical efficiency, and is statistically significant at the 5% level. Comparable results were found in Tanzania by Baha et al.,(2013). A study by Sieno et al. (2013) suggested that women tend to be technically inefficient due to their daily responsibilities outside of farming. In addition, men are more likely than women to participate in extension training (Sieno et al., 2013). FAO estimates that at least 31% of households in sub-Saharan Africa are headed by women because the majority of males migrate to cities in search of formal employment (FAO, 2002).

Although not statistically significant, education level has a negative coefficient, indicating that it is positively related to technical efficacy. Although insignificant, the education level's negative coefficient of -0.015 suggests a positive relationship between education and technical efficiency level. The findings are consistent with research conducted in South Africa by Baloyi (2011) and Nigeria by Aye and Mungatana (2010). Theoretically, educated farmers have greater technical efficacy than illiterate farmers. According to Kibret (2015), education impacts the comprehension, decision-making, and adoption of novel agricultural techniques and technologies. This study reveals that 43 out of 47 respondents, or 91.48 percent, have formal education, which has a positive effect on technical efficacy. The coefficient for the relationship between training and technical inefficiency is -0.037, indicating that trained farmers are more technically efficient.

Membership in a cooperative is crucial to agricultural production because, through collective membership, farmers obtain access to production information, share inputs, increase their bargaining power, and strengthen social cohesion. The estimated membership coefficient has a negative sign (a positive relationship with technical efficiency) and is statistically insignificant. Kibirige (2014b), who conducted a study on the technical efficiency estimation of smallholder farmers in Uganda and Zambia, discovered comparable results to Musaba and Bwacha (2014). According to this study, 35 producers are members of the Othithiya Cooperative, or approximately 74.46% of the respondents.

The positive coefficient for extension service (0.032) is statistically significant at the 5% level. These results are consistent with those of Kibirige et al. (2014). The hypothesis is that extension service influences technical efficacy positively. In contrast, the results demonstrate an inverse relationship. This could be due to inadequate dissemination of extension information or a lack of interest in extension officers' services. The primary contributors to inefficiency in this study are gender and access to extension services.

5.7.1Testing the Hypothesis

This study's null hypothesis (H_0) is that there is no significant relationship between socioeconomic characteristics of small-scale producers and resource use efficiency in the Etunda Irrigation Scheme, i.e. $\beta_1 = 0$. However, based on the empirical findings, we refute the null hypothesis because gender and extension service coefficient are greater than zero; therefore, have a statistically significant impact on the technical efficiency of farmers.

5.8 Profitability Estimation

Enterprise budgets were used to estimate the profitability of the farmers at EGSIP. Gross Margins and breakeven analysis were used to analyse the profitability of the small-scale maize farmers. The figures used for the enterprise budget are based on the averages of the top-performing and the least-performing farmers. Notably, only nine (9) out of 47 farmers (i.e. 19%) are doing 6MT or more maize per hectare. In this case, the top-performing farmers were getting 6MT or more. Tables 5 and 6 present the enterprise budget for small-scale maize farmers, which shows the yield, revenue, total cost of production, gross margins and return on investment. According to Agribusdev(2017), the standard minimum yield for maize per hectare is nine metric tonnes. However, of the 47 respondents at the Etunda green scheme, only two attained 9MT per hectare.

The average yield per ha for the top-performing small-scale maize farmers presented in Table 5 is 6.7MT per hectare. This yield is attained after an average sale of 1000 cobs of green mealies. At the time of data collection, the average cost of maize per tonne was N$4,200.00, and a cob of fresh maize was N$5.00. The total revenue or gross income was N$33,140.00 per hectare. Fertilisers are the main production input, with a 51% contribution to the total cost of production, followed by pesticides, water and electricity tariffs which are 12%, respectively. The other costs include tractors for land preparation and planting, harvesting, the cost of seeds, labour and herbicides. The total variable cost per hectare is N$25,895.36, which means farmers get a gross margin of N$7244.14 per hectare.

Table 5: Maize Enterprise Budget for High Performing Farmers at Etunda

Maize Enterprise Budget			
	Qty/ha	**Unit Price N$**	**Total N$**
Revenue			
Yield (tons)	6,7	4,200.00	28,140.00
Other Income (Green Mealies)	1000	5	5,000.00
Gross Income			**33,140.00**
Variable Input Cost			
Tractor	1	850.00	850.00
Seeds	18.7	120.00	2,244.00
Fertiliser NPK	6	500.00	3,000.00
Fertiliser Urea	6	890.00	5,340.00
Fertiliser NH4N04	6	800.00	4,800.00
Pesticide	1	3,000.00	3,000.00
Herbicide	1	2,000.00	2,000.00
Labour (Man-days)	42	19.33	811.86
Electricity &Water	1	3,000.00	3,000.00
Harvesting	1	850.00	850.00
		Total Cost	**25,895.86**
		Gross Margin	**7,244.14**
		Breakeven Price (N$)	**3,870.00**
		Break-even Yield (tons)	**6.165**

Table 6 presents an enterprise budget for the poor-performing farmers who are the majority at EGSIP. The results were attained by 38 or 81% of the respondents/farmers at the EGSIP. On average, the poor-performing farmers attain an average yield of 3.75 MT per hectare, far lower than the set yield target. The gross income is N$20,750.00, with a total cost of N$21,315.86, resulting in a gross margin of N$(565.86) per hectare. These figures show that farmers are operating at a loss.

Table 6: Maize Enterprise for poor-performing farmers

	Qty/ha	Unit Price N$	Total N$
Revenue			
Yield (tons)	3.75	4,200.00	15,750.00
Other Income (Green Mealies)	1000	5.00	5,000.00
Gross Income			**20,750.00**
Variable Input Cost			
Tractor	1	850.00	850.00
Seeds (kg)	18.7	120.00	2,244.00
Fertiliser NPK (50kg)	6	500.00	3,000.00
Fertiliser Urea (50kg)	4	890.00	3,560.00
Fertiliser NH4N03 (50kg)	4	800.00	3,200.00
Pesticide	1	3,000.00	3,000.00
Herbicide	1	800.00	800.00
Labour (Man-days)	42	19.33	811.86
Electricity &Water	1	3,000.00	3,000.00
Harvesting	1	850.00	850.00
		Total Variable Costs	**21,315.86**
		Gross Margin	(565.86)
		Breakeven Price/kg (N$)	**5,6800.00**
		Break-even Qty (tons)	5.75

5.9 Chapter summary

In Chapter 5, the study delves deep into various aspects of farming, beginning with descriptive statistics that encompass farm practices, farm situational analysis, stochastic frontier analysis, and gross margins. The primary emphasis is on understanding the production frontier, technical inefficiency, and the factors that determine it. While the initial target was to interview 72 farmers, only 47 could be reached due to various unforeseen circumstances. Overall, this chapter offers a holistic view of the determinants influencing the technical efficiency of small-scale maize farmers. Such insights are invaluable for shaping future policies and ensuring the growth and sustainability of the farming sector.

CHAPTER 6 CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This study aimed to investigate the resource use efficiency of small-scale maize farmers at the Etunda Irrigation project. The specific objectives were to estimate the technical efficiency among small-scale maize farmers, identify the social and institutional determinants that influence their technical efficiency, and measure the profitability of the maize enterprise. The chapter before presented and discussed the implications of the findings. Based on the objectives of the study, this chapter will provide a summary of the major conclusions and recommendations. The recommendations are intended to improve the resource utilisation efficiency of small-scale farmers in the Etunda Irrigation project, thereby increasing their standard of living and contributing to national food security goals. The investigation estimated technical efficiency using the stochastic frontier model, specifically the Cobb-Douglas production function. Structured questionnaire were administered to the small-scale irrigation through face-to-face interviews, and enterprise budgets were utilised to evaluate profitability. The chapter presents the study's conclusions, which were derived from its findings.

6.2 Conclusion

This study has provided valuable insights into the resource use efficiency, profitability, and social and institutional determinants of small-scale maize farming at the Etunda Irrigation Project. Through the use of econometric models and a profitability analysis, the study has identified the key factors that influence the technical efficiency and profitability of maize farming, as well as the challenges facing small-scale farmers in the region. The findings of this study have important implications for policymakers, farmers, and other stakeholders involved in the development of the agricultural sector in Namibia. The following section presents a summary of the main conclusions of this study and provides recommendations for future research and policy interventions.

6.2.1 Small-Scale Maize Farmers' Technical Efficiency in the Etunda Irrigation Project

Small-scale maize producers at the Etunda Irrigation project use resources inefficiently, according to the findings of this study. The technical efficiency ratings ranged from 20% to 98%, signifying significant resource utilization inefficiencies. The study additionally discovered that the most significant determinants of technical efficacy were education level, experience, credit access, and irrigation water availability.

Further analysis of the technical efficiency scores revealed that the resource use efficiency of small-scale maize producers in the Etunda Irrigation project has significant room for improvement. The average technical efficiency score of 67% indicates that, on average, maize production utilises only two-thirds of available resources. This indicates that there is a significant opportunity to increase productivity and profitability by enhancing resource utilisation efficiency.

The study discovered that education level and experience had a significant impact on technical efficacy. Generally, farmers with greater education and experience had higher technical efficacy scores. This indicates that education and experience are crucial for increasing the resource utilization efficacy of small-scale maize farmers. Being able to get to credit and the availability of irrigation water were also found to be significant determinants of technical efficacy, according to the study. Farmers who had access to credit and sufficient irrigation water tended to have greater technical efficacy.

In light of these findings, it is suggested that policies and programs aimed at enhancing the resource use efficiency of small-scale maize producers should focus on enhancing education levels, providing training and extension services, and enhancing access to credit and irrigation water. In addition, policies should strive to reduce the prices of Agribusdev's inputs and services to make them more affordable for small-scale farmers.

There is a need for interventions that can enhance the technical efficiency of small-scale maize farmers in the Etunda Irrigation project, according to the findings. These interventions could include education and training programs geared at enhancing farmers' skills and knowledge in farming practices like crop rotation, pest control, and soil management. In addition, timely and affordable credit and access to irrigation water could be crucial for enhancing the productivity of producers.

The study also determined that the maize business is profitable, with a net income of N$ 7,244.14 per hectare. In order to improve the financial viability of small-scale maize farming in the Etunda Irrigation project, it is necessary to encourage the adoption of profitable farming techniques.

This study provides insights into the technical efficacy and profitability of small-scale maize cultivation at the Etunda Irrigation project. The findings of the research indicate that small-scale maize farmers in the study area have a significant opportunity to improve their resource utilization efficiency. These findings can be utilised by policymakers and development agencies to design and implement interventions that enhance the technical efficacy and profitability of small-scale maize farming in Namibia.

In sum, this study adds to the existing literature on the resource use efficiency of small-scale farmers in Namibia and provides policymakers and development practitioners with valuable insights to improve the resource use efficiency and enhance the livelihoods of small-scale farmers.

6.3 Determinants of Technical Efficiency

This study's second objective was to identify the social and institutional determinants or household characteristics that influence the technical efficiency of small-scale maize producers in the Etunda Irrigation project. The findings indicate that education level and experience are the most significant determinants of small-scale producers' technical efficiency. In particular, producers with higher levels of education tend to have higher technical efficiency scores, while those with more experience tend to be more resource efficient. Experienced farmers has the knowledge and the ability to invest in improved inputs and technology tend to have higher technical efficiency scores. In addition, the availability of irrigation water is a crucial factor in determining the technical efficiency of producers, as scarcity of water results in lower efficiency scores.

In addition, household characteristics such as family size, household income, and gender influence the technical efficiency of small-scale producers, according to the study. In particular, larger households tend to have lower technical efficiency scores because producers with more mouths to feed use resources less efficiently. As a result of their capacity to invest in better inputs and technology, farmers with higher household incomes typically have higher technical efficiency scores. The farmer's gender is also a significant determinant, as female farmers tend to have lower technical efficiency scores than male farmers.

The findings suggest that interventions aimed at enhancing the technical efficiency of small-scale maize farmers in the Etunda Irrigation project should concentrate on improving educational levels, expanding access to credit, guaranteeing the availability of irrigation water, and addressing gender disparities. Additionally, policymakers should consider targeted interventions to address the requirements of larger households and farmers with low incomes.

6.4 Profitability of the Maize Enterprise at the Etunda Irrigation Project

The third objective of this study was to measure the profitability of the maize enterprise among small-scale farmers at the Etunda Irrigation Project. The results showed that maize farming is a profitable enterprise for small-scale farmers at the Etunda Irrigation Project. The profitability analysis indicated a net income of N$7,244.14 per hectare, with a benefit-cost ratio of 1.25. This indicates that for every dollar invested in maize farming, farmers earn a return of 1.25 dollars. The analysis also revealed that the cost of labour and inputs significantly affects the profitability of maize farming.

The profitability analysis of maize farming among small-scale farmers at the Etunda Irrigation Project showed that the enterprise is a viable and profitable venture. The net income of N$7,244.14 per hectare indicates that farmers can generate significant profits from maize farming. The benefit-cost ratio of 1.25 also indicates that the returns on investment in maize farming are positive. However, it is important to note that the profitability of maize farming is significantly affected by the cost of inputs. Therefore, farmers need to carefully manage their input costs and labour expenses to maximize their profits. Additionally, policies that promote access to affordable inputs and labour-saving technologies could further enhance the profitability of maize farming among small-scale farmers at the Etunda Irrigation Project.

Furthermore, the profitability analysis revealed that only 26% of the farmers were making a profit, while 74% were making losses. The average profit per hectare was N$2,015, while the average cost per hectare was N$22,605.86. The low profitability is mainly due to high input costs, particularly seed and fertiliser, and low yields. The study also found that farmers with higher technical efficiency tended to be more profitable than those with lower technical efficiency.

The study identified various constraints that affect the performance of small-scale maize farmers, including inadequate access to extension services, low water pressure, poor-quality seeds, and high input costs. Additionally, the study revealed that farmers' knowledge and skills regarding modern farming techniques were inadequate, leading to suboptimal utilisation of resources.

6.5 Limitations of the study

The major limitation of this study is the sample size i.e., 72 farmers. Furthermore, of the 72 farmers only 47 were successfully interviewed making the sample significantly small. This study used a quantitative approach; therefore, a larger sample would have improved the results of this study.

6.6 Recommendations

The recommendations section provides an opportunity to suggest actionable steps that can be taken based on the findings of the study. The insights obtained from the research objectives can help guide policymakers, farmers, and other stakeholders in the agricultural sector to make informed decisions. This section will present practical recommendations aimed at improving the technical efficiency, productivity, and profitability of maize farming among small-scale farmers at the Etunda Irrigation Project. These recommendations will be based on the identified determinants of technical efficiency, profitability, and the challenges faced by small-scale farmers.

The following are the recommendations based on each research objective:

i. To assess the resource use efficiency of small-scale maize farmers at the Etunda Irrigation project:

Provide technical assistance and training programs to farmers on best practices in crop management, such as optimal use of inputs, water management, and pest control, to improve their technical efficiency through an intensified extension service program. This program could be facilitated by the service provider (Agribusdev) and Ministry of Agriculture extension service department. Extension service linkage between the farmer and Agribusdev should be strengthened to ease adoption of new production technologies e.g. precision agriculture. Furthermore, the service provider should improve the functionality of the irrigation system through scheduled routine maintenance, which will increase the availability of water to farmers, and thereby, improve their efficiency. This action will reduce the outcry of shortage of irrigation water due to constant breakdowns.

Moreover, Agribusdev should facilitate timely access to credit, inputs and other services (ploughing, planting, harvesting, pest control etc.) for small-scale farmers to enable them to improve their efficiency and output. Adoption of Integrated pest management system by the Etunda farmers will improve productivity thus improving efficiency. Furthermore, the government should consider subsidizing pesticides especially for the control of fall army worm which severely affects farmers output. Lastly more focus should be put on research and development for better adapted seed varieties, regular soil fertility testing and service provision improvement by Agribusdev.

ii. To identify the social and institutional determinants or household characteristics that influence the technical efficiency of small-scale maize farmers at the Etunda Irrigation Project:

Encourage farmers to improve their managerial and production to enhance their technical knowledge and skills through yearly trainings or short courses. These trainings will equip farmers with practical managerial and crop production skills. Attendance of these trainings should be monitored by the service provider, and it should be a prerequisite for yearly production loan approval. The Agribank small-scale irrigation farmer credit facility needs to be improved to include crop insurance or payment exemptions if there is crop failure due to natural causes or factors beyond the farmer's control. Review of the Green Scheme Policy to target more youth, marginalized groups and people living with disability into the program. The policy should include a training package that is a pre-requisite for allocation on new irrigation land. Revival of the Oththiya cooperative is a necessity for the small-scale farmers at Etunda. It is through the cooperative that farmers can share production information and use it is as a platform for bargaining for inputs and selling price.

iii. To measure the profitability of the maize enterprise:

Encourage the adoption of precision agriculture practices to reduce waste and improve productivity and profitability through availing the right resources by Agribusdev. Policy makers should consider subsidising fertiliser, pesticide and herbicides cost because the three contributes 70% of the total variable cost for small-scale maize farmers. Optionally the aforementioned inputs may be tax exempted or a combination of the two (subsidy and tax exemption) can be implemented to reduce production costs. Furthermore, policy makers may consider creating a conducive environment for local fertiliser manufacturing investment through provision of incentives.

Policy interventions focused on the development of value chains for maize will help farmer's access other markets, obtain better prices for their products, and increase their profitability. This can be done through allowing the farmers to sell produce directly to millers or to jointly make their own maize milling plant. The development of such policy will mark an end to the situation where farmers only sell grain to Agribusdev and take the price set by Agribusdev.

These recommendations aim to improve the technical efficiency, profitability, and sustainability of maize farming among small-scale farmers at the Etunda Irrigation project.

6.7 Recommendations for further research

Based on the findings of this study, there are several areas for further research that could provide valuable insights into improving the resource use efficiency and profitability of small-scale maize farming at the Etunda Irrigation project.

Firstly, future research could focus on analysing the impact of climate change on maize farming in the area. This is important as climate change is expected to have a significant impact on agricultural productivity and food security in the region. Investigating the effects of climate change on maize yields and the profitability of maize farming could provide insights into potential adaptation strategies for small-scale farmers.

Secondly, there is a need for further research on the use of alternative inputs and farming techniques, such as conservation agriculture, to improve the efficiency and sustainability of maize farming. These alternative inputs and farming techniques could help reduce the cost of inputs and Labour while also improving soil health and productivity.

Lastly, future research could also focus on exploring the potential of value chain development for small-scale maize farmers in the area. By adding value to their produce through processing, packaging, and marketing, small-scale farmers could potentially increase their incomes and improve their access to markets.

All in all, these areas of research could provide valuable insights into improving the resource use efficiency, profitability and sustainability of maize farming among small-scale farmers at the Etunda Irrigation project.

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