# Smallholder sugarcane producers' perceptions and practices in bioenergy production in Ehlanzeni District, Mpumalanga Province, South Africa.

**By**

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## DEDICATION

I dedicate this effort to GOD who is responsible for all achievements. With His assistance, I was able to do this assignment within the time span provided. In difficult situations, He supplied leadership and direction. Through His blessings, I completed my studies successfully, recognizing Him as the supreme deity and placed my complete reliance in Him. Despite facing personal challenges during 2021 and 2022. With the help of God, I was able to forge ahead my study. This experience serves as a testament to the power of persistence and hard work. Luke 1 verse 37 “For nothing will be impossible with God”.

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## DECLARATION

I, Delisile Priscilla Mabila, thus certify that my dissertation, presented for a master's degree in Agricultural Economics at the University of South Africa, is my own. It has not previously been submitted for a master's degree at this or another university. All reference material contained therein has been recognized.

Signature: D.P Mab. Date: 29 September 2024

## ABSTRACT

Smallholder sugarcane production has an important role in promoting the participation of smallholder farmers in the bioenergy sector. There is not much which is known about smallholder farmers' potential and willingness to engage in the bioenergy sector. The main objective of the research was to assess small-scale farmers' potential and willingness to engage in bioenergy production from sugarcane. The specific objectives of the study were to determine factors affecting small-scale sugarcane producers' potential to participate in bioenergy production; assess the current practices and the level of engagement in bioenergy production of smallholder sugarcane producers; evaluate factors affecting farmers' willingness to participate in bioenergy production from sugarcane; and highlight what resources and institutional support is required for the smallholders to fully participate in the bioenergy sector. Bioenergy is a form of renewable produced from biomass, primarily derived from plants such as forest residues, woody crops, and crop waste, among others. Renewable energy helps to reduce the carbon footprint of energy sources. Smallholder farmers have an opportunity to contribute to the reduction in the greenhouse gas emissions and contribute to climate change mitigation.

The study was conducted with smallholder sugarcane farmers in Ehlanzeni District, Mpumalanga Province, South Africa. A quantitative research approach was employed for the research. Following an ethical clearance with Reference 2022/CAES_HREC/050 from the College of Agriculture and Environmental Science's Health and Research Ethics Committee, Thus, given a population of 893 smallholder farmers, a sample size of 269 smallholders was generated using Microsoft Excel's rand function. A total of 134 farmers were interviewed in November 2021. The data was collected using a semi-structured questionnaire. Both descriptive statistics and econometric model were used to analyze the data. Two regression models (Ordinal Least Squares regression and Principal Components Regression were estimated). Data was analyzed using both SPSS V28 and STATA 17.

The findings showed that none of the farmers are currently engaged in bioenergy production. However, interest to engage in the sector was very high. Sugarcane harvesting is mainly manual, though a few uses mechanical harvesting, which is expensive. Most of the farmers burn their sugarcane before harvesting. Four factors were significant in influencing the bagasse potential from farmers ‘sugarcane production. These were the farmer’s age, land ownership, access to credit and cooperative membership. Also, four factors were significant in influencing them willingness to participate in the bioenergy sector these were land under sugarcane production, land tenure security and their perceptions on land and food security.

The study concludes that it is important to focus on young farmers to promote the bioenergy sector in smallholder farming. Inadequate land inhibits smallholder sugarcane farmers from seizing opportunities from the bioenergy sector. The current financial support mechanisms for smallholder farmers in the sugarcane industry and collective action arrangements do not enhance farmers’ propensity to participate in bioenergy production. It was also concluded that improving the land tenure security of smallholder sugarcane farmers would enhance their willingness to participate in bioenergy production. Furthermore, smallholder farmers who believe that the production of bioenergy requires large tracts of land are more willing to engage in bioenergy production compared to their counterparts. This is because of the anticipation of support which comes with such kinds of projects. Unfavourable opinions on the possible compromise between food security and bioenergy.

The study advocates for youth development activities to boost young participation in sugarcane cultivation. A revamp of the financial support system and collective action arrangements would enhance the participation of farmers in the bioenergy sector. The farmers’ sugarcane trash management practices should be changed. Green harvesting should be promoted in smallholder sugarcane farming. Knowledge is critical and thus training is needed to improve the farmers’ knowledge of trash management practices, bioenergy, and associated processes. Land reform/ redistribution in the country should support the creation of secure land tenure rights for farmers. The farmers’ fears regarding the bioenergy sector should be addressed before any intervention. The negative perceptions can derail any progress made in promoting bioenergy within the smallholder farming sector. There is also a need to ensure that any bioenergy programme in the smallholder sugarcane sector should not affect the production of crops for food security.

**Keywords**: Sugarcane, Bioenergy, Perception, Awareness, and smallholder farmers

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| | |
|---|---|
| ACB | Agricultural Credit Board |
| AGRA | Alliance for a Green Resolution Revolution in Africa |
| BIS | Biofuel industrial Strategy |
| $CO_2$ | Carbon dioxide |
| DAFF | Department of Forestry and Fisheries |
| DME | Department of Mineral and Energy |
| DOE | Department of Energy |
| EU | European Union |
| FAO | Food and Agriculture Organization |
| GBEP | Global Bioenergy Partnership |
| GDP | Gross domestic product |
| GHG | Greenhouse gas |
| Ha | Hectares |
| IEA | International Energy Agency |
| IPP | Independent Power Producer |
| ITAC | International Trade Administration Commission of South Africa |
| MDGs | Millennium Development Goals |
| NBTT | National Biofuels Task Team |
| NCS | non-cognitive skills |
| NSO | National Statistics Office |
| OECD | Organization for Economic Co-operation and Development |
| PTO | Permission to Occupy |
| REN 21 | Renewable Energy 2011 |
| SACGA | South African Cane Growers Association |
| SA DOME | South African Department of Minerals and Energy |
| SASA | South African Sugar Association |
| SDG | Sustainable Development goals |
| SPSS | Social Package for Social Sciences |
| SSA | Sub-Sahara Africa |
| StatsSA | Statistics South Africa |
| TS | Transvaal Suikar |

| | |
|---|---|
| TSB | Transvaal Suikar Beperk |
| UNDO | United Nations Industrial Development Organization |
| US | United States of America |
| WEC | World Energy Council |
| WHO | World Health Organization |

# CHAPTER 1

# INTRODUCTION

## 1.1. Background

In Sub-Saharan Africa (SSA), biomass (fuelwood and coal) and fossil fuels (crude oil and coal) are the most widely used sources of energy (IEA, 2014; World Bank, 2011). Insufficient access to sustainable energy sources, along with the harmful effects of fossil fuel use, contribute to higher poverty rates, particularly in rural areas. To combat this issue and promote energy security, diversification, and rural development, it is important to prioritize the use of renewable energy sources such as bioenergy (IEA, 2019). Given the desire to mitigate climate change, the use of bioenergy has the potential to reduce greenhouse gas (GHG) emissions while increasing job prospects for the rural poor (Gasparatos et al., 2013; 2016).

South Africa is Africa's top energy consumer, accounting for around 31% of total primary energy consumption in 2012 (BP, 2013). The country relies on fossil fuels (coal and other petroleum products) to generate electricity and transport in agriculture and other sectors of the economy. Because of its high energy consumption, the country generated around 1.4% of world $CO_2$ emissions in 2011 and over 40% of those in Africa, making it a large carbon emitter (IEA, 2013). The country's energy usage has increased, and current statistics suggest that South African cities, like Nigeria, have a significant carbon footprint. Exposure to carbon emission in Africa has reduced the life expectancy to below 50 years and increased food insecurity and malnutrition (IPCC, 2012). Hence, the continued reliance on fossil fuel will prove to be more costly and unsustainable overall, demonstrating the need for alternative energy options.

Bioenergy is an alternative source of energy obtained from biological resources that includes biofuels, biomass, and biogas. Biofuels (biodiesel and bioethanol) make up most global bioenergy sources (IRENA, 2018). They get biomass or waste feedstocks, particularly from crops such as sugarcane, maize, wheat, sorghum, and others are considered as important sources of renewable energy (Kanda et al., 2020; Dandu and Nanthagopal, 2019). Biofuel production envisions a long-term alternative to oil imports, with the potential to boost rural investment and contribute to poverty alleviation (Von

Malititz and Brent, 2008; UNCTAD, 2009). Sugarcane is one of the most used crops in South Africa to produce biofuel. Biofuel is blended with diesel or petrol to increase octane/cetane levels and lower vehicle emissions (Foong et al., 2014). Most rural communities in Mozambique cook using ethanol (IPCC, 2012). As a result, using bioenergy would improve energy security and rural people's lives.

Developed and developing countries have devised a variety of strategies to promote bioenergy production as a means of decreasing greenhouse gas emissions. South Africa has implemented a few policies targeted at boosting the production and use of bioenergy, including biofuels and renewable electricity. These policies aim to stimulate rural development, alleviate poverty, and generate economic opportunities in rural regions by creating a conducive environment for biofuel production and marketing (DME, 2020).

The policies target smallholder farmers, particularly those in disadvantaged communities, as possible sources of feedstock reduction and emphasize the importance of the Comprehensive Agricultural Support Programme and the Land Bank's financial support for this strategy. They also emphasize the importance of encouraging farmers in impoverished areas to participate in agricultural production through cooperatives (where possible) (AGRA, 2017; Jayne et al., 2017). The policies also prohibit the use of maize as a bioenergy crop for food security reasons. However, feedstocks from sugarcane can still be used to generate electricity. Available research indicates that further progress in bioethanol production technology will lead to more bagasse, resulting in more production/generation of energy, while the raw material for bioethanol can be utilized to synthesize various other bio-products (Weide et al., 2013).

Desiring to mitigate climate change, the use of bioenergy has a potential to reduce greenhouse gas (GSG) emissions and disaster risk reduction while increasing jobs for the rural poor. As well as maintaining and protecting ecosystems allow using and further developing hydropower sources of electricity and bioenergy. This aligns with SDG 7 (Affordable and Clean Energy) by promoting access to sustainable energy and SDG 13 (Climate Action) by reducing emissions and mitigation climate change.

Aside from policies, bioenergy production is dependent on available resources such as crop acreage, yields, production costs, the quality of government support services, and access to agricultural inputs (Searle and Malins, 2015). These resources are limited, thus there is almost always a trade-off between bioenergy and food production. South Africa has limited water resources, with 60% used for agriculture (SA Dome, 2007; Haw and Hughes, 2007). As a result, the development of bioenergy will put additional strain on existing water resources because feedstocks like soybeans, maize, and jatropha require a lot of water (Gasparatos et al., 2012). This extends to all other resources, including participation in bioenergy production. Smallholder farmers, who are disadvantaged and marginalized in most areas, including access to knowledge, markets, and money, face particularly difficult challenges. This has resulted in the fact that, despite investments in the bioenergy sector in South Africa, smallholder farmers have not benefited, despite the promise that exists in some sectors, such as the sugarcane business.

Sugar milling enterprises have benefited from the use of sugarcane byproducts (bagasse and molasses) given by smallholder farmers to their mills to create steam and power for running their facilities and produce biofuels (Dixon and Bullock, 2004). This is even though South Africa already has over 19000 active smallholder farmers, primarily in Kwa-Zulu Natal and Mpumalanga. These indicate the bioenergy potential of smallholder farmers in the sugarcane sector. However, it is unclear whether they are aware of this possibility or whether they are interested in capitalizing on such chances. As a result, the study focused on the smallholder sugarcane sector and its potential contribution to bioenergy generation.

## 1.2. Problem statement

Smallholder farmers' participation in bioenergy production has been minimal, notably in South Africa (Sakai et al., 2020). South Africa has adequate land and water resources for producing biofuel crops (Smeets et al., 2004). Von Maltitz (2008) estimated that the country has around 320 000 hectares (Ha) that smallholder farmers might use to grow sugarcane. A similar conclusion is reached by (Gasparatos et al., 2015). However, the country has not used these resources to enhance the participation of smallholders in the bioenergy business.

The smallholder sector's minimal participation in biofuel production in South Africa has also been attributed to insufficient policies, institutional frameworks, and limited infrastructural investment (Estemhuizen, 2009). There has also been a lack of emphasis on smallholders' awareness and knowledge of biofuel and green energy production options. Less is known about their attitudes towards bioenergy technologies, the use of such energy sources, and the usefulness of bioenergy in decreasing greenhouse gas emissions. This understanding is crucial because it provides the basic data required to establish strategies for increased participation of smallholder farmers in the sector. The present Independent Power Producer (IPP) approach (DOE, 2015) aims to increase the national power supply by 2030 through the use of diverse energy carriers, technologies, and scales, including bioenergy (DOE, 2011; DOE, 2015 and Eskom, 2015). Nonetheless, the IPP scheme for small-scale renewable energy projects ranges from 1 to 5 MW in size (Eskom, 2015).

Bioenergy technology understanding is critical for rural development in Africa. Despite advances in other innovation technologies such as fertilizer use, conservation farming, and improved seeds, bioenergy technology have been difficult to spread in South African rural communities. As a result, most communities have failed to capitalize on new bioenergy potential and markets. As a result, the income disparity gap has widened, reaching 1.1% in 2015. This is confirmed by recent research by Wuepper et al. (2019), which demonstrates the role of noncognitive talents in decision making among smallholder farmers. However, insufficient study has been conducted on bioenergy awareness and views in South Africa's smallholder sector. The legal framework and environmental and sustainability policies and regulations addressing bioenergy generation, as well as the handling of farm and processing residues are either immature or do not exist (Pegels, 2010 and Fritz, 2012). There are endeavours to build renewable energy applications (Pegels, 2010 and Fritz, 2012) and to support cogeneration (DOE, 2015).

Dandedjrohoun et al. (2012) perceived that McBridge's (1999) study did not draw any conclusions on what influences awareness of technology and advances. However, McBridge (1999) studied how socioeconomic variables influenced awareness of participation in innovative technology. Experience is another aspect that can influence a person's decisions. As a result, the purpose of this study was to determine the extent to which awareness and perceptions influence smallholder participation/engagement in the South African bioenergy sector. The study assesses small-scale farmers importance of awareness and perceptions, practices & willingness to engage in bioenergy production from sugarcane.

## 1.3. Objectives of the study

The main objective of the research is to assess small-scale farmers’ importance of awareness and perceptions, practices & willingness to engage in bioenergy production from sugarcane.

The specific objectives of the study are as follows:

a. To determine factors affecting small-scale sugarcane producers’ potential to participate in bioenergy production.
b. To assess the current practices and the level of engagement in bioenergy production of smallholder sugarcane producers.
c. To evaluate factors affecting farmers willingness to participate in bioenergy production from sugarcane.
d. To highlight what resources and institutional support is required for the smallholders to fully participate in the bioenergy sector.

### *1.3.1. Research Questions*

a. What factors affect small-scale sugarcane producers’ potential to participate in bioenergy production?
b. How is their participation affected by their perceptions?
c. What are the smallholder sugarcane producers’ current practices and the level

of engagement in the bioenergy sector?

d. How organized are they? Are they passive or active participants?
e. What factors determine such practices and level of engagement?
f. What resources and institutional support are required by such farmers to participate and benefit from the opportunities in the bioenergy sector?
g. What are the factors affecting farmers willingness to participate in bioenergy?

*1.3.2. Hypothesis*

a. Farmer perceptions affect their participation in the bioenergy sector.
b. Smallholder farmers' demographic factors (age and gender) affect their willingness to participate in bioenergy production.

## 1.4. Justification Contribution of the study

The study proposed ways for increasing smallholder farmers' bioenergy production. This strategy comprises youth development programmes, improved financial support mechanisms, encouraging farmers to take collective action, and introducing green harvesting methods. Additionally, there is a need to better understand cooperative governance and the trade-off between bioenergy and food security. The four criteria have a substantial impact on the bagasse potential of farmers' sugarcane crop. These include the farmer's age, land ownership, financial availability, and cooperative membership. Four factors have a substantial influence on farmers' willingness to produce bioenergy. These include the farmer's land under sugarcane, land tenure security, and food security. The study focused on smallholder sugarcane farmers' willingness to participate or become more involved in bioenergy production.

This was determined by examining the importance of small-scale farmers' awareness, views, practices, and desire to participate in sugarcane bioenergy production. It also emphasises the Sustainable Development Goals (SDGs), such as SDG 7 (Affordable and Clean Energy), which promotes access to sustainable energy, and SDG 13 (Climate Action), which reduces emissions and mitigates climate change. As a result, our research fits into a larger global policy framework. While many farmers are hesitant to adopt innovations, the adoption rate of sustainable innovations remains below the level set by the United Nations' Sustainable Development Goals (SDGs) for 2030, despite recognition of the benefits of sustainable practices (D'Amato et al. 2021;

Foguesatto et al. 2020; Zeweld et al. 2017, 2018).

## 1.5. Limitations & Delimitation of the study

- Limitations

Due to the Coronavirus (Covid-19), some farmers did not participate because the surveys required in-person interviews. Some farmers did not recognize the significance of the study, which may have influenced the study's outcomes. It was difficult to reach farmers via cell phone because most farms are in areas without a network.

- Delimitations

The study focuses on smallholder producers of sugarcane in Ehlanzeni District Mpumalanga. Therefore, the study excluded other smallholder produces of sugarcane in other districts in Mpumalanga or provinces.

## 1.6. Ethical clearance

Before conducting or performing interviews with farmers, appropriate authorities in Ehlanzeni District were contacted, including the district council, which oversees farming and land issues. The study's aim and objectives were clearly communicated to the participants, who are smallholder sugarcane producers. They have the right to confidentiality regarding all responses and participation. The study did not hurt the subjects or expose any information acquired from them. Ethical clearance was considered with Reference 2022/CAES_HREC/050 from the College of Agriculture and Environmental Science's Health and Research Ethics Committee.

## 1.7. Definitions of key words

### *1.7.1. Awareness*

The term awareness is most used to describe having knowledge or being aware of something (Thellufsen et al. 2009). The study then focuses on the domain sugarcane producer's bioenergy awareness, which basically means their knowledge of bioenergy, opinions, and attitudes towards bioenergy, as well as their intents to employ it.

### *1.7.2. Perceptions*

This phrase refers to attitude. Perception arises when a person discusses a specific issue or gives meaning to his or her current situation. According to Pickens (2011), stimuli have a major impact on perception, awareness, and acceptance.

### *1.7.3. Bioenergy*

Bioenergy can be utilised to generate fuel, heat, electricity, and other items. This benefited the country in a variety of ways, including the use of renewable resources to produce biofuel, which has played an important role in ensuring energy security and diversifying energy supply, as well as agricultural development and investment in rural areas, which has reduced greenhouse gas (GHG) emissions and created job opportunities, thereby alleviating poverty, and improving living conditions. According to Nguyen et al. (2010), bioenergy intends to assist the environment by reducing $CO_2$ emissions and enhancing diversity in disadvantaged rural areas.

### *1.7.4. Smallholder producers*

According to Wiggins et al. (2010), disadvantaged farmers have limited access to a variety of resources, including land, while advantaged farmers have access to such resources. These farmers are assigned to the world's poorest regions, which are marked by poverty (Ahieri and Koohafkam, 2008). In South Africa, smallholders are defined as small-scale farmers that produce a little amount of product for their households while hiring family members to generate cash after marketing the output. This farmers' success is hampered for a multitude of causes (Stringer et al., 2020). Dorward et al. (2009) identified six factors: water, energy, credit, knowledge, inputs, and markets, each with an inadequate system for collecting and selling products.

### *1.7.5. Resources*

Is just everything that could be used to create value. Nyawakan Miller and Spoolman (2011) define a natural resource as anything that comes from the environment and is used by humans, whether for a need or a want. A biological and ecological resource is anything that serves the needs of living organisms (Ricklefts, 2005). A resource can be classified as renewable or non-renewable.

### *1.7.6. Institutional support*

Is the long-standing set of established and ingrained social rules and traditions that control social interactions (Hodgson 2001). Examples of institutional assistance include institutes, conferences, and reference bureaus, as well as services provided to specific regions of the community. This assistance usually comprises public broadcasting services, cooperative extension services, and community services.

### *1.7.7. Non-cognitive factors*

According to Schultz (1975) and Feder et al. (1985), economists have long recognised farmer differences in terms of adapting to different environments, until it became clear that non-cognitive skills such as personality, beliefs, and motivations play a significant role in farmers (Lybbert and Wydick, 2018). Heckmen and Kautz (2012) referred to NCS as "soft skills," however Luthans and Youssef- Morgon (2017) defined them as psychological or personal qualities (Almund et al. 2011). NCS are mostly a psychological component of human capital (Lyndberg, 2017). John and Srivastava (1999) define personality traits as conscientiousness, agreeableness, extraversion, openness to new experiences, and emotional stability.

### 1.8. Overview of the structure of the dissertation/ thesis

***Table 1.1:*** *Summary of the study objectives*

| No | Objective | Research questions | Data requirement | Data analysis |
|---|---|---|---|---|
| 1 | To determine factors affecting small-scale sugarcane producers' potential to participate in bioenergy production. | What factors affect small-scale sugarcane producers' potential to participate in bioenergy production? How is their participation affected by their perceptions? | Age of the farmer, gender, land ownership, access to credit, cooperative membership, access to extension services, resource availability (using asset index as a proxy) and psychological capital | Ordinary Least Square regression |
| 2 | To assess the current practices and the level of engagement in bioenergy production of smallholder sugarcane producers. | What are the smallholder sugarcane producers' current practices and the level of engagement in the bioenergy sector? How organized are they? Are they passive or active participants? | sugarcane cropping area, harvesting practices, trash management practices, marketing of bioenergy products and knowledge on bioenergy production The assessment was categorized by gender, level of education and location. | Descriptive statistics |
| 3 | To evaluate factors affecting farmers willingness to participate in bioenergy | What factors determine such practices and level of engagement? | Age, gender of farmer, land under sugarcane, land tenure security, access to credit, access to extension, | Principal Components Regression and OLS Model regression |

| | | | | |
|---|---|---|---|---|
| | production from sugarcane. | | cooperative membership, bioenergy training, PC 1: land, PC 2:food security. | |
| 4 | To highlight what resources and institutional support is required for the smallholders to fully participate in the bioenergy sector. | What resources and institutional support are required by such farmers to participate and benefit from the opportunities in the bioenergy sector? What are the factors affecting farmers willingness to participate in bioenergy? | Land, water, labour, capital, and psychological capital, while institutional variables included financing, market access, and extension support are resources required to participate in bioenergy. | This objective was evaluated using outcomes from objective 1 and 3. |

# CHAPTER 2

# LITERATURE REVIEW

## 2.1. Introduction

Between 2005 and 2015, global biofuel usage rose considerably, from 19.6 to 74.8 million tonnes of oil (BP, 2016). Countries such as the EU and the United States had launched attempts to reduce greenhouse gas emissions by introducing blending requirements for transportation fuels. In South Africa, the transition began with the development of the Bioenergy Industrial Strategy (BIS), which aimed to foster a suitable environment for biofuel marketing. The strategy sought to boost rural development and create income-generating opportunities (BIS, 2007). According to the Department of Mineral and Energy (DME), the plan was created to promote the use of cleaner and more environmentally friendly energy, increase renewable energy production, strengthen the agricultural sector by using surplus farming land, promote sustainable development, and improve energy.

This chapter, therefore, provides an overview of the literature on bioenergy development and production. It begins by analyzing the literature on bioenergy and climate change, then discusses renewable energy as an alternative energy source, the importance of bioenergy as a fuel source, bioenergy production in Africa and South Africa, and advances in the biofuel sector. The final section analyses literature on smallholder participation in bioenergy production.

## 2.2. Bioenergy (biofuel) and climate change

Bioenergy production in Sub-Saharan Africa (SSA) has the potential to improve water use, water quality, greenhouse gas emissions, atmospheric pollution, soil quality/erosion, biodiversity, economic/rural development, energy security, food security, and land access (Gasparatos et al., 2012; Van Eijck et al., 2014; Von Eijck et al., 2014). Since 1900, industrial activity has increased atmospheric carbon dioxide ($CO_2$) levels. The rate of increase of these gases is linked to the use of fossil fuels (Energy Insights, 2011). As a result, reducing the usage of fossil fuels will lower greenhouse gas emissions.

## 2.3. Curbing climate change in Africa

Africa has borne the brunt of climate change induced by greenhouse gas emissions. Most individuals are unaware of the environmental consequences of wealthy nations' and their own governments' actions. The International Business Times (2016) reported on rising sea levels and coastal storms in Kenyan locations. Climate change continues to have an impact on crop output in Sub-Saharan Africa, causing food shortages. Some refugee situations are linked to global warming induced by high carbon emissions. The usage of solid biomass, such as firewood, and fossil fuel products also contributes to a rise in carbon emissions in Africa. Africa has been struck the worst because agriculture is its people's principal source of income.

According to the IPCC (2007), water stress might affect 75-750 million people over the next ten years, and more than 1.8 billion by the end of the century. They also predict that rainfall and agriculture in some parts of Africa will reduce by 50% by 2020. These conclusions emphasise the significance of long-term measures to minimise the effects of climate change. Several such solutions have been proposed in the past, including the following (IPCC, 2007):

a. Reducing subsidies for fossil fuel.
b. Forestation helps reduce carbon emissions. According to the IPCC (2007), tree removal accounts for an estimated 20% of carbon emissions, which is more than the combined emissions of vehicles, planes, and trucks.
c. Increase biofuel production to supplement fossil fuels.
d. Increase biotechnology crop output on dry and barren land to address food shortages and poor caloric intake.
e. Improve energy research and technologies.
f. Encourage the use of renewable energy, including water, wind, and solar, to minimise reliance on coal, oil, and natural gas.

## 2.4. Importance of biofuel in South Africa

South Africa has the greatest energy usage in Africa (BP 2004). From 2001 to 2011, energy consumption increased by 18% (IEA, 2013). The transportation industry consumes most of the energy in the country. By 2012, South Africa used roughly 98.6 million litres (609 000 bbl) of petroleum fuel per day, equivalent to approximately 68 million litres (428 000 bbl) imported per day. In 2012, petrol and diesel accounted for 43% and 41%, respectively. The country's energy use has sparked more requests to increase investment in renewable energy.

South Africa's renewable energy portfolio includes wind, solar, hydropower, and biofuels. According to the South African Renewable Policy, the country is expected to generate around 10,000 GWh by 2013. The primary focus of bioenergy has been on biofuels such as bioethanol and biodiesel. Biofuels can improve local energy access, strengthen the agriculture business and its markets, increase GDP, and ensure rural development. Despite the establishment of policies, biofuel production in South Africa is still in its early phases, with only a few biofuel facilities operational (Estemhuizen 2009). Global biofuel output climbed from about 20 billion litres (125 million barrels) in 2001 to more than 110 billion litres (692.5 million barrels) in 2011 (IEA, 2013). In 2011, South Africa's expected ethanol and biodiesel production was 16,000 and 4770 litres per day, respectively (IEA, 2013). In 2007, the National Biofuels Task Team conducted a feasibility study and created biofuel industry plans (NBTT, 2006). The strategies included increasing rural investment, promoting agricultural growth, reducing poverty through long-term income earning possibilities, and replacing foreign oil imports.

By-products of sugarcane processing are utilised to produce biofuels such as ethanol. Bagasse is the most important byproduct and the primary fuel used to generate steam and electricity for sugarcane and other facilities (Dixon & Bullock, 2004). According to Serna-Saldivar and Rooney (2014), the composition of bagasse fibre left after juice extraction from sugarcane and sweet sorghum varies depending on intrinsic and extrinsic factors such as genotype, maturity (lignification), and environment. Molasses, another lucrative byproduct of sugarcane processing, is used to produce ethanol. Other lighter grades of sugarcane molasses can be used to make culinary seasonings and sweets.

## 2.5. Bioenergy production in Africa and South Africa

From 2005 to 2015, global biofuel consumption increased from 19.6 to 74.8 million tonnes oil equivalent. According to the OECD-FAO (2015), rising oil prices in the mid-2000s boosted demand for biofuels. More countries are implementing new and higher fuel blending rules, which is expected to drive up demand for biofuel. In Africa, the argument for biofuel is said to be motivated by the possibility of domestic biofuel production replacing oil imports while investing in agriculture and easing poverty.

Most African countries are net oil importers; therefore, biofuel would aid their balance of payments and consequently economic stability. This would alleviate the negative repercussions of oil price increases (trade deficit, inflation, and unemployment), which South Africa experienced between 2011 and 2014 (Wakeford 2013). The usage of biofuels has the potential to boost rural development, particularly among small-scale farmers, by increasing feedstock sales and providing jobs in value-chain businesses.

However, the development and expansion of biofuels may have a significant impact on food security, particularly the use of important staple food crops such as maize and soybeans for biofuel production. It may also result in the diversion of inputs (land, labour, and water) away from food production. However, Zilberman et al. (2013) argue that previous research has revealed a mixed and country-specific negative impact on food security. Several studies have found that potential improvements in household income would be sufficient to offset increases in food prices (Ewing and Msangi, 2009; Arndt et al., 2012; Negash and Swinnen, 2013; Schuenemann et al., 2016).

## 2.6. Sources of bioenergy

Palm oil, palm kernel, cassava, sugarcane, rice, peanut, sweet sorghum, and jatropha are among the biofuel (bioethanol and biodiesel) sources in Africa. Maize is not widely used for biofuel generation in Africa since it is a strategic crop for food security. Legume plants for bioenergy include babool, Indian rosewood, yellow flame tree, and locust bean. Some components, such as pods, are employed as a substrate in the biofuel fermentation process (Gulalkayi et al., 2012).

- Monocot plants as a bioenergy source – These include plants such as corn, maize, wheat, sugarcane, sorghum etc.
    - *Corn as a bioenergy source* - The conversion of com to ethanol is referred to as familiar technology. This process occurs when corn is fermented to produce ethanol, with large plants producing 1L from 2.69 kg of corn grains. During the season, irrigation requires approximately 100 cm of water.

Irrigation is required for all farmed land at 8.1 cm per ha. Because maize intensive farming/cultivation is expensive, it is the most popular com Stover. This occurs when some grain remnants remain on the surface immediately after harvest. The remnants include cob, husks, leaves, and stalk fractions. Their high-value maize grain fraction, obtained from the Stover, is a co-product, explaining its abundance. This could lead to the physical availability of com Stover, which can be exploited as a bioenergy product. According to Klingenfeld (2008) and Zych (2008), maize Stover, a second-generation feedstock or cellulosic, can be used in bioenergy applications without harming food production.

- *Maize as a bioenergy source* - This is the most widely grown crop in the world, and it is critical to the creation of biofuel. Maize must be grown for two reasons to produce biofuel: grain production and better yielding stem biomass. Because of a variety of resources, including agronomy and genomic resources, it can be easily cultivated for dual cropping. According to Weijde et al. (2013), because maize has several benefits in terms of resource availability, it can be considered the best model for biomass quality in field study.

- *Wheat as a bioenergy source* - This crop has the potential to become a major crop if the method of turning wheat to ethanol via fermentation yields gasoline that is utilised by automobiles. Wheat is one of the C3 plant species, which are plants that use C3 photosynthesis. According to McKendry (2002), these plants can consume carbon dry mass, which produces enough biomass to convert energy.

- *Sugarcane as a bioenergy source* - Sugarcane is essential for collecting solar energy and converting it into chemical energy. Sugarcane is regarded as a biomass feedstock. When sugarcane is processed, the sugarcane bagasse is produced, which is then burned in boilers to generate steam and power. The advancement of bioethanol production technology will result in more bagasse, which will result in more power production/generation, while the raw material for bioethanol can be utilised to synthesise a variety of different bio-based products (Cushion et al., 2009; Weijde et al., 2013). Bagasse from sugarcane is a lignocellulosic substance. Lignocellulosic materials are made up of three main constituents: cellulose, hemicellulose, and lignin. To begin, cellulose is a glucose polymer, whereas hemicellulose is mostly composed of glucose, mannose, xylose, and arabinose. Sugarcane bagasse should be further processed through fermentable sugars to utilise as a raw material for bioethanol production. The process of separating lignin and hemicellulose from cellulose in bagasse should include a pre-treatment phase to improve bagasse quality and make cellulose hydrolysis easier (Elbehri et al., 2013).

- *Sorghum as a bioenergy source* - This is also regarded as a unique species since it contains two types of grains: sugar type and biomass type. Because the sorghum genome is available, it offers up potential for first- and second-generation biofuel crops. Forage sorghum produces a high volume of biofuels. Sorghum can be produced using the same methods/procedures as biofuels. Sweet sorghum has several advantages over sugarcane, including abiotic stress tolerance and resource use efficiency. Because of its simpler genetics and annual nature, sorghum can be enhanced as a bioenergy crop by combining genetics, agronomic techniques, and processing technology.

## 2.7. Potential for bioethanol production in Southern Africa

South Africa has an ideal climate, arable land, and water for biofuel production (Smeets et al., 2004; Schut et al., 2010). The availability of resources allows for large-scale production of crops such as maize, sugarcane, sugar beetroot, sweet sorghum, jatropha, castor beans and soybean oil, which are used as first-generation feedstocks. On the other hand, sugarcane-based ethanol has been regarded as the most viable first-generation technology for manufacturing biofuels. Other feedstocks and developing technology channels provide alternatives for ramping up production. After all, there are multiple stages of biofuel development, each with varying levels of certainty about their economic feasibility.

Sugarcane production is encouraged as a foundation for biofuel generation for a variety of reasons. To begin, sugarcane has been one of the most popular bioethanol feedstock endeavours in Africa due to its lengthy history of usage as a bioethanol feedstock in other countries, particularly Brazil, as well as its high yields and long history of cultivation in the region (Braude, 2015; Dubb et al., 2016). One of its qualities is that it contributes significantly to climate change mitigation by lowering carbon dioxide emissions, and while stated estimates vary due to different assumptions, sugarcane is frequently regarded as the best crop in first generation feedstocks (European Parliament, 2015). Sugar prices are currently reducing on the global market (OECD-FAO, 2015). However, the removal of EU sugar production beginning in 2017 has a favourable impact on African sugar exports to the region, where it has previously enjoyed free quota access for raw sugar.

The production of vast quantities of biofuel feedstocks, such as sugarcane, varies throughout Southern Africa. Sugarcane production is best suited to places with superior soils, higher rainfall, and better irrigation, such as northern Mozambique and Zambia (Von Maltitz, 2008). South Africa's output of biofuel feedstocks is limited. While it has the biggest sugarcane land in the region, with approximately 320,000 hectares (Ha), biophysical factors hinder its expansion (Von Maltitz, 2008). According to the South African Sugar Association, replacing around 2% of petroleum usage with sugarcane-based ethanol would require 10% of South Africa's present sugar land (SASA, 2007). According to ITAC (2014), a dollar-based import charge protects domestic sugar manufacturers from low worldwide sugar prices. However, domestic producers can continue to profitably make ethanol before addressing domestic sugar demand.

## 2.8. Smallholder participation in bioenergy production in Africa and South Africa

*Biofuel feedstocks in SSA*

Jatropha (for straight vegetable oil or biodiesel) and sugarcane/molasses (for bioethanol) are the two most common biofuels investments in Africa. Other feedstocks that produce positive results include cassava (for bioethanol), tropical sugar beets (for bioethanol), canola oil (for biodiesel), and sunflower oil (for biodiesel) (Mitchel, 2014; Van Eijck et al., 2012; Vang Rasmussen et al., 2012; Negussie et al., 2015). According to Field et al. (2008), SSA is most likely to have a large feedstock. However, a lack of knowledge, infrastructure, and qualified technical personnel has resulted in little exploitation of the prospects afforded by this feedstock (IEA, 2010).

Jatropha became one of the main biodiesel crops in Southern Africa between 2005 and 2009, when it peaked (Von Maltitz, 2014; Lerner et al., 2010). This brought attention to nations like Ghana, Kenya, Tanzania, Senegal, Mali, Burkina Faso, and Benin (Romijn and Canies, 2011). It began in 2008, with approximately 12 000 ha of land (13% of the global total) set aside for jatropha growth in SSA. Gexsi (2008) projected that around 2 million acres of jatropha were scheduled for cultivation in SSA in 2015. However, it was revealed that jatropha cultivation required a large amount of water, approximately 1500 mm/year, to be successful (Trabucco et al., 2010). This impacted productivity in several semi-arid locations across the continent. However, jatropha was found to be effective in a few countries, including Mozambique and Malawi, with high production on arable abandoned plantations, but in Zambia and Malawi, it happened on existing agricultural land (Von Maltitz et al., 2014).

Sugarcane is often regarded as the top crop for biofuel production in SSA (FAO, 2014). Sugarcane production takes a huge amount of land, and the top producers in SSA are Kenya, Malawi, Mozambique, Tanzania, Zambia, and Zimbabwe (Watson, 2011). According to Watson (2011), six Southern African countries have around 6 million hectares of land suitable for sugarcane production. In certain countries, such as Malawi and Tanzania, yields exceed 100 t/ha (FAO 2014). The existing output of sugarcane and ethanol in several countries in SSA implies that availability to land may be a limiting issue in sugarcane expansion. Malawi has shown promising results in sugarcane ethanol production, and this biofuel option is gaining popularity in countries with hundreds of thousands of hectares of sugar production land, such as Mozambique, Tanzania, Sierra Leone, Zambia, and Zimbabwe (FAO, 2014). It is crucial to note that in some of these countries, high potential sugarcane production and energy returns can be attained with minimal land acquisition (Gasparatos et al., 2012).

### 2.9. Summary

The review focused on bioenergy development and production in Africa and South Africa. The review discussed the relationship between bioenergy (biofuel) and climate change, the significance of biofuels in South Africa, bioenergy production in Africa and South Africa, bioenergy sources, the potential for bioethanol production in South Africa, and smallholder participation in bioenergy production.

When compared to fossil fuels, bioenergy has the potential to dramatically cut greenhouse gas emissions. Using waste biomass for energy helps to reduce climate change by trapping carbon that would otherwise be discharged into the atmosphere. Bioenergy encourages the optimal use of agricultural and forestry wastes, thereby reducing waste and environmental damage. It also promotes the recycling of organic waste into useful energy resources. Bioenergy improves resource efficiency by using agriculture and forestry leftovers and byproducts, as well as supporting sustainable land management methods. The use of bioenergy byproducts, such as biochar, can increase soil health and fertility, hence increasing agricultural productivity and sustainability.

Access to bioenergy can improve the quality of life in rural regions by providing cleaner cooking fuels, lowering indoor air pollution, and promoting healthier lifestyles. Bioenergy projects frequently involve local communities in decision-making processes, instilling a sense of pride and empowerment. Community-based bioenergy initiatives can help to build social cohesion and promote sustainable development.

Bioenergy generation and use can help to develop jobs in rural regions. In addition to providing sustainable electricity and limiting load shedding/load reduction. This improves the livelihood of rural people. In addition, the global policy for the Sustainable Development Goals (SDGs) 7 (Affordable and Clean Energy) and 13 (Climate Action) will be improved. Improve youth participation in bioenergy.

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This chapter concentrated on the technique utilized in the study. It presented the historical background of Ehlanzeni District in Mpumalanga Province, as well as a population sample from the area. It also described the collecting and analysis methods, as well as a description of the data that was collected. Each aim was presented and explained separately in terms of data requirements and analysis methodology. Sections 3.2-3.6 discuss the study's conceptual framework, subject area, research design, data gathering techniques, and provides analysis information for each target. Section 3.7 summarized the study's approach.

## 3.2 Conceptual framework

The conceptual framework of this study is mostly based on the notion of reason action. According to the idea of reason action behaviour, a person's intentions or behaviour are determined by their attitude and subjective norms. In this study, smallholder farmers' attitudes and subjective laws could potentially influence their participation in bioenergy production. Their perceptions will impact their actions and behaviour. Previous research has defined awareness as knowledge or consciousness, according to (Thellufsen et al., 2009).

For example, environmental awareness consists of five components: environmental knowledge, environmental values, environmental attitudes, revealed desire to act, and actual conduct, which provide excellent insights into critical indicators of emphasis (Zsoka, 2008). This means that smallholder farmers who want to participate in bioenergy production must be knowledgeable, have a good attitude towards alternate forms of energy, and be prepared to invest time and resources. Bioenergy awareness refers to farmers' understanding of bioenergy, as well as their perceptions, attitudes, and plans to employ it. It is worth noting that different scholars have suggested that perceptions can occur even when the perceiver is unaware of it (Merikle et al., 2001).

Several factors have the potential to influence smallholder farmers' engagement in bioenergy production (Figure 1). Awareness is strongly tied to one's perceptions. According to Feola and Binder (2010) and Ohlmer et al. (1998), it is critical to first understand the farmer's viewpoint and decision-making behaviour before adopting new sustainable methods. Other elements that could affect farmers' decisions and behaviours include access to water, access to electricity, credit knowledge, inputs, markets, and procedures for collecting and selling crops. These issues may limit the efficient use of land, output commercialization, and revenue creation (Dorward et al., 2009; Stringer et al., 2020). The bioenergy sector is worse since present assistance (both information and resources) is oriented towards large agribusiness corporations rather than smallholder farmers (Hall 2009).

Smallholder farmers have reaped nothing but poverty and social injustice from participation in the bioenergy market due to a lack of awareness, insufficient expertise, poor policies, and related social networks (Woods, 2008; Hall, 2009). Policies and institutional support are crucial for increasing bioenergy production (Sakai et al., 2020). Furthermore, farmers' psychological abilities may influence their willingness to participate in bioenergy production (Frese and Gielnik, 2014; Chipfupa et al., 2021). According to Adekunle et al. (2009) and Ahaibwe et al. (2013), youth view agriculture as a low-status, unclean, and unpleasant vocation. According to Abdullah et al. (2012), agriculture is viewed as a part-time employment rather than a professional or sustainable living. Qwabe (2018) found that elders in smallholder agriculture are not upfront about their profitability, leading young people to believe that agriculture is unprofitable. However, the National Planning Commission (2012) reported that agriculture has the potential to provide a million jobs by 2030.

This is because farming entails a lot of decisions and tasks that require psychological preparation. Finally, smallholder farmers' participation in the bioenergy sector is predicted to contribute significantly to rural development by providing energy security, food security, job creation, and income diversification (GBEP, 2011).

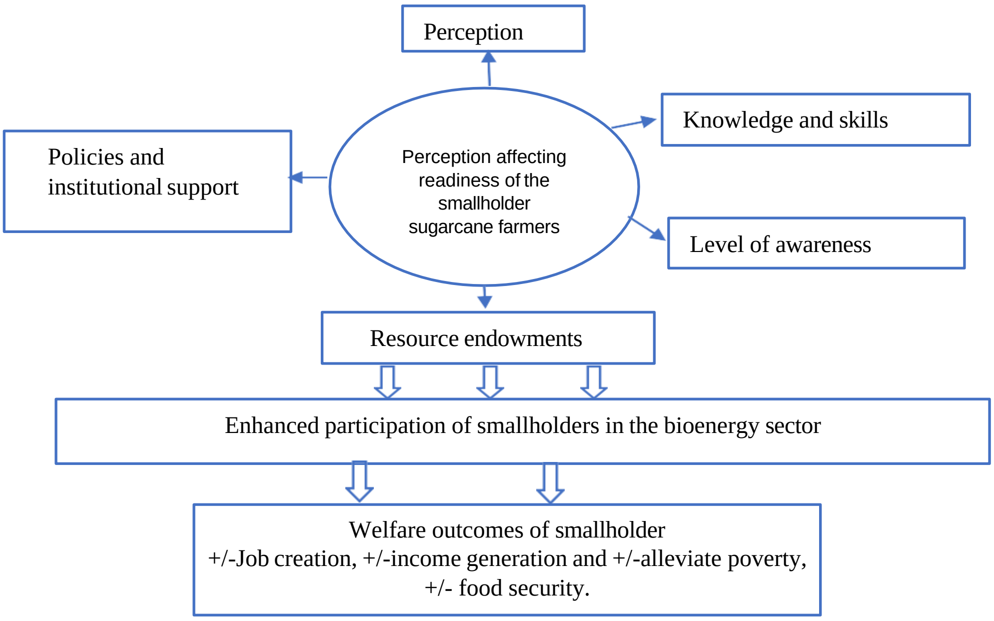


**Figure 1:** Participation of smallholder farmers in the bioenergy sector

### 3.3 Study area.

Ehlanzeni District is part of Mpumalanga Province. The district is located at the following coordinates. Latitude: 25°29'27" S, longitude: 31°30'21" E. It is situated to the east of Mozambique and north of Swaziland. It connects the national road (N4) and the Mozambique railway line. According to the Ehlanzeni Integrated Development Plan (2014), it is linked to Swaziland via two provincial plans. The district covers 4786.86 km2, or 23% of the province's land mass (Municipalities, 2020). Agriculture, tourism, and forestry dominate the Nkomazi Local Municipality, benefiting the area's economic activities.

The average monthly income in the district is R1 600p/m, which is significantly lower than the R3 200 minimum income required to support a typical home. Wholesale and retail employ the most people, accounting for 32%, followed by community and social services at 24%. Agriculture, according to the Komati/Ngwenya Private Sector Forum (2007), is the third largest source of employment, accounting for 13%. Sugarcane production takes up around 18 000 hectares of land, while other crops like banana growing take up about 6000 hectares. Nkomazi has a subtropical climate, with hot, humid summers and mild winters (Census 2020).

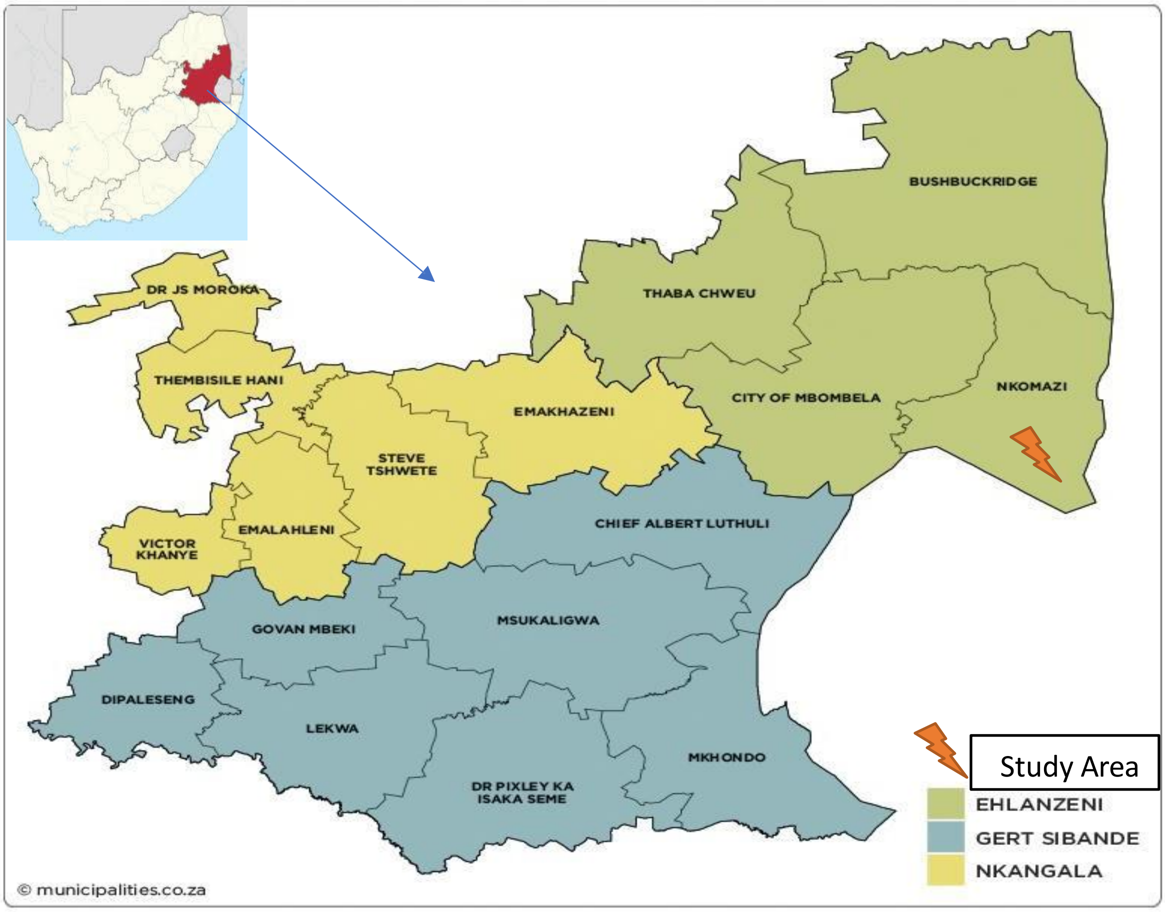


**Figure 2:** Ehlanzeni District showing Nkomazi Municipality.

**Source:** http://municipality.co.za; Accessed on 27 August 2020

### 3.3 Research Design

The study followed a cross-sectional research design. Cross-sectional design is just a temporal study in which data is collected once. The study is quantitative in nature; hence data was collected using a semi-structured questionnaire. The data was collected at a single point in time to evaluate smallholder sugarcane producers' perceptions and practices in bioenergy production. Key informant interview was used. The participants in the study were chosen using the sampling method described in Section 3.5.

### 3.4 Data collection methods

The study's sample population consisted of smallholder sugarcane producers from the Ehlanzeni district. According to data from the Department of Agriculture, Rural Development, Land, and Environmental Affairs in the district, there are approximately

893 active smallholder sugarcane growers. The study's sample was selected from the entire population. The sample unit was the household. The sample size for the investigation was calculated using the formula below (Krejcie and Morgan, 1970).

*3.4.1. Sample population and sample size.*

s= $X^2$ NP (1 - P) ÷ $d^2$ (N - 1) + $X^2$ P (1 - P).

s=required sample size

$X^2$=the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841)

N= the population size

P= the proportion (assumed to be .50 since this would provide the maximum sample size)

D= the degree of accuracy expressed as a proportion (.50)

S= $(3.841)^2$ × 893×0.50÷ $(0.50)^2$ (893-0.50) + $(3.841)^2$× 0.50 (1-0.50)

Thus, given a population of 893 smallholder farmers, a sample size of 269 smallholders was generated using Microsoft Excel's rand function. The study's final interview sample size was 134 which was interviewed in November 2021. The remaining farmers were either unavailable for the poll or declined to be interviewed. Research weariness is the primary reason why some people might refuse.

*3.4.2. Data collection tool*

a. Primary data

Primary data were acquired by a questionnaire survey of active smallholder sugarcane growers. The questionnaire sought information on farmers' demographics, socioeconomic level, awareness, perceptions, and existing practices in bioenergy production, among other topics. The questionnaire consisted of both structured and semi-structured questions. Interviews were held in Swati and English to suit all farmers.

b. Secondary data

This data was collected through the literature review set on awareness, perceptions, and current practices in bioenergy production among sugarcane producers. The administration records/reports were used and internet web sites as sources of secondary data. This gave a guide on either they are suitable or not.

### 3.5 Data analysis

A combination of descriptive statics (frequencies, cross tabulations, graphs) and econometric models were used to analyze data and make informed conclusions regarding the hypotheses of the study. Some inferences were made using inferential statistics such as the t-statistic, Person Chi-square test and Levene's F test to obtain a comprehensive analysis.

*3.5.1. Objective 1 - To determine factors affecting small-scale sugarcane producers' potential to participate in bioenergy production.*

This objective was measured by evaluating the factors influencing farmers' potential to participate in the production of bioenergy from sugarcane. The farmers potential to participate, measured as the amount of bagasse from their 2021 production, is the dependent variable. The amount of bagasse was calculated based on evidence from previous studies adjusted for local conditions. According to Solomon and Singh, (2005), "if a factory processes a 100 ton of sugarcane it yields 10 tons of sugar, 30-34 ton of bagasse, 4.45 tons of molasses, and 3 tons of filter mud (press mud)". Hence, one tonne of sugarcane produces an estimated 0.3 tonnes of bagasse.

The study used these figures to determine the potential bioenergy production from farmers current supply to the market. The independent variables included in the model are age of the farmer, gender, land ownership, access to credit, cooperative membership, access to extension services, resource availability (using asset index as a proxy) and psychological capital. Psychological capital was represented by three principal components. The principal components analysis results are represented in Chapter 5. Below is the specification of the Ordinary Least Squares regression model (Gujarati, 2004).

Please note the dependent variable was log-transformed to standardize the variable.

Hence, the model became a log linear regression.

$\text{Log } Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots\ldots + \beta_n X_n + \varepsilon$

Where:

Y - Amount of bagasse (tons)

$X_1 – X_n$ - Independent variables

$\beta_1$ - $\beta_n$ – Parameter estimates

$\beta_0$ – Constant

$\varepsilon$ - Error term

**Table 3.1**: Explanatory variable used in the Ordinary Least Square regression.

| Variable | Variable description | Values | Expected sign |
|---|---|---|---|
| $X_1$ =Age | Age | | -/+ |
| $X_2$= Gender | Gender | 0= Female; 1=Male | -/+ |
| $X_3$=Land ownership | Land ownership | | -/+ |
| $X_4$=Access to credit | Access to credit | 0= No; 1=Yes | -/+ |
| $X_5$=Cooperative membership | Cooperative membership | 0=No; 1=Yes | -/+ |
| $X_6$=Access to extension services | Access to extension services | 0=No; 1=Yes | -/+ |
| $X_7$=Asset index | Asset value (Log) proxy for resource availability | 0=No; 1=Yes | -/+ |
| $X_8$ = PC1 | Confidence | | -/+ |
| $X_9$ = PC2 | Resilient but opportunistic | | -/+ |
| $X_{10}$=PC3 | Risk takers | | -/+ |

**Note**: See section 5.2.1 for description of the PCs

*3.5.2. Objective 2 - To assess the current practices and the level of engagement in bioenergy production of smallholder sugarcane producers.*

Descriptive statistics was used to assess current practices and the level of engagement which include the sugarcane cropping area, harvesting practices, trash management practices, marketing of bioenergy products and knowledge on bioenergy production, among others. The assessment was categorized by gender, level of education and location.

*3.6.1.3. Objective 3 - To evaluate factors affecting farmers willingness to participate in bioenergy production from sugarcane.*

The objective was analyzed using Principal Components Regression. Compared to binary measures, OLS and PCA provided a more detailed and flexible way to quantify willingness. They offer deeper insights into the variables influencing willingness and enable the investigation of intricate linkages. A PCA was first conducted to reduce the dimensionality of the variables measuring farmers' willingness to engage in the bioenergy sector. The resulting PCs, with eigenvalues greater than 1, according to the Kaiser Criterion, and explaining most of the variable in the data were stored as scores in the dataset to be used as dependent variables in the OLS regression. Only factor loadings greater than 0.3 were considered in the interpretation of PCA results (Jollife, 2002).

The specification of the Principal Component Regression and OLS Model regression was estimating determinants of farmers' willingness to participate in bioenergy production is given as follows:

$Y = \beta 0 + \beta 1\ X1 + \beta 2\ X2 + \beta 3\ X3 \ldots\ldots + \beta n\ Xn + \varepsilon$

Where:

Y –Willingness (Principal Component of farmers willingness to engage)

X 1 – X n - Independent variables

β1 - βn – Parameter estimates

β0 – Constant

ε - Error term

**Table 3.2**: Description of variables for the Principal Component Regression OLS Model

| **Variable** | **Variable description** | **Values** | **Expected sign** |
|---|---|---|---|
| Independent variables | | | |
| $X_1$ = Age of farmer | Age of farmer | | -/+ |
| $X_2$ = Gender of farmer | Gender | Male=0; Female= 1 | -/+ |
| $X_3$= Land under sugarcane | Land under sugarcane | | -/+ |
| $X_4$ = Land tenure security | Land tenure security | 1= Strongly disagree; 2= Disagree; 3= Neutral; 4= Agree; 5= Strongly agree | -/+ |
| $X_5$= Access to credit | Access to credit | 1=Yes; 2= No | -/+ |
| $X_6$= Access to extension | Access to extension | 1= Yes; 2= No | -/+ |
| $X_7$ = Cooperative membership | Cooperative membership | Member of a cooperative = 1; Otherwise =0 | -/+ |
| $X_8$ = Bioenergy training | Bioenergy training | 1= Yes; 2= No | -/+ |
| $X_9$ =PC 1 | Land | | -/+ |
| $X_{10}$ =PC 2 | Food security | | -/+ |

**Note:** See Section 5.3.1. for description of the PCs

*3.6.4. Objective 4 - To highlight what critical resources and institutional support is required for the smallholders to fully participate in the bioenergy industry.*

This objective is evaluated using the outcomes from objectives 1 and 3. The emphasis was on variables related to resource endowment and institutional support. Critical elements were land, water, labour, capital, and psychological capital, while institutional variables included financing, market access, and extension support. Additional data on general problems was obtained and used to supplement the model's results. Using the empirical model results, we ensured that recommendations only addressed obstacles that had a significant impact on farmers' willingness to participate in bioenergy production.

## 3.7. Summary of chapter

The methodology gave additional information about the study, including the study area. A cross-sectional search was conducted to identify 134 smallholder farmers who were accessible or willing to participate in the survey. The data was gathered using primary and secondary data. Several models, including the ordinal least squares regression model, descriptive statistics, inferential model, and principal components regression, were described. The study's conclusion was drawn based on the outcomes of objectives 1 and 3 obtained after conducting the study.

# CHAPTER 4

# SOCIO-DEMOGRAPHIC AND ECONOMIC CHARACTERISTICS OF SMALLHOLDER SUGARCANE FARMERS

## 4.1. Introduction

This chapter provides a descriptive examination of the demographic and socioeconomic features of smallholder sugarcane producers. The assessment was carried out to summarize the data collected and better understand the characteristics of smallholder sugarcane growers. The data presented in this chapter was analyzed using frequencies, means, t-tests, and Chi-squared.

## 4.2. Descriptive characteristics of smallholder farmers

### 4.2.1Type of a farmer

The table shows the composition of farmers in the study sample. The findings reveal that most of the farmers operated independently (96.5%). Despite government efforts to promote cooperatives in smallholder agriculture as a stimulus for rural development, farmers continue to choose individualistic modes of operation. This tendency represents the underlying obstacles that cooperative structures face in the South African environment. According to Van der Walt's (2005) research, the most common causes of cooperative failures in South Africa are a lack of leadership trust, ineffective application of governance principles in cooperative management, and a lack of accountability.

**Table 4.1** Type of a farmer

| Type of a farmer | Percent |
|---|---|
| Individual farmer | 96,5 |
| Part of a cooperative | 3,5 |
| **Total** | **100,0** |

**Source**: Survey (Nov 2021)

### 4.2.2. Socio-economic characteristics of a farmer (Gender, Marital status, Main Occupation)

The offered table depicts the gender distribution among survey participants, demonstrating that male farmers (58.5%) are more involved in sugarcane cultivation than their female counterparts. Muntema and Blackden's (2001) examination into gender and poverty in Africa highlights the limited access and control that women in Sub-Saharan Africa have over critical assets and resources such as land, technology, financial services, and labour, as opposed to men. This lack of control presents itself in women taking on passive roles in sugarcane cultivation, as confirmed by Stockbridge (2007), who classifies sugarcane as a largely male-associated cash crop.

The findings highlight the patriarchal nature of Africa's smallholder agricultural sector, as indicated by Montshwe's (2006) recognition of widespread male dominance in South Africa's agricultural domain. Cheteni (2014) has a similar observation about gender dynamics in agriculture. Respondents from the Eastern region also emphasize the prevalence of male membership in agricultural organizations or societies. Notably, research by Dubbert (2019) and Meemken et al. (2019) suggests that women's limited participation in contract farming might be attributable mostly to household duties.

The following table indicates the respondents' marital status. The findings reveal that married people (89%) are more involved in sugarcane cultivation than others. Martially unified agricultural practitioners are more likely to engage in enhanced sugarcane farming as a method of supporting their livelihoods and meeting increased parental responsibilities. Machimu (2017) stated that married couples are more likely to participate in CF activities than unmarried couples, owing to a higher sense of family commitment. According to Oladele (2011) a larger proposition of married farmers may contribute to increased family agricultural labour.

The table below shows the primary occupations of the respondents. According to the findings, sugarcane cultivation involves more full-time farmers (87%) than other crops. According to StatsSA (2017), 41% of households in Limpopo Province are involved in some sort of agricultural production, making it the province with the highest proportion of such households nationwide (De Cock et al., 2013).

**Table 4.2** Socio-economic characteristics (Gender, marital status and main occupation)

| Socio-economic characteristics | Frequency | Percent |
|---|---|---|
| **Gender** | | |
| Male | 83 | 58,5 |
| Female | 59 | 41,5 |
| **Marital status** | | |
| Married | 89 | 62,7 |
| Single | 25 | 17,6 |
| Windowed | 18 | 12,7 |
| Divorced/separated | 6 | 4,2 |
| Cohabiting | 4 | 2,8 |
| **Main Occupation** | | |
| Fulltime farmer | 124 | 87 |
| Regular salaried job | 8 | 5,6 |
| Retired | 4 | 2,8 |
| Self-employed | 3 | 2,1 |
| Temporary employed | 1 | 0,7 |
| Unemployed | 1 | 0,7 |
| Student | 1 | 0,7 |

**Source:** Survey (Nov 2021)

### 4.2.3. Socio-economic characteristics (Age, household size, dependency ratio)

The table shows the age distribution of respondents, with a mean age of 59.6 years among farmers. Most farmers, 52.8%, were 60 years or older, with only 4.2% being young. These findings support Antwi and Seahlodi's (2011) assertion that such demographic patterns pose a significant threat to the future of agriculture, particularly in terms of productivity and the development of a viable succession planning strategy as ageing farmers retire.

According to Akinwumi et al. (2000), elderly farmers' risk aversion and reduced flexibility in comparison to their younger counterparts may lead to a reluctance to adopt no agricultural advances, thus limiting agricultural progress. This incongruity is most likely due to younger farmers' proclivity to be more receptive to researching and implementing innovative agricultural approaches, combined with a reduced aversion to risk and longer planning horizons. Furthermore, as stated by Onweremadu and Mathews-Njoku (2007), older farmers frequently stick to traditional farming methods, resulting in a decreased propensity and responsiveness to knowledge about developing agricultural technologies.

Drawing on Kabwe's (2012) findings, it is discovered that elder farmers have greater expertise in agricultural production and have developed important networks, resulting in a more productive conduct of their agricultural enterprises when compared to their younger counterparts.

The table shows the household size distribution among survey participants, with males outnumbering females. According to Asfaw and Admassie (2004), male-headed families disseminate information about novel agricultural technologies faster than female-headed households. Similarly, the Department of Agriculture, Forestry, and Fisheries (2012) emphasized a decrease in agricultural activity among female-headed families, influencing their awareness levels about agricultural advances. Balarance and Oladele (2012) stated that, while higher household sizes may provide benefits in terms of farm work, they also have a negative impact on farm income.

Swain's (2018) academic remarks also supported the findings, indicating that farmers were more likely to include their family members in agricultural duties rather than hire outside workers.

A comparison of male and female mean ages reveals that more males (mean age = 5.3) participate in smallholder sugarcane cultivation than females (mean age = 5.4). This may have an impact on the success of male and female farmers in the sector.

The following table illustrates the respondents' dependency ratio. The ratio was less than 1 for both male and female headed households. This means that there are more economically productive members in the households compared to dependents. The data indicate that female headed households are more economically burdened compared to male households. This might affect their participation in economic activities such as farming. This supports the Department of Agriculture, Forestry, and Fisheries' (2012) claim that women-led households engage in agriculture at a low rate.

**Table 4.3** Socio-economic characteristics (Age, household size, dependency ratio)

| Socio-economic characteristics | N | Mean | Std.Dev | Std.Error |
|---|---|---|---|---|
| **Age Category** | | | | |
| 18 -34 years | 6 | 30,5 | 1,9 | 0,8 |
| 35 - 59 years | 61 | 51,1 | 6,5 | 0,8 |
| 60 years and above | 75 | 68,8 | 7,5 | 0,9 |
| **Household size and member** | | | | |
| Male | 83 | 5,3 | 1,9 | 0,2 |
| Female | 59 | 5,4 | 2,2 | 0,3 |
| **Dependency ratio** | | | | |
| Male | 79 | 0,7 | 1 | 0,1 |
| Female | 57 | 0,8 | 1 | 0,1 |

**Source:** Survey (Nov 2021)

### 4.2.4. Average social grant per annum received by farmers.

The respondents' age categories are shown in the table below. According to the findings, 51 farmers over the age of 60 receive grants as a source of income, outnumbering young farmers. According to Steyn (2023), there are four distinct categories of grants: The Child Support Grant, established in 1998 to replace the State Maintenance Grant (valued at R510 in 2023); the Foster Child Grant, designed for parents fostering children (valued at R1,130 in 2023); and the Old Age Grant, designed for individuals aged 60 and up, subject to a means test.

Prior to 2008, the eligibility age for men was 65, and for women it was 60 (valued at R2,090 in 2023); the Grant in Aid, intended for Older Persons in need of full-time care, introduced in 1996 (valued at R510 in 2023); the Disability Grant, allocated to temporarily or permanently disabled individuals (valued at R2,090 in 2023); the Child Care Dependency Grant, established in 1996 for disabled children requiring full-time care (valued at R2,090 in 2023); and the Covid-19.

**Table 4.4** Social grant by age category of the farmer (n=86)

| Age category | N | Mean | Std. Dev | Std. Error | Minimum | Maximum |
|---|---|---|---|---|---|---|
| 18 - 34 years | 5 | 8388,0 | 8558,8 | 3827,6 | 0,0 | 20400,0 |
| 35 - 59 years | 30 | 13554,7 | 11744,4 | 2144,2 | 0,0 | 40000,0 |
| 60 years and above | 51 | 17181,5 | 8983,9 | 1258,0 | 0,0 | 40000,0 |
| **Total** | **86** | **15405,1** | **10197,1** | **1099,6** | **0,0** | **40000,0** |

**Source:** Survey (Nov 2021)

### 4.2.5. Access to credit by small-scale sugarcane farmers

The table below indicates whether farmers had access to financing or not. Most farmers (61,3%) have access to financing. Farmers borrow money from local cooperatives but struggle to repay them on time due to long payback periods and sugar mill delays (DADO-Sunsari, 2017; DADO-Morang, 2017; Sharma, 2013). Credit provided through microfinance channels is repaid in incremental and predefined instalments (Ledgerwood, 2002). These findings are consistent with those found by Baloyi (2011), suggesting that financial resources have a significant impact on successful output. This is especially true in sugarcane farming, where the use of hired manpower, irrigation equipment, and rented tractors requires financial remuneration.

**Table 4.5** Access to credit for farmer

| **Access to credit** | **Percent** |
|---|---|
| Yes | 61,3 |
| No | 37,3 |
| **Total** | **100,0** |

**Source:** Survey (Nov 2021)

The table below lists the various financial institutions and providers for smallholder farmers. This demonstrates the influence of microfinance institutions, such as the lending company Akwandze Agricultural Finance, on farmers' participation in sugarcane cultivation. According to empirical data, having access to financial services can reduce household vulnerability, increase earnings, and promote entrepreneurial activity (King and Levine, 1993; King and Levine, 1993a; Levine, 2004; Merton and Bodie, 2004; Seidman, 2005; Amendariz de Aghion and Morduch, 2010; Nayak, 2015). According to Mahjabeen (2008) micro agricultural finance institutions play an important role in raising rural households' income and consumption standards, reducing income gaps, and increasing overall welfare.

This highlights the usefulness of micro-agricultural finance as a strategic development method, with substantial policy implications for poverty alleviation, equitable income distribution, and achieving the Millennium Development Goals (MDG). It is worth noting that, as Hanekom (1998), stated that the South African government has historically established the Agricultural Credit Board (ACB) to handle the resource and debt needs of economically fragile commercial farmers.

**Table 4.6** Financial institutions/providers for smallholder farmers.

| Where did you get your loan? | Percent |
|---|---|
| Micro finance | 34,5 |
| Money lenders | 7,7 |
| Banks | 7,0 |
| Savings club | 3,5 |
| Government | 0,7 |
| Non applicable | 46,6 |
| **Total** | **100,0** |

**Source:** Survey (Nov 2021)

## 4.3. Sugarcane production and practices

### 4.3.1. Farm size of plot (hectares) you own/ have access to

Farm size of plot you own/access for sugarcane A t-test using independent samples was used to compare the quantity of land owned by men and women. There were significant differences in hectares (p=0.027), with males having a mean of 1.24 and a standard deviation of 0.53 compared to females, who had a mean of 1.15 and a standard deviation of 0.36. Significant differences in the means varied in magnitude from 1.24 to 1.15. According to the overarching perspective stated by Basnayake and Gunaratne (2002), the insignificance of land in sugarcane production implies that land size has little influence on the process. The hypothesis was so supported.

**Table 4.7** Farm size of plot (hectares) you own/have access to

| Gender | Mean | Std. Dev | t | Two- sided P |
|---|---|---|---|---|
| Female | 1,2 | 0,4 | -1,1 | 0,3 |
| Male | 1,2 | 0,5 | -1,2 | 0,2 |

**Source:** Survey (Nov 2021)

### 4.3.2. Means of ownership for the farm size of plot 1 owned by farmer.

Crosstabs were used to compare the means of ownership for plot 1's farm size by gender. In comparison to female farmers, about 66 male farmers owned land PTO, 15 owned lands through private rights, one leased/rented land, and one borrowed land. Several businesses, including cooperatives, individual growers, and collaborative arrangements like the Transvaal Suiker Beperk (TSB), have reached agreements, including those with communities obtaining restitution awards. This strategic move by TSB arose from the awareness that a significant percentage, 62%, of sugarcane production land had been handed to black communities.

According to James and Woodhouse (2017), the joint-venture approach entails establishing farming services companies as a 50/50 partnership between an organization representing the applying community (such as trusts or community property associations) and TSB Shubombo Agricultural Services. The trusts are compensated by these joint venture entities for leasing the land. The effectiveness and efficiency demonstrated by joint-venture farms in sugarcane production highlight the success of land restitution in Mpumalanga's sugar industry, as described in this perspective.

**Table 4.8** Means of ownership for the farm size of plot 1 owned by farmer.

| Means of ownership | Male | female | Total |
|---|---|---|---|
| Owned – PTO | 66 | 50 | 116 |
| Owned - private rights | 15 | 9 | 24 |
| Leased/rented | 1 | 0 | 1 |
| Borrowed | 1 | 0 | 1 |
| **Total** | **59** | **83** | **142** |

**Source:** Survey (Nov 2021)

### 4.3.3. Area of sugarcane planted (ha) in 2020/21 season.

The table below displays the area of sugarcane planted (ha). The average sugarcane output for farmers is 8.0 hectares. According to the SASA (2023), in the years 2020/21, there were 360,800 hectares dedicated to sugarcane growing in South Africa. However, the area increased dramatically by 2023/24, reaching 379,500 hectares (SASA, 2023). These findings are consistent with data from the National Statistics Office (NSO, 2020), which show that 92.8% of rural households engaged in agricultural activities.

**Table 4.9** Area of sugarcane planted (ha) (n=122)

| Area (ha) | N | Mean | Std. Dev | Std. Error |
|---|---|---|---|---|
| **Total** | 122 | 8,0 | 5,6 | 0,5 |

**Source:** Survey (Nov 2021)

### 4.3.4. Quantity of sugarcane harvested (tons/kgs) in 2020/21 season.

The table below displays the quantity of sugarcane collected (tons/kgs). Farmers harvested an average of 551.5 tonnes per kilogram. According to the SASA (2023), in 2020/21, 17 199 179 MT of sugarcane was harvested in South Africa. However, the quantity collected increased dramatically by 2023/24, reaching 18,500,000 MT (SASA, 2023).

**Table 4.10** Quantity of sugarcane harvested (tons/kgs) (n=121)

| Quantity harvested (tons/kgs) | N | Mean | Std. Dev | Std. Error |
|---|---|---|---|---|
| Total | 121 | 551,5 | 442,7 | 40,2 |

**Source:** Survey (Nov 2021)

### 4.3.5. Quantity of sugarcane sold (tons/kgs) in 2020/21 season.

The table below displays the quantity of sugarcane sold (tons/kgs). The average amount of sugarcane sold by farmers is 551.2 tons/kg). In 2020/21, the yield per hectare was 69 metric tonnes. By 2023/24, the yield per hectare had reached 74 MT (SASA, 2023).

**Table 4.11** Quantity of sugarcane sold (tons/kgs) (n=120)

| Quantity sold (tons/kgs) | N | Mean | Std. Dev | Std. Error |
|---|---|---|---|---|
| Total | 120 | 551,2 | 444,6 | 40,6 |

**Source:** Survey (Nov 2021)

### 4.3.6. Yield of sugarcane in 2020/21 production

The yield of sugarcane is displayed in the table below (t/ha). The average sugarcane yield for the farmers is 73.4t/ha. According to Emana and Gebremedhin (2007), the correlation between farm size and crop production (yield—tonnes/ha) cannot be predicted in advance. Observations indicate a diminishing trend in sugarcane production and a reduction in the count of small-scale sugarcane farmers among the agricultural community in the Nkomazi Local Municipality, as highlighted by studies conducted by (James and Woodhouse ,2017; Metiso & Tsvakirai, 2019).

**Table 4.12** Yield of sugarcane (t/ha) (n=120)

| Yield of sugarcane (t/ha) | N | Mean | Std. Dev | Std. Error |
|---|---|---|---|---|
| Total | 120 | 73,4 | 34,1 | 3,1 |

**Source:** Survey (Nov 2021)

The table below shows the average sugarcane yield by gender (t/ha). The yield is 75.3 t/ha higher than in male. According to Eweg et al. (2009), insufficient replanting rates may contribute to lower sugarcane yields. As a result, smallholder sugarcane growers' cultivated farm area and sugarcane yield (tonnes/ha) are likely to be favorably or negatively associated. According to SASA (2023), in South Africa's agricultural context for the 2023/24 timeframe, relevant metrics include an extent of 352,500 hectares committed to sugarcane growing, with 251,000 hectares reflecting actual harvested area. The total amount of cane processed is 18,530,000 metric tonnes, resulting in an average productivity rate of 74 tonnes per hectare.

**Table 4.13** Average yield of sugarcane by gender t/ha (n = 120)

| Gender | N | Mean | Std. Devi | Std. Error |
|---|---|---|---|---|
| Female | 48 | 75,3 | 28,3 | 4,1 |
| Male | 72 | 72,1 | 37,6 | 4,4 |

**Source:** Survey (Nov 2021)

### 4.3.7 Market outlets of sugarcane grown in 2020/21

The table below shows the market outlets for sugarcane. Farmers' average market outlets are Millers (TSB - Transvaal Suikar Beperk), with 85.5% assigned to Malelane and Komatiport. In 2020/21, Nkomazi's sugar industry consisted of only one milling business, TSB, which operated two mills. The original mill, Malalane, was completed in 1967 and had been enlarged multiple times. It had a nominal milling capacity of 1.83 million tonnes of cane per year. The second mill, Komati, was erected in 1994 and later extended in 1998 and 2006. Its nominal the milling capacity was 2.5 million tonnes of cane per year. TSB also maintained a refinery in Malalane, which processed both the Malalane Mill's production and a portion of the Komati Mill's raw sugar output. The remaining raw sugar output from the Komati Mill was shipped through Maputo. Molatek, another TSB facility at Malalane, generated animal feed from the sugar mills' molasses byproduct. In early 2014, the Remgro group sold TSB to Rainbow Chicken Ltd (RCL), which is also owned by Remgro. This sale was part of the group's reorganization and aimed to improve integration within its agricultural business.

**Table 4.14** Markets outlets of sugarcane grown in 2020/21

| Market outlet | Frequency | Percent |
|---|---|---|
| Millers | 121 | 85,2 |
| Not applicable | 21 | 14,8 |
| **Total** | **142** | **100,0** |

**Source:** Survey (Nov 2021)

### 4.3.8 Manure used for sugarcane production in 2020/21 season.

The table below shows the amount of manure used in sugarcane cultivation, as well as the total cost. The average amount of manure utilized in sugarcane cultivation is 13,2 kg per ha.

**Table 4.15** Amount of Manure in (kg)/per used for sugarcane production in 2020/21 season (n=13)

| Manure used | N | Mean | Std. Error | Std. Dev |
|---|---|---|---|---|
| Average per ha of manure used | 13 | 13,2 | 4,4 | 15,7 |

**Source:** Survey (Nov 2021)

### 4.3.9 Amount of basal fertilizer used for sugarcane production in 2020/21 season.

The table below shows the amount of basal fertilizer needed for sugarcane production, as well as the total cost. The average amount of basic fertilizer applied is 192,3kg per ha. The study conducted by Baiyegunhi and Arndt (2011) found that the amount of fertilizer used by the participants had a positive effect.

**Table 4.16** Amount of fertilizer (kg) per ha used for sugarcane production (n = 85)

| Basal fertilizer used | N | Mean | Std. Error | Std.Dev |
|---|---|---|---|---|
| Average per ha of basal fertilizer used | 85 | 192,3 | 89,9 | 829,2 |

**Source:** Survey (Nov 2021)

### 4.3.10 Transport used and total transport cost of sugarcane in season 2020/21

The number of journeys made by sugarcane farmers to bring their sugarcane to the miller (TSB) in Komatiport/Komati, as well as the cost of each trip. The average number of journeys was 131 56 349,0 with a total transportation cost of R37 521,3.

**Table 4.17** Transport used in sugarcane production in 2020/21 season (n= 16)

| Transport | N | Mean | Std. Dev | Std. Error |
|---|---|---|---|---|
| Number of trips | 16 | 56349,0 | 131807,7 | 32951,9 |
| Total transport cost | 44 | 37521,3 | 11771,1 | 11771,1 |

**Source**: Survey (Nov 2023)

### 4.3.11 Main Challenges of Sugarcane Production

To obtain the critical support required to participate in bioenergy crops efficiently, multiplied response was implemented. This indicates how insufficient water (45.4%), pests and diseases (40.3%), and limited access to land (33.6%) affect farmers' engagement in bioenergy production. According to Kumah's (2018) research, cultivators and irrigation facilities were too expensive for most farmers. As a result, these resources were made available to them via their respective farmer organizations. Pests are a significant factor that reduces sugarcane yield (Raza et al., 2019). As a result, sugarcane growers frequently use deadly chemicals to control the amount of pest insects. Insects are growing more resistant to insecticides because of their continuous application (Singh et al. 2019).

Excessive insecticide use endangers the environment, threatens the health of sugarcane growers, and eliminates pests' natural opponents. Furthermore, it destroys the natural ecosystem. This leads to lower productivity. Bellemare (2018) and Ragasa et al. (2018) found that the application of improved agricultural practices, such as fertilizers and pesticides, resulted in higher yields among smallholder farmers.

**Table 4.18** Challenges of sugarcane

| **Challenges in the production of sugarcane** | **Percent of Cases** |
|---|---|
| Insufficient water | 45,4 |
| Pests and diseases | 40,3 |
| Limited access to land | 33,6 |
| Stray’s animal destroying crops | 30,3 |
| Unaffordability of inputs | 16,0 |
| Theft | 14,3 |
| Poor output prices | 10,9 |
| Insecure land ownership | 10,9 |
| Lack of adequate storage facilities | 9,2 |
| Transport of produce | 7,6 |
| Poor access to markets | 5,9 |
| Drought | 4,2 |
| Risks of product not being sold | 2,5 |
| Electricity | 0,8 |

**Note:** This was a multiply response question

**Source:** Survey (Nov 2021)

## 4.4. Bioenergy production potential, perceptions, and awareness

### 4.4.1Willingness to put more land under sugarcane production.

The table below shows respondents' desire to increase the quantity of land utilized to cultivate sunflowers, sorghum, and sugarcane. This demonstrates that more male farmers (58.2%) reacted positively than female farmers, indicating that they are more inclined to devote more land to sugarcane cultivation. According to the SACGA (2010/11), input costs, transportation charges, and replant rates may have a higher influence on production than farm size.

In South Africa, certain smallholder farmers who have recently benefited from the land redistribution initiative must choose between cultivating food crops for personal consumption and/or commercial sale and engaging in emerging opportunities in the biofuels sector, such as biofuels feedstock contracts and biofuels land rental contracts (Cartwright, 2010; Colin and Woodhouse, 2010).

**Table 4.19** Desire to put more under sugarcane production.

| **Gender** | **Yes (%)** |
|---|---|
| Male | 58,2 |
| Female | 41,8 |
| **Total** | **100,0** |

**Source:** Survey (Nov 2021).

### 4.4.2. Awareness of the use of residues from sugarcane for producing energy

The independent-sample t-test was used to determine whether respondents were aware that crops like sugarcane may be used for energy production in bioenergy projects. Yes, respondents had a mean of 1.0 and a standard deviation of 0.0, which was significantly higher than the mean of 0.6 and a standard deviation of 0.5. The difference in means between =1,0 and 0,6 was significant in size. The hypothesis was so supported.

**Table 4.20** Awareness of the use of residues from sugarcane for producing energy.

| **Bioenergy project beneficiary** | **Mean** | **Std. Dev** | **T** | **Two-Sided p** |
|---|---|---|---|---|
| Yes | 1,0 | 0,0 | -10,3 | 0,0 |
| No | 0,6 | 0,5 | -2,2 | 0,0 |

**Source:** Survey (Nov 2021)

### 4.4.3. Sugarcane trash management practices

Crosstabs were used to compare the use of field trash and crop leftovers. Approximately 35 male farmers and 26 female farmers burn it. The chi-square test indicates a relationship between the variables with a value of 0.3. The heavy reliance on fossil fuels for energy generation has resulted in several environmental and socioeconomic challenges on a local, regional, and global scale. These challenges include the depletion of non-renewable resources, the ozone layer, acidification, and global warming. Notably, the role of energy generation in contributing to the latter situation is significant, owing to the release of carbon dioxide ($CO_2$) and other greenhouse gases (GHGs) during the combustion of fossil fuels. This has considerably exacerbated the negative consequences of climate change. According to the International Energy Agency (IEA) (2010), the combustion of fossil fuels for energy purposes accounted for nearly 65% of worldwide greenhouse gas emissions in 2008. The continuation of this trajectory raises legitimate concerns.

**Table 4.21** The use of trash/ crop residues from the field.

| What do you do with the trash/ crop residue from your field? | Female | Male |
|---|---|---|
| Burn it | 26 | 35 |
| Use it as a compost | 12 | 17 |
| Level it in the field | 7 | 16 |
| Feed Livestock | 7 | 5 |

**Source:** Survey (Nov 2021)

#### 4.4.4. Critical support required to effectively participate in production of bioenergy crops.

To obtain the critical backing required to participate in bioenergy crops efficiently, a multiple response was implemented. This indicates how financial resources, at 49.6%, influence farmers' engagement in bioenergy production. The lack of financial assistance, such as operational loans essential to maintain agricultural production, has typically discouraged South Africa's small-scale agricultural industry (Sibanda, 2012). According to Girei and Giroh (2012), smallholder sugarcane out-growers in South Africa and Nigeria have major hurdles due to insufficient loan access and a lack of extension support. However, the sugarcane industry has been fortunate to receive support for more than 50 years, and as a result, deliveries to mills are suspended as a security precaution (SASA, 2012).

**Table 4.22** Critical support required to participate in production of bioenergy crops.

| Resources required to participate | Percent of cases |
|---|---|
| Financial resources | 49,6 |
| Training/skills | 39,6 |
| Land | 32,4 |
| Information | 23,7 |
| Transport | 14,4 |

| | |
|---|---|
| Market | 10,1 |
| Labour | 4,3 |
| Fertilizer | 3,6 |

**Note:** This was a multiply response question

**Source:** Survey (Nov 2021)

### 4.4.5. What are your main reasons for crop farming?

The table below summarizes the primary motivations for crop growing. The majority of sugarcane producers farm to achieve a 59.0% profit from agricultural sales. According to Stockbridge (2007), men frequently have control over cash crop output income. Spending priorities differ from those of women.

**Table 4.23** Main reason for farmers to engage in farming.

| Crop farming reasons | Percent of Cases |
|---|---|
| Earn an income from the sales of my farming | 59,0 |
| Have sufficient food to feed my family | 57,6 |
| Create employment for myself and family | 41,0 |
| Create employment for people in the community | 32,4 |
| Store wealth | 7,9 |
| Cultural/ritual purposes | 3,6 |

**Note:** This was a multiply response question

**Source:** Survey (Nov 2021)

## 4.5. Challenges and support required.

Smallholder farmers in South Africa face numerous challenges that impede their progress and capacity to contribute successfully to the agricultural economy (DAFF, 2012). Thebethe (2013) discovered that age, educational attainment, marital status, landholding size, off-farm income, and experience were key determinants influencing allocative efficiency in sugarcane. One of the obstacles faced by farmers is the difficulty in receiving financial support. Since 1990, the South African government has developed several programs to increase access to financial services to address challenges of low productivity and poverty. These measures include a 1992 exemption from the Usury Act for loans under R6,000, which aimed to increase access to microloans. The success of this government project has the potential to increase participation in biofuel farming.

In South Africa's small-scale agricultural industry, inadequate access to critical financial support, such as operational loans necessary for agricultural production, has caused chronic issues (Sibanda, 2012). According to Mandla et al., (2011), the connection between small-scale sugarcane growers and financial institutions is complex, as these growers rely on such institutions for working capital to sustain their sugarcane farms. Despite these issues, the sugarcane industry has had rather advantageous conditions, getting financial assistance for over five decades and currently using supplies to mills as a security mechanism (SASA, 2012).

Governments have responded to these issues by establishing institutional support systems, such as agricultural cooperatives and agricultural extension services, with the goal of addressing challenges, increasing smallholder agricultural production, and providing farmers with training, information, and market access (Msuya et al. 2017).

The sugar industry in Mpumalanga asserts that an unprecedented degree of land transfer to black ownership has occurred, with 62% of the land that provides sugarcane to TSB's two mills in Nkomazi now in black hands. This considerable shift in land ownership is highlighted because of the rapid rate of change, with TSB actively contributing to mitigating the risks associated with decreasing land ownership and the potential termination of production. The company's involvement has been critical in the resolution of land disputes, including restitution, which means selling TSB's 6,000 hectares of property back to the government (RCL Foods, 2014).

The system also allows for leasing; nevertheless, property utilized for commercial agriculture is subject to an annual tax of R150 per hectare charged by the Matsamo traditional authority. Growers' capacity to avoid rental payments is hampered by their reliance on traditional authorities for fundamental services such as residence verification and financial document authorization. This position implies that the current course of action is congruent with the former apartheid mandate, which called for tribal officials to regulate all African land ownership (Delius and Beinart, 1913). Notably, traditional leaders known as Indunas have played an important role inside the trusts, such as through their participation in small-scale sugarcane growing on 'community' land.

Research suggests that smallholder irrigation can improve agricultural productivity, household food security, and reduce rural poverty (Bacha et al. 2011, Gebregziabher et al. 2009, Hussain and Hanjra 2004, Kumar 2003, Lipton et al. 2003, Sinyolo et al. 2014). Governments in South Africa have made significant investments in smallholder irrigation installation, rehabilitation, and revitalization (Denison and Manona, 2007; Shah et al., 2002). Despite its potential, smallholder irrigation systems have underperformed in South Africa and elsewhere (Fanadzo, 2012; van Averbeke, 2012; Speelman 2009; Yokwe, 2009; Hope et al., 2008; Perret 2002; Bembridge 2000).

In 2005, the Department of Rural Development and Land Reform (DRDLR) started a tractor service programme to help farmers out. This initiative, named "Masibuyele Emasimini" (translated as "Let us return to farming"), was a component of the larger Food Security and Agricultural programme in Mpumalanga province, valued at R500 million, and launched between 2005/06 and 2009/10 (Sikwela 2013:95). The DRDLR purchased 20 tractors, distributing ten each to the Dinglydale and New Forest districts, and then hired a contracted service provider for operational deployment and maintenance. These tractors, stationed at the New Forest irrigation cooperative offices, covered an area of about 1000 hectares of dryland farming. However, a significant difficulty arose in August 2013, when only one tractor under the cooperative's control remained operable, leaving the remaining 20 tractors provided by the DRDLR inaccessible to irrigators. Furthermore, landowners expressed support for bioenergy, owing largely to their perceptions of its good effects on employment and rural economic growth (Panoutsou 2008; Paulrud and Laitila 2010; Paula et al. 2011; Aguilar et al. 2013).

In India, north-eastern Brazil, South Africa, southern Thailand, and Zimbabwe, adaptive tactics have primarily concentrated on cultivating drought-tolerant, disease-resistant crop types with high yields. This has coincided with developments in irrigation systems, as discussed by (Flack-Prain et al., 2021; Linnenlueke et al., 2020). However, it is critical to emphasise the sustainable development of irrigation systems to prevent the loss of water resources, especially given the water-intensive character of sugar cane agriculture, as underlined by Linnenlueke et al. (2020).

The difficulty farmers have in obtaining education and training relevant to sugarcane cultivation has been identified as a major hindrance. Existing research on agricultural awareness and technical improvements by McBridge (1999) and Dandedjrohoun et al. (2012) does not provide a consistent foundation for defining or influencing awareness. Recognizing the importance of agricultural extension services, they are considered important for farmers, working as conduits connecting them to authorities such as the Department of Agriculture and other stakeholders.

As described by (Davies, 2008:16), these services provide access to resources and information while encouraging the development of necessary capacity for increased productivity. According to Tsion (2008), training improves farmers' knowledge levels and serves as a mechanism to keep them up to date on agricultural innovations. Furthermore, training overcomes limits by imparting relevant knowledge and establishing new abilities, as highlighted by Wegulo et al. (2009). As a result, this not only improves understanding of the intricacies of innovations, but also promotes their effective acceptance and implementation.

Woods (2008) argues that indigenous cooperatives play an important role in fostering social and political reforms that affect smallholder farmers. Several government policies may be effective in encouraging smallholder farmers to participate in bioenergy production. Smallholder farmers in South Africa rely on favorable legislation and a controlled operational environment to capitalize on sectoral opportunities (AGRA, 2017; Jayne et al., 2017). According to Frese and Gielnik (2014), engaging smallholder farmers in the sector requires both technical and psychological abilities.

**4.6. Summary of the chapter**

Recognizing the motives that drive smallholder farmers to engage in sugarcane production to better their standard of living, this study highlights a persistent lack of awareness, information, and critical support required for active engagement in the bioenergy business. As a result, the lack of bioenergy resources is expected to have little effect on the well-being of smallholder farming households in terms of rural development activities.

Moreover, farmers remain uninformed about the potential advantages of utilizing agricultural residues as bioenergy sources. An array of challenges, including pests, diseases, land constraints, inadequate water supply, fertilizer shortages, labour issues, market access, transportation limitations, information gaps, training deficits, financial constraints, and various other resource shortages, hinder farmers from active engagement in sugarcane production. Interventions are imperative to augment the involvement of smallholder farmers in bioenergy production. Irrigation was established to alleviate smallholder farmers' water scarcity concerns, hence promoting small-scale irrigation has the potential to promote sustainable livelihoods. It is critical to maximize the use of existing schemes and prepare irrigation development plans, including identifying prospective locations for new projects. The data also show that young and female farmers have lesser participation in sugarcane farming, owing to the belief that it is a cash crop designated for men.

# CHAPTER 5

## FACTORS INFLUENCING SMALL-SCALE SUGARCANE FARMER'S POTENTIAL AND WILLINGNESS TO PARTICIPATE IN BIOENERGY PRODUCTION IN EHLANZENI DISTRICT

### 5.1. Introduction

The chapter presents and discusses the findings of the empirical analyses conducted to assess factors influencing small-scale producers' bioenergy production potential and their willingness to engage in the industry. Two models were estimated. As noted in Chapter 3, an OLS model was estimated to assess what determines the farmers' potential production of bioenergy. A Principal Components Regression was estimated to assess the farmers' willingness to engage in bioenergy production. The chapter is structured as follows. The first section (Section 5.2) presents the PCA results for the farmer's psychological capital endowment, followed by the OLS model results in Section 5.3. Section 5.4 discusses results of the Principal Components Regression followed by a summary of the chapter in Section 5.5.

### 5.2 Empirical Results: Determinants of the Farmers' Bioenergy Potential

#### 5.2.1 Principal components analysis results

A PCA was conducted to reduce the dimensionality of psychological capital variables. This was done to obtain explanatory variables to be included in the OLS regression model. Table 5.1 presents a correlation matrix for the variables included in the PCA. The matrix shows that the variables had a high correlation except for two. This shows that the data was appropriate for a PCA analysis.

**Table 5.1** Correlation matrix of variables included in the PCA.

| | Fact1 | Fact2 | Fact3 | Fact4 | Fact5 | Fact6 | Fact7 | Fact8 | Fact9 | Fact10 | Fact11 | Fact12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fact1 | 1.00 | | | | | | | | | | | |
| Fact2 | 0.42 | 1.00 | | | | | | | | | | |
| Fact3 | 0.36 | 0.66 | 1.00 | | | | | | | | | |
| Fact4 | 0.49 | 0.65 | 0.64 | 1.00 | | | | | | | | |
| Fact5 | 0.17 | 0.45 | 0.54 | 0.48 | 1.00 | | | | | | | |
| Fact6 | 0.21 | 0.05 | 0.06 | 0.16 | 0.17 | 1.00 | | | | | | |
| Fact7 | 0.51 | 0.59 | 0.49 | 0.52 | 0.27 | 0.12 | 1.00 | | | | | |
| Fact8 | 0.43 | 0.69 | 0.50 | 0.59 | 0.32 | 0.12 | 0.70 | 1.00 | | | | |
| Fact9 | 0.13 | 0.32 | 0.32 | 0.22 | 0.20 | 0.00 | 0.21 | 0.24 | 1.00 | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fact10 | 0.18 | 0.10 | 0.20 | 0.19 | 0.25 | 0.29 | 0.14 | 0.05 | 0.36 | 1.00 | | |
| Fact11 | -0.17 | -0.08 | -0.01 | -0.06 | 0.03 | 0.07 | -0.12 | -0.12 | 0.22 | 0.39 | 1.00 | |
| Fact12 | 0.17 | 0.00 | -0.01 | 0.13 | 0.07 | 0.17 | 0.14 | 0.06 | 0.24 | 0.37 | 0.36 | 1.00 |

Note: ‘Fact’ - factor

**Source:** Survey (Nov 2021)

Table 5.2 shows the results of the PCA conducted on psychological capital variables. Only three principal components (PCs) with eigenvalues greater than 1 were retained. These PCs were explained based on the highest factor loadings. Only factor loadings greater than 0.3 were considered as suggested by Jolliffe (2002). PC1 represents confident and optimistic farmers. These farmers are confident and optimistic about the bioenergy industry and the positive changes it will bring to their lives. According to Schott et al. (2015), human capital refers to acquired skills, knowledge, and experience. Based on Luthans et al. (2015) an individual's mental state has a significant impact on decision-making, productivity, and efficiency.

Positive psychological development is referred to as "psychological capital. Luthans et al. (2007) identified four constructs for determining psychological capital, including (1). Previous research by Chipfupa and Wale (2018) and Cele (2017) highlights the significance of psychological capital in influencing decision-making among smallholder farmers. Optimism is characterized by an optimistic attitude towards life. An optimistic individual sees the good in every circumstance and views failure and setbacks as transient. According to Maluleke (2016), entrepreneurship is a "challenging" journey that requires a certain mindset. Understanding that setbacks and failures are only transitory is crucial.

"PC 2 represents farmer who cope with any shock but are only farming because there are no other better opportunities. Therefore, the PC was named ‘Resilient but Opportunistic. According to Luthans et al. (2007), resilience refers to the ability to recover from tough situations such as failure, conflict, or increased obligations.’ PC 3 represents farmer who would not be farming if there was a better alternative source of income. Therefore, the PC was named ‘Risk taking.’

**Table 5.2** Results of the PCA of Psychological Capital Variables

| Variable | **PC1: Confident** | **PC2: Resilient but opportunistic** | **PC3: Risk taking** |
|---|---|---|---|
| Confident in bioenergy production as a lucrative venture (Fact1) | 0.299 | -0.061 | 0.437 |
| I am confident in bioenergy production as a lucrative farming business (sBq7b) | **0.401** | -0.143 | -0.173 |
| I am confident and have belief in myself as a farmer (sBq7c) | 0.380 | -0.058 | -0.266 |
| I believe I have the power to affect the outcome of my farming business (sBq7d) | **0.395** | -0.057 | 0.018 |
| I am optimistic about the future of the bioenergy sector/ agriculture in my area (sBq7e) | 0.288 | 0.062 | -0.210 |
| I am willing to take more risk than other farmers in my community (sBq7f). | 0.111 | 0.225 | **0.618** |
| I have hope about the prospects of smallholder agriculture/ the bioenergy sector (sBq7g) | 0.367 | -0.115 | 0.157 |
| I am willing to forget profit opportunity in the short- run to benefit from potential profits in the long-run (sBq7h) | 0.379 | -0.167 | 0.044 |
| I am willing to try new ideas even without full knowledge about the possible outcomes (sBq7i) | 0.205 | 0.295 | -0.397 |
| I can cope with shocks drought and other natural disasters) and other potential risks that threaten my farming business (sBq7j) | 0.158 | **0.521** | 0.058 |
| I would not be farming if there was a better alternative source of income (sBq7k) | -0.012 | **0.538** | -0.231 |
| The government is responsible for the wellbeing of rural farming households (sBq7l) | 0.096 | 0.476 | 0.205 |
| Eigenvalues | 4.304 | 1.962 | 1.150 |
| Variance explained (%) | 35.9% | 16.4% | 9.6% |
| Cumulative variance (%) | 35.9% | 52.3% | 61.9% |

**Source:** Survey (Nov 2021)

### 5.2.1. OLS Model results

#### *5.2.1.1 Normality density plot for the dependent variable*

Figure 3 shows the normality density plot of the natural logarithm of the dependent variable, e.g., the potential bagasse from farmers sugarcane output. The graph shows a normal standard distribution. Normality of the dependent variable is an important assumption of OLS regression. Transforming the dependent variable into its natural logarithm was a form of standardization to remove outliers (Malmendier and Tate, 2005).

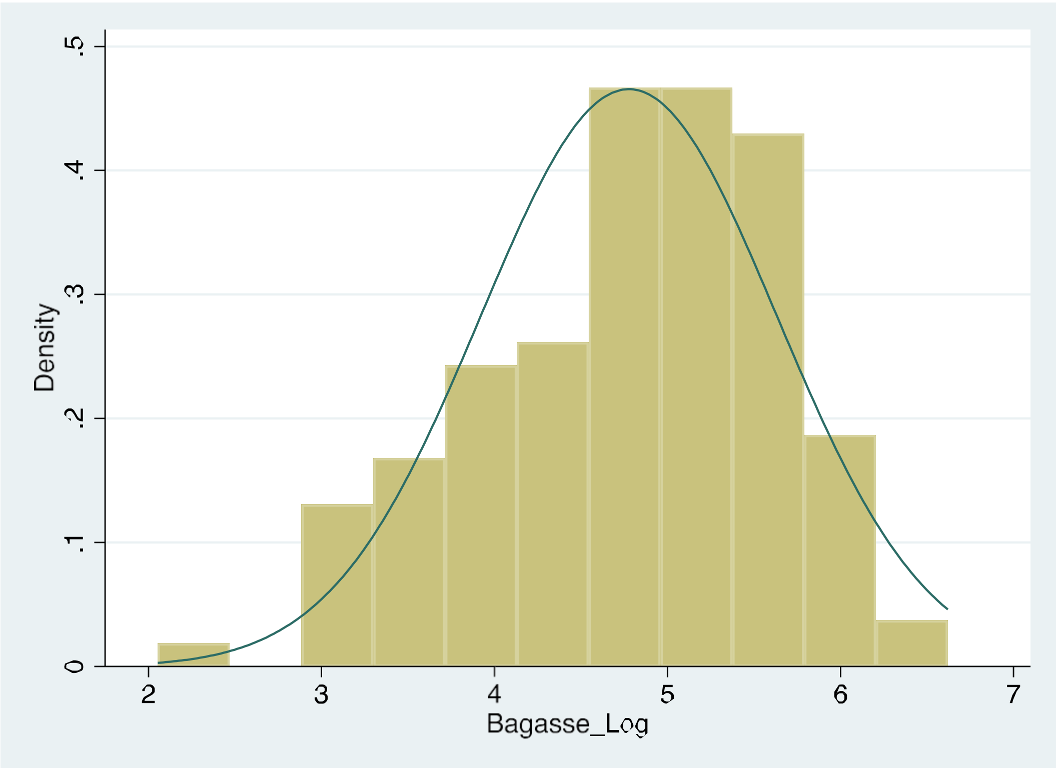


Figure 3: Histogram of the dependent variable with a normal density plot

**Source:** Survey (Nov 2021)

#### *5.2.1.2 Model specification tests*

Table 5.2 presents the OLS model results. The model F-statistic was significant showing a good model fit. The Ramsey RESET test for omitted variables was insignificant ($F = 2.06$, $p > 0.10$). The test results fail to reject the null hypothesis; hence the model has no omitted variables. Multicollinearity was not a problem in the model since the mean VIF was 1.13, way below the rule of thumb of 10. The model was estimated using robust standard errors thereby addressing any heteroscedasticity issues.

#### *5.2.1.3 Determinants of farmers' bioenergy potential*

The model results show that four factors significantly influence the bagasse potential from farmers' sugarcane production. These are the age of farmer, land ownership, access to credit and cooperative membership.

**Table 5.3** OLS results for factors influencing farmers' bioenergy potential

| Bagasse Log | Coefficient | Robust std. err. | T-value | P-value | VIF |
|---|---|---|---|---|---|
| Age of farmer | -0.011 | 0.005 | -2.230 | 0.027** | 1.05 |
| Gender of farmer | -0.082 | 0.131 | -0.620 | 0.534 | 1.10 |
| Land ownership | 0.035 | 0.021 | 1.710 | 0.090* | 1.19 |
| Access to credit | -0.398 | 0.139 | -2.850 | 0.005*** | 1.13 |
| Cooperative membership | -0.302 | 0.145 | -2.080 | 0.039** | 1.09 |
| Access to extension | -0.038 | 0.043 | -0.900 | 0.371 | 1.23 |
| Asset index (log) | 0.052 | 0.076 | 0.680 | 0.495 | 1.26 |
| PC1: Confident | -0.033 | 0.034 | -0.970 | 0.335 | 1.05 |
| PC2: Resilient but opportunistic | 0.027 | 0.052 | 0.520 | 0.605 | 1.17 |
| PC3: Risk takers | 0.036 | 0.069 | 0.530 | 0.599 | 1.06 |
| Constant | 5.357 | 0.481 | 11.130 | 0.000 | |
| | | | | | |
| Number of orbs | = | 128 | | | |
| F (10, 117) | = | 3.48 | | | |
| Prob > F | = | 0.001 | | | |
| R-squared | = | 0.238 | | | |
| Root MSE | = | 0.781 | | | |
| Mean VIF | = | 1.13 | | | |

Note: *, **, *** means statistically significant at 10%, 5% and 1%, respectively

**Source:** Survey (Nov 2021)

Farmer's age has a significant relationship with the potential amount of bagasse from their production. The coefficient of the variable **'Age of farmer**' is negative and statistically significant at 5%. This means younger farmers have a higher production of bagasse compared to older farmers. A one-year increase in the farmer's age is associated with a 1.1% reduction in the amount of bagasse. Older farmers have been in the sector for long and over the years have faced several challenges in the sector. They are more likely to be tired and demotivated. Younger farmers still have the energy and motivation to work and earn a living from sugarcane production. These findings show that there is a need to support more young people to enter small-scale sugarcane production as this will grow the industry (Tagwi and Chipfupa, 2023).

Many studies show that currently young people in South Africa are inclined to shun agriculture and rural areas for white collar jobs in the cities (Pillay & Maharaj, 2013; Statistics South Africa, 2014). Van Niekerk et al. (2011) stated that one of the problems in small-scale farming is the lack of involvement of young people in the sector. However, Kabwe (2012), discovered that senior farmers have greater production knowledge and have created the required contacts, allowing them to run their businesses more efficiently than younger farmers.

Land ownership has a significant relationship with the amount of bagasse from their production. The coefficient of the variable **'Land ownership'** is positive and statistically significant at 10%. This means those with more land have a higher production of bagasse compared to those with a limited amount. A 1 ha increase in land ownership is associated with a 3.5% increase in the amount of bagasse. Increasing the land size of farmers and providing property rights to the land can enhance output (DAFF,2016). According to research conducted by the South African Cane Growers Association (SACGA) in 2011, productivity levels may depend on other factors including input costs, transportation costs, replanting rates, and management practices rather than the size of a farm.

All these are critical to increase productivity. Emana and Gebremedhin (2007) state that it is impossible to definitively predict the relationship between crop productivity and farm size, particularly in terms of yield per hectare. However, holding other factors constant, the study results demonstrate that having more land is advantageous as it means you can grow more compared to others. Farmers did indicate that they would require more land to expand production.

Access to credit has a considerable impact on the amount of bagasse produced. The coefficient for the variable **'Access to credit'** is negative and statistically significant at 1%. This indicates that farmers with access to credit potentially produce less bagasse compared than those without. The results are contrary to expectations which acknowledges that access to financing is a key barrier in agriculture, particularly for subsistence farmers, smallholders, and agribusiness businesses. (DAFF, 2007). The importance of loan availability and has implemented policies such as MAFISA to increase financial inclusion and promote sustainable agricultural production (DAFF,2007). It emphasizes the need of harnessing financial resources from the market via strategic partnerships. According to Guirkinger and Boucher (2008) and the lack of access to financing is a hurdle in smallholder farming. Baloyi (2011) also revealed that financial resources play a vital role in efficient production because sugarcane production frequently involves hired manpower, irrigation equipment, and hired tractors, all of which require payment.

However, the situation with the Sugarcane Industry in South Africa is unique. Small-scale sugarcane farmers receive huge loans from a company affiliated with the millers. Maltitz et al. (2019) found that farmers were dependent on financial institutions for loans to expand irrigation infrastructure, notably for irrigated sugarcane farming. These loans are automatically deducted from the farmers' earnings when they deliver to the market. In most cases, the farmer gets very little or sometimes is even left in debt. This form of financing has made farmers resent the loans and those providing them. This could explain the results of this study.

Cooperative membership has a significant relationship with the farmers' potential amount of bagasse from their production. The coefficient of the variable **'Cooperative membership'** is negative and statistically significant at 5%. This means farmers who belong to a cooperative have a lower bioenergy potential. Belonging to a cooperative membership is associated with a 30.5% reduction in the amount of bagasse. Collective action South Africa's agricultural sector has not performed well. Farmers belong to cooperatives not because they understand the importance of collective action but because it is a requirement for receiving support from government and other stakeholders.

However, if given a choice farmers would want to work as individuals. Farmers' cooperatives in South Africa are affected by the lack of transparency, lack of accountability, free riding, lack of properly constituted governance structures and principles (Van der Walt (2005). According to Thaba et al. (2015), cooperatives promote poverty reduction, job creation, income generation, and broad-based economic empowerment (BBEE), leading to sustainable human development in South Africa.

## 5.3 Empirical Results: Determinants of the Farmers Willingness to Engage in Bioenergy

### *5.3.1 PCA: Willingness to engage in bioenergy.*

Table 5.4 shows the results of PCA conducted on few variables that solicited farmers' willingness to engage in bioenergy. Few perceptions were used to gauge participant's willingness to participate in bioenergy. The variables were measured on a five-point Likert scale with 1 representing those who strongly disagree with the statement and 5 those who strongly agree. Only one PC with an eigenvalue greater than 1 was retained. Only factor loadings greater than 0.3 were considered as noted in Section 5.2.1. The PC explains 83.6% percent of the variation in the data. It generally shows farmers with an uninterested in engaging in the bioenergy sector.

**Table 5.4** Willingness to engage in bioenergy PCA

| Variable | Willingness |
|---|---|
| I am willing to harvest and supply trash/crop residues from my land to a bioenergy producer | 0.497 |
| I believe selling of trash/crop residues would earn my family extra income | 0.511 |
| I am willing to hire more or machinery to harvest trash/crop residues to meet the demand | 0.495 |
| I am willing to go into a contractual agreement with energy producers for supply of trash/crop residues | 0.497 |
| | |
| Eigenvalue | 3.344 |
| Variance explained (%) | 83.60 |

**Source:** Survey data (Nov 2021)

Table 5.5 below shows PCA results for variables that were measuring farmers' perception of bioenergy. Two factors were retained after applying the Kaiser Criterion. The PCs are named after the most dominating factor with the highest factor loading. The first PC, which explains 50.89% of the variation in the data, represents farmers who believe that producing crops for bioenergy needs large tracts of land and is labour-intensive. The PC is named as Land. The second PC explains 21.2% of the variation. It represents farmers are believing that bioenergy production will have a negative effect on food security. The same farmers also think that producing crops for bioenergy is not for smallholder farmers but commercial. The PC is named as food security.

**Table 5.5:** Perceptions on bioenergy production

| Variable | Land | Food security |
|---|---|---|
| Lack of knowledge on the bioenergy industry affects participation of farmers | 0.413 | -0.526 |
| Producing crops for bioenergy is not good for food security | 0.354 | **0.582** |
| Producing bioenergy crops requires large tracts of land | **0.537** | -0.166 |
| Producing bioenergy crops is laborious to smallholder farmers | **0.523** | -0.211 |
| Producing bioenergy crops is not for smallholder farmers but commercial farmers | 0.377 | **0.558** |
| | | |
| Eigenvalue | 2.544 | 1.067 |
| Variance explained (%) | 50.89 | 21.24 |
| Cumulative variance (%) | | 72.23 |

**Source:** Survey data (Nov 2021)

#### *5.2.2.3 Model specification test*

A Breusch–Pagan/Cook–Weisberg test for heteroskedasticity was conducted after estimating the model. The results were significant ($Chi^2$ = 21.34; Prob > $Chi^2$ = 0.0000) which shows the presence of heteroskedasticity. This means the estimated parameter coefficients were biased. Hence, the model was re-estimated again using robust standard errors to address the issue of heteroscedasticity. Only the results of the latter model are presented in Table 5.6 below.

The model F-statistic was significant showing a good model fit. Multicollinearity was not a problem in the model since the mean VIF was 1,09, way below the rule of thumb of 10.

### *5.3.3 Determinants of farmers' willingness to engage in the bioenergy sector.*

The model results show that four factors significantly influence the willing from farmers' bioenergy production. These are the farmer's land under sugarcane, land tenure security, land, and food security.

Land under sugarcane has a significant relationship with bioenergy production from their production. The coefficient of the variable **'Land under sugarcane'** is negative and statistically significant at 10% with a VIF of 1,09. This means farmers who do not put their land in sugarcane production have a higher production of bioenergy compared to those who put their land in sugarcane. A 1 ha increase of land under sugarcane is associated with a 4,2% reduction in the bioenergy production. Protecting the quality of cultivated land has many benefits due to its multifunctionality (Jiang et al., 2020). To safeguard farmers' cultivated land quality, it is important to consider their perceived rewards and efforts while making behavioral decisions (Sapbamerer et al., 2021). Farmers assess if their land quality preservation practices suit individual needs (Xu et al., 2014). A study published in the South African Journal of Agricultural Extension found that farm size has a statistically significant and positive influence on sugarcane production output (DAFF,2016).

Land tenure security has a significant relationship with bioenergy production from their production. The coefficient of the variable **'Land tenure security'** is positive and statistically significant at 10% with a VIF of 1,16. This means those farmers with land tenure security under (PTO) have a higher production of bioenergy compared to others without land tenure security. Increase in land tenure security is associated with a 1,16% increase in the bioenergy production. This finding is consistent with those obtained by Baiyegunhi and Arnold (2011) and Thabethe (2013), who discovered that increasing land size had a large and favorable influence on agricultural productivity.

Land has a significant relationship with bioenergy production from their production. The coefficient of the variable **'Land'** is positive and statistically significant at 1% with a VIF of 1,04. This means the farmers who have land have a higher bioenergy production. Farmers' perceived value of cultivated land quality preservation is based on their subjective judgement of its benefits and contributions in decision-making (Li et al., 2020). According to Wang and Guo (2020), farmers prioritize obtaining significant rewards while protecting their farmed land quality. At the same time, the

Sustainability impact of perceived benefits and perceived risks on farmers' desire and behavior is asymmetrical (Li et al., 2020).

Food security has a significant relationship with bioenergy production from their production. The coefficient of the variable **'Food security'** is negative and statistically significant at 10% with a VIF of 1,14. This means farmers who do not have food security have a higher production of bioenergy compared to others. Biofuels can reduce emissions and store carbon in feedstock and soil, potentially leading to greater climate benefits than other land-based mitigation approaches (El Alkari et al., 2018; Jeswani et al., 2010; Meijide et al., 2020; Yang and Tilman, 2020 and Field et al., 2020). First-generation biofuels have been linked to negative sustainability impacts, including land use change, biodiversity loss, increased GHG emissions, carbon loss from soil, water overexploitation, water pollution, loss of land tenure, social conflicts, and gender inequality (Gibbs et al., 1980; Ruli et al., 2016; Filoso et al., 2015; Savilaako et al., 2014; Achten and Verchat, 2011; Fargione et al., 2008; Harris et al., 2015; Alshawaf et al., 2016; Boardonal et al., 2018).

However, food security is the most divisive sustainability consequence of biofuels (Kline et al., 2017). Research has examined the influence of biofuels on food security at the local, national, and worldwide levels (Brinkman et al., 2020; Ahmed et al., 2021), including the impact of land use changes on food availability. Research has examined the influence of biofuels on food security at the local, national, the impact of income/employment on food access (Hervas and Isakson, 2020), female labour diversion on nutrition (Mingorria et al., 2014), and food pricing among other factors.

**Table 5.6:** Principal Components Regression results for willingness to engage: OLS.

| WILLINGNESS | Coefficient | Robust std. err. | T-value | P-value | VIF |
|---|---|---|---|---|---|
| Age of farmer | -0. 011 | 0.009 | -1.290 | 0.201 | 1.06 |
| Gender of farmer | 0.215 | 0.283 | 0.760 | 0.448 | 1.06 |
| Land under sugarcane | -0.042 | 0.025 | -1.680 | 0.096 * | 1.09 |
| Land tenure security | 0.258 | 0.138 | 1.870 | 0.065 * | 1.16 |
| Access to credit | 0.392 | 0.292 | 1.340 | 0.182 | 1.04 |
| Access to extension | 0.090 | 0.074 | 1.220 | 0.224 | 1.15 |
| Cooperative membership | -0.450 | 0.332 | -1.350 | 0.178 | 1.04 |
| Bioenergy training | -0.287 | 0.378 | -0.760 | 0.45 | 1.1 |
| PC – Land | 0.384 | 0.114 | 3.370 | 0.001*** | 1.04 |
| PC – Food Security | -0.272 | 0.146 | -1.860 | 0.066 * | 1.14 |
| Constant | -0.313 | 0.886 | -0.350 | 0.725 | |
| | | | | | |
| Number of obs | = | 129 | | | |
| F(10, 118) | = | 3.2 | | | |
| Prob > F | = | 0.0011 | | | |
| R-squared | = | 0.2548 | | | |
| Root MSE | = | 1.6708 | | | |
| Mean VIF | = | 1.09 | | | |

Note: *, **,*** means statistically significant at 10%, 5% and 1%, respectively

**Source:** Survey data (Nov 2021)

### 5.4. Summary

The goal of this chapter was to present and discuss the findings of empirical analyses conducted to assess factors influencing small-scale sugarcane farmer’s potential and willingness to participate in bioenergy production in the industry. Two models were estimated by OLS. The model was a multivariate regression and the second was a principal components regression analysis. The first analysis focused on factors affecting bioenergy potentially of smallholder farmers to engage in bioenergy production. The findings show that the farmer's age, land ownership, access to credit and cooperative membership significantly affect potential bioenergy production. The second analysis showed that farmers’ willingness to engage in bioenergy production is influenced by land under sugarcane production, land tenure security and their perceptions on land and food security. The conclusions, policy recommendations, and topics of further research based on the study's findings are presented in the next chapter.

# CHAPTER 6
# CONCLUSIONS AND RECOMMENDATIONS

## 6.1. Recapping the purpose of the study

Smallholder sugarcane production has an important role in promoting the participation of smallholder farmers in the bioenergy sector. There is not much which is known about smallholder farmers' potential and willingness to engage in the bioenergy sector. Therefore, the main objective of the study was to assess small-scale farmers' potential and willingness to engage in bioenergy production from sugarcane. The specific objectives of the study were as follows: To determine factors affecting small-scale sugarcane producers' potential to participate in bioenergy production; assess the current practices and the level of engagement in bioenergy production of smallholder sugarcane producers; evaluate factors affecting farmers' willingness to participate in bioenergy production from sugarcane; and highlight what resources and institutional support is required for the smallholders to fully participate in the bioenergy sector. This chapter discusses the conclusions and recommendations from the study.

## 6.2. Conclusion

The following are the primary conclusions drawn from the findings of the study.

### 6.2.1. Factors influencing bioenergy potential of farmers in sugarcane production

Several factors were found to affect the bioenergy potential of smallholder sugarcane farmers. The negative relationship between the age of the farmer and their bioenergy potential demonstrates the need to focus on young farmers to promote bioenergy production in the sector. The youth are the future of smallholder agriculture and to sustain the sector more investment should focus on developing this age group. Given the rising youth unemployment in South Africa, focusing on the youth will also help create jobs and revive the sugarcane industry.

The positive relationship between land ownership and smallholder farmers' potential to participate in sugarcane production demonstrates how 'smallholder farmers with land have a higher potential for sugarcane production. This shows that land remains a critical resource in promoting smallholder agriculture. Without land smallholder farmers are limited and would not be able to seize opportunities from other sectors such as the bioenergy industry. The finding shows the importance of programs such as 'Masibuyele Emasimini' and their effective implementation has huge benefits for the farmers (employment creation, income, food security, etc.) and the rural economy. Contrary to expectations, access to credit has a negative relationship with smallholder farmers' bioenergy potential. This might be related to the financial/credit support mechanism currently being employed in the smallholder sugarcane industry. The current system is perceived as placing a huge financial debt/burden on the farmers. A different financial support mechanism would be required to promote smallholder sugarcane farmers' participation in the bioenergy sector.

Collective engagement remains a challenge among smallholder farmers. The findings show that a complete transformation is required regarding the structure, purpose, and governance of agricultural cooperatives in the country. Currently, farmers would rather work as individuals rather than in cooperatives, yet collective action has several advantages for small farmers given their level of production. Certainly, for bioenergy production smallholder sugarcane farmers would have to work together to have a significant amount of biomass feedstock. In cooperatives, farmers would also be able to share resources.

### 6.2.2. Current practices of farmers in sugarcane production

None of the farmers are currently engaged in bioenergy production. Most farmers profit in. The lack of knowledge is because there is no training that directly addresses bioenergy as an opportunity for smallholder sugarcane farmers. However, smallholder sugarcane farmers know that there is more than one product that is obtained from the sugarcane that they deliver to the market. However, they have not received any compensation for these byproducts. The contracts that farmers have signed with the millers are such that they can only receive compensation for the sugarcane delivered through the RV value determined based only on the sucrose content and quality.

Sugarcane harvesting among smallholder farmers is mainly manual though a few uses mechanical harvesting which is expensive. Hence, most resort to burning their sugarcane to make it easier to cut the cane and improve the quality of the sucrose. However, sugarcane burning has negative environmental effects which no one takes into consideration. Other farmers use the trash as compost or just leave it in the field while a few uses it as animal feed. These other uses are better compared to burning. However, if the opportunity cost of sugarcane burning to the farmer, on an individual basis, is higher than that of the other uses including bioenergy production there will not be incentives for farmers to stop burning.

### 6.2.2. Willingness of farmers to engage in bioenergy production

The findings show a lot of interest from smallholder farmers to participate in bioenergy production from sugarcane. However, this interest or willingness is affected by several factors including land under sugarcane production, land tenure security and negative perceptions on bioenergy. Farmers who currently have more land under sugarcane production are enjoying higher profits from sugarcane production and do not see a need to engage in bioenergy production. However, those with limited land see bioenergy production as an opportunity to obtain the best value from their existing land.

The study concludes that improving the land tenure security of smallholder sugarcane farmers would enhance their willingness to participate in bioenergy production. Given that most farmers have PTOs, this suggests that this form of tenure is regarded among farmers as secure. There is limited to no threat that the farmers' PTO will one day be withdrawn from the farmer. Even if the farmer passes on, the PTO to the sugarcane land remains in their family. Hence, farmers are not afraid to invest in their land because of the security of tenure that they enjoy. The only challenge is that farmers cannot use the PTO to obtain credit from financial institutions.

Farmers who believe that production of bioenergy requires large tracts of land are more willing to engage in bioenergy production compared to their counterparts. From experience similar projects in the past have resulted in farmers receiving support in the form of land and other resources. This also points to the need to ensure the availability of land and support for labour provision if smallholder bioenergy engagement would succeed. Furthermore, farmers who believe that bioenergy negatively affects food security have a lower interest in engaging in the sector. The food security and bioenergy tradeoff has been discussed extensively in literature. Therefore, it is important to ensure that any bioenergy project addresses this important issue if it is to succeed. Indeed, the use of sugarcane for bioenergy purposes mainly utilizes secondary products such as trash, bagasse, molasses, etc., and thus will have little to no impact on food security

## 6.3. Recommendations

### 6.3.1. Factors influencing bioenergy potential of farmers in sugarcane production

The study recommends the promotion of youth development programs to encourage youth involvement in sugarcane production. This could be accomplished through incentivized internships/learnerships, and mentorships programs supported by the government and other stakeholders in the industry. The CASP programme could provide resources to support such initiatives in the smallholder sugarcane sector.

The study advocates for the provision for more land to smallholder sugarcane farmers with an interest in producing biomass for bioenergy production. The more land one has the more their contribution to the available bioenergy feedstock. Similarly, the government working with the Sugar Industry should support the creation of markets for bioenergy feedstock. This entails for the development of new bioenergy value chains in farming communities to serve the farmers. The Sugar Act should be amended to recognize the secondary products of the sugar milling process so that smallholder farmers can be compensated for their contribution.

There is also a need to revamp the existing financial support system and collective action arrangements in smallholder sugarcane farming. Financial support should be provided with conditions that do not leave the farmers in more debt. Support for cooperatives is required. The support should focus on building farmers' understanding of the importance of collective arrangements, cooperative governance and accountability mechanisms, and strategies for avoiding free riding. Addressing these issues will revitalize smallholder sugarcane farmers interest to work in cooperatives.

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### 6.3.2. Current practices of farmers in sugarcane production

The study recommends support for the creation of new bioenergy value chains including markets for secondary products such as sugarcane trash. Training is also needed on the wider environmental and health consequences of pre-harvest burning of sugarcane. Farmers should be supported to start implementing green harvesting approaches. It is common knowledge that green harvesting might require the use of machinery not available to smallholder farmers. Strategies would thus be needed to incentivize farmers to use environmentally friendly approaches to harvesting sugarcane.

### 6.3.3. Willingness of farmers to participate in sugarcane production

Improving the land tenure security of smallholder sugarcane farmers would enhance their willingness to participate in bioenergy production. Therefore, the land reform/ redistribution programme in the country should support the creation of secure land tenure rights for farmers, especially smallholder farmers. There is also a need to ensure that any bioenergy programme in the smallholder sugarcane sector should not affect the production of crops for food security. The project should be carefully chosen to include those that mainly utilize secondary or by-products for energy generation. These are known as second generation energy sources. Regarding land, it important to ensure that some additional land is acquired for growing crops for bioenergy purposes. This will increase smallholder farmers' willingness to participate in the sector. Such land can include reclaimed or marginal land not previously suitable for agricultural production. The Indunas (traditional leaders)/councilor could assist in identifying such land in their communities.

## 6.4. Future research direction

The study's main objective was to examine small-scale farmers' potential and willingness to engage in bioenergy production from sugarcane in Ehlanzeni District, Mpumalanga Province. The study examined current farming methods, perceptions, resources, and financial institutions. Due to resource and time constraints, the study only included data from one district in Mpumalanga. The paper suggests that future research be broadened to include more areas and provinces in South Africa. This will provide a comprehensive understanding of the potential and willingness in the whole smallholder sugarcane farming sector to participate in the bioenergy industry.

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**Appendix 1**

## SECTION A: INTRODUCTION AND IDENTIFICATION INFORMATION

Hello, I am______________________________________. I am working with a research team from the University of South Africa as an enumerator. The survey is part of a research project titled **"Development pathways for promoting small-scale farmers contribution to the bioenergy sector in South Africa**."

The objective of the research is to review and evaluate the potential contribution of small-scale farmers to the bioenergy industry (biomass, biofuel, and biogas) and provide pathways for improving their livelihood and welfare through the green economy in South Africa.

The information to be captured in this questionnaire is strictly confidential and will be used for research purposes by staff and students at the University of South Africa. There are no wrong or right answers to these questions.

Participation is voluntary and that there is no direct benefit or gain that will be obtained from participating. Also, there is no penalty or loss of benefit for non-participation. You are under no obligation to participate. You are free to withdraw at any time during the completion of the questionnaire without giving a reason. Your personal details will remain confidential and will not be disclosed at any time whether in the dataset or reports and publications emanating from the survey.

**Would you like to participate in this survey? 1 = Yes 0 = No**

______________________________________

Date ______________________________________________________

| | | | |
|---|---|---|---|
| Questionnaire Code | | Enumerator name | |
| Municipality | | Ward No. | |
| Type of farmer **(code)**[1] | | Land reform (**code)**[2] | |
| Bioenergy project beneficiary **1 = Yes 0 = No** | | Name of organization supporting bioenergy project | |
| Type of bioenergy project | | | |
| Respondent gender **(Code A5)** | | Education level of respondent | |

**<u>Codes[1] for type of farmer:</u>**

1=Individual farmer

2= Part of a cooperative

**<u>Codes[2] for land reform:</u>**

1=Land reform beneficiary

2=non-land reform beneficiary

## SECTION A: HOUSEHOLD DEMOGRAPHICS

**A1.** What is the total number of members in your household? **(***Please include only those who stay in the household for 3 or more days per week and eat together*)

_____________________________

**Please complete the table below for the youth's household members where applicable. (*Record respondent and household head details in the first and second row, respectively*).**

| **A2.** Household member | **A3.** Relationship to household head ***(code)*** | **A4.** Age | **A5.** Gender ***(code)*** | **A6.** Marital status ***(code)*** | **A7.** Main occupation ***(code)*** | **A8.** Education level completed (Specify, e.g. Grade 7) |
|---|---|---|---|---|---|---|
| Member 1 – Head | **1** | | | | | |
| Member 2 | | | | | | |
| Member 3 | | | | | | |
| Member 4 | | | | | | |
| Member 5 | | | | | | |
| Member 6 | | | | | | |
| Member 7 | | | | | | |
| Member 8 | | | | | | |
| Member 9 | | | | | | |
| Member 10 | | | | | | |
| Member 11 | | | | | | |

**Key**

| ***Code for A3*: Relation to household head.** | ***Code for A5*: Gender** | ***Code for A6*: Marital status.** | ***Code for A7*: Main occupation!** |
|---|---|---|---|
| 1=Self 7= Mother<br>2=Spouse 8= Father<br>3=Son 9= Grand mother | 0=Female<br>1=Male<br>2=Other (specify) | 1=Single<br>2=Married<br>3=Divorced/Separated<br>4=Widowed<br>5 = Co-habiting | 1=Fulltime farmer<br>2=Regular salaried job<br>3=Temporary job<br>4=Self-employed (other business) |

| | | | |
|---|---|---|---|
| 4=Daughter 10 = Grand father<br>5=Grandson 11 = Other (specify)<br>6=Grand daughter | 3=Does not want to disclose | 6 = Any other (specify) | 5=Student<br>6=Retired<br>7=Unemployed<br>8=Other (specify) |

| | **Characteristics of the farming household** | **Response** |
|---|---|---|
| **A9** | Does the household have any members with chronic illness (conditions that require one to be on medication always)? *1=Yes 0= No* | |
| **A10** | Does the household have any member who got sick from COVID 19 in the past 12 months? *1=Yes 0= No* | |
| **A11** | If yes to **A10**, was the sick person between 15-65 years old? *1=Yes 0= No* | |
| **A12** | If yes to **A10**, did the household incur significant costs in seeking medical attention? *1=Yes 0= No* | |
| **A13** | Did anyone who contributes money/labour to the household lose their job/ was unable to go to work and earn an income due COVID 19 lockdowns? *1=Yes 0= No* | |

## SECTION B: HUMAN CAPITAL AND PSYCHOLOGICAL CAPITAL

**Have you ever received training skills in the following areas?**

| Skill | **B1:** 1=Yes 0=No | **B2.** If Yes, who offered the training? **(Code)** | **B3:** Training received for which enterprise |
|---|---|---|---|
| a. Soil and land use management | | | |
| b. Weed control | | | |
| c. Pest & disease management | | | |
| d. Proper crop harvesting | | | |
| e. Farm mechanization | | | |
| f. Irrigation and water use management | | | |
| g. Conservation agriculture | | | |
| h. Farm financial management | | | |
| i. Agricultural commodity marketing | | | |
| j. Business planning | | | |
| k. Contract negotiation | | | |
| l. Trash/Residue harvesting and baling | | | |
| m. Operation of small-scale bioenergy plant (from crops) | | | |
| n. Livestock production | | | |
| o. Biomass management | | | |
| p. Other (please specify) | | | |

**Code for B2: 1** = Government extension officers **2** = Fellow farmers **3** = Private company **4** = NGO **5** = Parents/relative knowledge **6** = Other (please specify)

_______________________________

**Code for B3:** **1** = Sugarcane 2 = Sorghum 3 = Livestock 4 = Sunflower 5 = Other crop (specify) **6** = All of them

**B4.** Were you able to use or apply the skills learnt above? 1 = Yes 0 = No

**B5.** If no to **B4,** why?

_______________________________________________________________________________

___________________

_______________________________________________________________________________

________________________________________

**B6.** Are you are interested in learning new skill sets that are bioenergy related? 1 = Yes 0 = No

**To what extent do you agree with the following statements regarding bioenergy production?**

**Use this Likert scale in your response:** 1=strongly disagree 2=Disagree 3=Neutral 4=Agree 5=strongly agree

| **Psychological capital constructs** | **B4.** Response |
|---|---|
| a. I am confident in bioenergy production as a lucrative farming business | |
| b. I am confident and have belief in myself as a farmer | |
| c. I believe I have the power to affect the outcome of my farming business | |
| d. I am optimistic about the future of the bioenergy sector/agriculture in my area | |
| e. I do not give up easily | |
| f. I am willing to take more risk than other farmers in my community | |
| g. I have hope about the prospects of smallholder agriculture/the bioenergy sector | |
| h. I am willing to forgo a profit opportunity in the short-run to benefit from potential profits in the long-run | |
| i. I am willing to try new ideas even without full knowledge about the possible outcomes | |
| j. I can cope with shocks (drought and other natural disasters) and other potential risks that threaten my farming business | |
| k. I would not be farming if there was a better alternative source of income | |
| l. The government is responsible for the wellbeing of rural farming households | |

## SECTION C: PHYSICAL ASSETS

**Complete the following table on ownership and access to assets.**

| Assets | **C1.** Number of assets owned or have access to | **C2.** Estimated current market value per unit (s) (Rand) |
|---|---|---|
| a. Cellphone | | |
| b. Radio/Television | | |
| c. Computer/Laptop | | |
| d. Trailer/cart | | |
| e. Water tank | | |
| f. Motor vehicle (e.g. bakkie) | | |
| g. Tractor | | |
| h. Wheelbarrow | | |
| i. Trash baler | | |
| j. Ethanol efficient stove | | |
| k. Biodigester | | |
| l. Gas stove | | |
| m.Storage shed | | |
| n. Other (specify) | | |

## SECTION D: CROP & LIVESTOCK PRODUCTION AND MARKETING

**D1.** What are your main reasons for **(a) crop farming? ____________________(b) livestock farming____________________**

**1** = Have sufficient food to feed my family **2** = Earn an income from sale of crops and animal products **3** = Create employment for myself and family members **4** = Create employment for people in the community **5** = Leisure **6** = Store wealth **7** = Cultural/ritual purposes **8** = Other (specify) ___________________(multiple answers possible)

## CROP PRODUCTION AND MARKETING

**D2**. Number of years of experience in **crop farming ____________________**

D3. How much arable land in hectares do you own/have access to?__hectares

**Please complete the following table regarding the land that you own/have access to.**

| **Plot** | **D4.** Size of plot (hectares) | **D5.** Means of ownership (Code) | **D6.** How much in Rands/ha do you pay for leased/rented plots |
|---|---|---|---|
| a. Plot 1 | | | |
| b. Plot 2 | | | |
| c. Plot 3 | | | |

**Code for D5:**

**1** = Hold the PTO rights (Land given by the Chief) **2** = Owned (have title deeds to the land)

**3** = Leased or rented **4** = Borrowed 6 = Other (specify) ______________________________

**D7.** Do you think your land tenure holding right is secure? **1** = strongly disagree **2** = disagree **3** = Neutral **4** = Agree

**5** = strongly agree

**Complete table for the sugarcane/ sorghum/ sunflower crops grown in 2020/21 season.**

| Crop | **D8.** Area (ha) | **D9.** Quantity harvested (tons/kgs) | **D10.** Quantity sold (tons/kgs) | **D11.** Unit of sale | **D12.** Price sold per unit | **D13.** Market outlet **(Code)** | **D14.** Do you harvest crop residue? **(1=Yes 0=No)** | **D15.** Quantity of residue harvested. (bales/kgs) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

**Note:** Unit of sale can be in kg/tons/50kg/bales

**Code for D13: 1** = Farmgate **2** = Hawkers/Van traders **3** = Local shops **4** = Millers **5.** Private companies **6**= Roadside **7**= Other (please specify)

**Complete the following table for inputs used for crop production in 2020/21 season.**

| Crop enterprise | Inputs | Unit (kg, etc.) | **D16.** Quantity | **D17.** Price per unit (R) | **D18.** Total Cost (R) |
|---|---|---|---|---|---|
| | a. Seeds | | | | |
| | b. Basal fertilizer | **kgs** | | | |
| | c. Urea | **kgs** | | | |
| | d. Manure (umquba) | **kgs** | | | |
| | e. Chemicals (pesticides)______________________ | **Litre** | | | |
| | f. Tractor/Ox services | **Hire** | | | |
| | g. Transport cost | **Trip** | | | |
| | a. Seeds | | | | |
| | b. Basal fertilizer | **kgs** | | | |
| | c. Urea | **kgs** | | | |
| | d. Manure (umquba) | **kgs** | | | |
| | e. Chemicals ______________________ | **Litre** | | | |
| | f. Tractor/Ox services | **Hire** | | | |
| | g. Transport cost | **Trip** | | | |

**Note:** Ignore the inputs that do not apply to a particular crop enterprise

**Complete following table on family and hired labour days for each crop enterprise in 2020/21**

| Crop enterprise | Production operations | **D19.** Family labour (man days) | **D20.** Hired labour. (man days) | **D21.** Hired labour wage/day. (Rands) |
|---|---|---|---|---|
| | Land preparation | | | |
| | Planting | | | |
| | Weed control | | | |
| | Pest control | | | |
| | Harvesting | | | |
| | Loading | | | |
| | Marketing | | | |
| | Land preparation | | | |
| | Planting | | | |
| | Weed control | | | |
| | Pest control | | | |
| | Harvesting | | | |
| | Loading | | | |
| | Marketing | | | |

**D22.** Indicate your THREE main challenges in the production of sugarcane/sorghum/sunflowers? _________________

**1** = Pests and diseases **2** = Limited access to land **3** = Insecure land ownership **4** = Insufficient water **5** = Poor access to markets **6**= Transport of produce **7**=Lack of adequate storage facilities **8**=Unaffordability of inputs **9**=Strays animal destroying crops **10**=Poor output prices **11**=Risk of product not being sold **12**=others (please specify)________________________

## LIVESTOCK PRODUCTION

**Complete following table on livestock ownership and sales in 2020/21**

| Type of livestock | **D23.** Number owned | **D24.** Estimated market value (Rand) |
|---|---|---|
| a. Goats | | |
| b. Cattle | | |
| c. Sheep | | |
| d. Poultry (broilers and layers) | | |
| e. Domestic chicken | | |
| g. Pigs | | |
| h. Donkeys | | |
| j. Others (specify) | | |

**D25.** What are your main challenges in livestock production?

**1** = disease outbreaks **2** = unable to vaccinate due to financial constraints **3** = no access to extension support services (e.g. veterinary services, etc.) **4** = limited access to grazing area 5 = access to output markets 6= access to inputs markets **7=** feed cost 8= others (please specify) ________________________(**multiple answers possible**)

**D26.** Do you sell some of your crop produce/products as a group? **1 =** Yes **0 =** No

**D27.** Do you sell your crop produce/products on social media? **1** = Yes **0** = No

**D28. If yes,** which social media do you use**? 1 =** WhatsApp **2 =** Facebook **3 =** Other social media platforms

**D29.** Distance to the nearest source of major inputs (kms)?

_________________________________________

**D30.** Distance to the major produce markets (kms)?

_______________________________________________

## SECTION E: FINANCIAL CAPITAL

**Complete the table below on sources of household income.**

| Source of income | **E1.** Source of income *1=Yes 0= No* | **E2.** Average income each time (Rands) | **E3.** How many times do you receive this income per year? E.g. once, 2, 3 or 4 times, per year, etc. |
|---|---|---|---|
| a. Social grant | | | |
| b. Remittances | | | |
| c. Arts and craft | | | |
| d. Permanent employment | | | |
| e. Temporary employment | | | |
| f. Retirement / Pension | | | |
| g. Crop sales | | | |
| h. Livestock sales | | | |
| i. Livestock products | | | |
| j. Own business | | | |
| k. Financial assistance from government or NPO | | | |
| l. Other (please specify) | | | |

**E4.** Did you have access to credit or any loan facility in the past year? **11** = Yes **0** = No **If no, SKIP to E8**

**E5. If yes to E4,** where did you get the loan?

_______________________________________

**1** = Relative or friend **2** = Money lender **3** = Savings club (e.g. stokvel or internal savings and lending schemes)
**4** = Banks **5** = Government **6** = Microfinance institutions **7** = I do not qualify 8= Others (please specify) _____________(**multiple answers possible**)

**E6.** Amount of loan taken. ________________________________

**E7.** What use did you put the loan that you obtained? **1** = Food and other basic household needs 2 = Pay for school fees, stationary, uniforms and medical expenses 3 = Bought household appliances **4** = agricultural purposes 5 = other (specify)

________________________________

**E8. If no to E4,** please specify the reason(s) for not taking and/or using credit (***multiple answers possible***)

**1** = The interest rate is high **2** = I couldn't secure the collateral *(isibambiso)* **3** = I have got my own sufficient money **4** = It isn't easily accessible **5** = I do not want to be indebted **6** = I do not qualify **7** = Other (please specify)

_______________________

**E9**. Do you have a bank account? **1=Yes 0=No**

## SECTION F: SOCIAL CAPITAL

Please answer the following questions regarding membership to different social networks or groupings.

| **Membership to local organizations.** | **F1. Response** |
|---|---|
| a. Are you a member of an agricultural/business cooperative? **1** = Yes **0** = No | |
| b. Are you a member of a credit and/or savings association **(Stokvel)?** **1** = Yes **0** = No | |
| c. Are you part of any other group in the community? **1** = Yes **0** = No | |

Please complete the following table regarding your sources of information on farming and markets.

| **Types of information Source** | **F2.** Used as an information source? 1=**Yes 0=No** | **F3.** Rank according to importance. **(Code)** |
|---|---|---|
| a. Extension officers | | |
| b. NPOs/ Contracting agencies | | |

| **Types of information Source** | **F2.** Used as an information source? 1=**Yes 0=No** | **F3.** Rank according to importance. **(Code)** |
|---|---|---|
| c. Media (newspapers, radio, TV) | | |
| d. Phones SMS | | |
| e. Internet and social media | | |
| f. Cooperative/social groups | | |
| g. Community meetings | | |
| h. Others (Please specify) | | |

***Code F3:*** *1= Not important 2 = Rarely important 3 = Neutral 4 =Important 5 = Most important*

**F4.** Do you have an email address? **1** = Yes **0** = No

**F5.** Number of extension contacts per months_____________________________________________

**F6.** Rate the quality of extension support received. **1** = very poor **2** = bad **3** = good **4** = Excellent

## SECTION G: ENGAGEMENT IN THE BIOENERGY SECTOR

**G1.** Are you willing and able to put more land under sugarcane/sorghum/sunflower production? **1 =** Yes **0 =** No

**G2.** If **yes to G1**, how much land? ______________________________hectares

**G3.** If **no to G1**, why?

________________________________________________________________________

_________________

**To what extent do you agree with the following statements regarding bioenergy production?**

**Use this Likert scale in your response:** 1=strongly disagree 2=Disagree 3=Neutral 4=Agree 5=strongly agree

| Perceptions on bioenergy | G4: Response |
|---|---|
| a. Lack of knowledge on the bioenergy industry affects participation of farmers | |
| b. Producing crops for bioenergy is not good for food security | |
| c. Production of bioenergy crops requires large tracts of land | |
| d. Producing crops for bioenergy is laborious to smallholders | |
| e. Producing crops for bioenergy is not for smallholder farmers but commercial farmers | |
| f. Smallholder farmers are not fairly compensated for their supply of bioenergy crops | |
| g. The sugarcane/sorghum/sunflower industry is not fair to smallholder farmers | |

**G5.** Are you aware that crops such as sugarcane/sorghum/sunflower can be used for producing energy? **1 =** Yes **0 =** No

**G6.** Besides the primary products such as sugar/oil, what other **by-products** are obtained from sugarcane/sorghum/sunflower?____________________________________________

____________________________________________________________________________

____________________________________________________________________________

**G7.** Do you think the market selling price for sugarcane/sorghum/sunflower obtained by smallholder farmers include the value of the different **by-products** obtained from it? **0 =** No **1 =** Yes **2 =** Not sure (Don't know)

**G8.** Are you aware of the use of residues from sugarcane/sorghum/sunflower for energy production? **1 =** Yes **0 =** No

**G9.** Are you aware that one can harvest the trash/crop residue and sell it? **1 =** Yes **0 =** No

**G10a.** Have you ever attempted to harvest and sell your trash/crop residues? **1 =** Yes **0 =** No

**G10b**. How much of the trash is harvested and sold? **1** = Small portion **2** = Some of it 3 = Most of it **4** = All of it

**G11.** If **no to G10a**, why?

______________________________________________________________________________

_____________

______________________________________________________________________________

____________________________________

**G12**. If **no to G10a**, what do you do with the trash/ crop residue from your field?

**1**= Leave it in the field **2**= Use it as compost manure 3= Burn it **4**= Feed livestock 5= Harvest and sell **6**= Others (specify)_________________________________

**G13.** If answer in **G12 is 3**, are you aware of the environmental implication of burning trash/crop residue? **1** = Yes **0** = No

**G14.** If you wanted to sell sugarcane trash/crop residue, do you know where to sell it? **1 =** Yes **0 =** No

**To what extent do you agree with the following statements? Use this Likert scale in your response:** 1=strongly disagree 2=Disagree 3=Neutral 4=Agree 5=strongly agree

| **Willingness to engage in the bioenergy sector** | **G15. Response** |
|---|---|
| a. I am willing to harvest and supply trash/crop residues from my land to a bioenergy producer | |
| b. I believe selling of trash/crop residues would earn my family extra income | |

| | |
|---|---|
| c. I am willing to hire people or machinery to harvest trash/crop residues to meet demand | |
| d. I am willing to go into a contractual agreement with energy producers for supply of trash/crop residues | |
| e. I do not possess adequate knowledge and skills in production and harvesting of bioenergy crops | |

**G16.** What critical support would you require to effectively participate in production of bioenergy crops?

1.______________________________________________________________________________

__________________________________

2.______________________________________________________________________________

__________________________________

3.______________________________________________________________________________

__________________________________

## SECTION H: FOOD SECURITY AND HOUSEHOLD EXPENDITURE

**Food diversity**

I would like to ask you about all the different foods that your household members have eaten in the **last 7 days**. Could you please tell me **how many days** in the past week your household has eaten the following foods? (for each food, ask what the primary source of each food item eaten that week was, as well as the second main source of food, if any)

| | FOOD CONSUMPTION AND FOOD SOURCES | | |
|---|---|---|---|
| | | **Female** | **Male** |
| **H1** | How many meals did the adults (**18+**) in this household eat **yesterday**? | | |
| **H2** | How many meals did the children between the age of **5-17** eat **yesterday**? | | |
| **H3** | How many meals did the children between the age of **2-<5** eat **yesterday**? | | |

| | Food items/groups | Examples<br><br>*Replace the example foods below with items commonly consumed in the survey area(s).* | **H4.1.** How many days **over the last 7 days**, did members of your household eat the following food items, prepared and/or consumed at home? | **H4.2. How was this food acquired?** Write the main source of food for the past 7 days. |
|---|---|---|---|---|
| | | | **Days** | **Source** |
| A | **Cereals or tubers** | **Rice, potato, naan etc.** | \|__\| | \|__\|__\| |
| A.1 | Foods made from grain | Porridge, bread, rice, chapatti, roti, pasta/noodles, or other foods made from grains | \|__\| | \|__\|__\| |
| A.2 | Roots and tubers | Potato, flesh sweet potato, amadhumbe and/or another tubers & root | \|__\| | \|__\|__\| |
| B | **Pulses and groundnuts** | **Beans, peas, etc.** | \|__\| | \|__\|__\| |
| C | **Milk and milk products** | **Fresh milk, powdered milk, yogurt, cheese, other dairy products** (exclude margarine/butte | \|__\| | \|__\|__\| |

| | | | | |
|---|---|---|---|---|
| | | r or small amounts of milk for tea / coffee) | | |
| D | **Eggs, meat, fish, shells** | **Organ meat, flesh meat, fish, eggs, etc.** | \|__\| | \|__\|__\| |
| D. 1 | Organ meat | Liver, kidney, heart, other organs | \|__\| | \|__\|__\| |
| D. 2 | Meat and poultry | Flesh meat: beef, lamb, goat, chicken, duck | \|__\| | \|__\|__\| |
| D. 3 | Fish and seafood | Fish, shellfish, dry fish | \|__\| | \|__\|__\| |
| D. 4 | Eggs | Chicken eggs, duck eggs | \|__\| | \|__\|__\| |
| E | **Vegetables** | **Carrots, spinach etc.** | \|__\| | \|__\|__\| |
| E.1 | Vitamin A-rich vegetables, roots and tubers | Carrot, red pepper, pumpkin | \|__\| | \|__\|__\| |
| E.2 | Dark green leafy vegetables | Spinach, broccoli, green pepper, and/or other dark green leaves | \|__\| | \|__\|__\| |
| E.3 | Other vegetables | Any other vegetables | \|__\| | \|__\|__\| |
| F | **Fruits** | **Mango, banana, etc.** | \|__\| | \|__\|__\| |

| | | | | |
|---|---|---|---|---|
| F.1 | Vitamin A-rich fruits | Mango, pawpaw, apricot, peach, | \|__\| | \|__\|__\| |
| F.2 | Other fruits | Banana, oranges, apples, tomatoes, pineapple, and any other fruits | \|__\| | \|__\|__\| |
| G | **Sugar** | **Sugar, honey, jam, cakes, candy, cookies, pastries, cakes and other sweet** (sugary drinks) | \|__\| | \|__\|__\| |
| H | **Oil** | **Vegetable oil, butter, margarine, other fats / oil** | \|__\| | \|__\|__\| |
| I | **Condiments** | **Condiments / Spices, tea, coffee / cocoa, salt, garlic, spices, yeast / baking powder, tomato / sauce** | \|__\| | \|__\|__\| |
| **Food acquisition codes:** 01 = purchase (cash) | | 04 = support from relatives/friends | 06 = borrowing 07 = begging/scavenging | 08 = gathering of wild foods (plants/insects) |

| | | |
|---|---|---|
| 02 = purchase (credit)<br>03 = food assistance | 05 = barter and exchange | 09 = hunting/fishing<br>10 = own production |

**Household Coping Strategies**

| **In the past 7 days, if there have been times when you did not have enough food or money to buy food, how many days has your household had to:** | **H5. Frequency: Number of days out of the past seven:** (Use numbers 0 – 7 to answer number of days; Use NA for not applicable) |
|---|---|
| 1. Rely on less preferred and less expensive foods? | |
| 2. Borrow food, or rely on help from a friend or relative? | |
| 3. Purchase food on credit? | |
| 4. Gather wild food, hunt, or harvest immature crops? | |
| 5. Consume seed stock held for next season? | |
| 6. Send household members to eat elsewhere? | |
| 7. Send household members to beg? | |
| 8. Limit portion size at mealtimes? | |
| 9. Restrict consumption by adults for small children to eat? | |
| 10. Feed working members of HH at the expense of non-working members? | |
| 11. Reduce number of meals eaten in a day? | |
| 12. Skip entire days without eating? | |

**7. Food Insecurity Experience Scale**

| **Now I would like to ask you some questions about food experiences in your household. During the last 12 MONTHS, was there a time when:** | **H6. Response** |
|---|---|
| 1. You or others in your household worried about not having enough food to eat because of a lack of money or other resources? | **1 =** Yes **0 =** No |

| | |
|---|---|
| 2. Still thinking about the last **12 MONTHS**, was there a time when you or others in your household were unable to eat healthy and nutritious food because of a lack of money or other resources? | **1 =** Yes **0 =** No |
| 3. Was there a time when you or others in your household ate only a few kinds of foods because of a lack of money or other resources? | **1 =** Yes **0 =** No |
| 4. Was there a time when you or others in your household had to skip a meal because there was not enough money or resources to get food? | **1 =** Yes **0 =** No |
| 5. Still thinking about the last **12 MONTHS**, was there a time when you or others in your household ate less than you thought you should because of a lack of money or other resources? | **1 =** Yes **0 =** No |
| 6. Was there a time when your household ran out of food because of a lack of money or other resources? | **1 =** Yes **0 =** No |
| 7. Was there a time when you or others in your household were hungry but did not eat because there was not enough money or other resources for food? | **1 =** Yes **0 =** No |
| 8. Was there a time when you or others in your household went without eating for a whole day because of a lack of money or other resources? | **1 =** Yes **0 =** No |

## SECTION F: WELFARE INFORMATION

### HOUSEHOLD CONSUMPTION AND NON-FOOD ITEMS EXPENDITURE AS A MEASURE OF WELFARE

| **Expenditure item** | **H7. Amount per week (for food) and Amount per month for non-food items** |
|---|---|
| 1. Own-produced food: Estimate cost of own produced food (assuming you are to buy in your local market) per week. | |
| 2. Purchased-Food: Estimate cost of food items (e.g., milk, meat, fish, oil, fruits, vegetables, salt, etc.) that you bought for the household per week. | |
| 3. Food as gift: Estimate cost of food giving to you as gift by relatives and friends (assuming you are to buy them) per week | |

| | | |
|---|---|---|
| 4. Accommodation (Assume how much you will pay if you are in your own house/room; maintenance cost should be included) | | |
| 5. Clothing | | |
| 6. Education | | |
| 7. Health or medication | | |
| 8. Transportation | | |
| 9. Utility; | (a) Water | |
| | (b) Electricity | |
| | (c ) Kerosene/paraffin | |
| | (d) LP Gas | |
| 10. Communication (telephone, postal etc.) | | |
| 11. Sanitation | | |
| 12. Ceremonies; | (a) Funerals | |
| | (b) Family rituals and other ceremonies | |
| | (c) Parties/entertainments | |
| | (d) Tithes and offerings | |
| | (e) Gifts | |
| | (f) Others……………………… | |
| 13. Fuel/ Firewood | | |
| 14. Saving | | |
| 15. Maintenance of assets (e.g. TV, Motto bikes, Cars etc) | | |
| 16. Others…………………………………………. | | |

**ANY OTHER COMMENTS**

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