The Impacts of Access to Credit and Information Communication Technology (ICT) on Small-Scale Sugarcane Farmers' Food Security Status in Ndwedwe Local Municipality of iLembe, KwaZulu Natal Province

By

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Thesis submitted in fulfilment of the academic requirements of the degree of Doctor of Philosophy in Agriculture.

In Agricultural Extension and Rural Resource Management
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Pietermaritzburg
South Africa
February 2024

ABSTRACT

Access to credit and Information Communication Technology (ICT) are the most valuable resources in improving small-scale sugarcane farmer's practices. These two resources make the life of these farmers easier financially, socially, and economically. Despite the significant contribution of credit and ICT on sugarcane production, small-scale farmers are faced with difficulties in accessing them which affect their ability to generate sustainable income. Apart from complications in accessing credit and ICT, the adoption of ICT by farmers is of paramount importance to ensure its applicability for the quick access to credit through online or the internet. Adopting Information Communication technology is important to help Small-scale farmers' access credit thereby increasing their farm production. Therefore, alleviating the disproportionate burden of food insecurity in South Africa requires focused initiatives to assist small-scale farmers to adopt Information Communication Technology and be able to access credit. The main objective of this study was to determine the impact that credit and ICT have on food security of small-scale sugarcane farmers. The specific objectives were to determine the effect of access to credit; and information and Communication technology on the income of small-scale sugarcane farmers, assess the impact that determinants of ICT and credit accessibility have on the food security of small-scale sugarcane farmers and to assess efficiency among small-scale sugarcane farmers in South Africa using the Zero-efficiency stochastic frontier approach.

A multi stage sampling procedure was used to select three villages namely, Ndwedwe Mission, Nhlangano, and Sonkombo of Ndwedwe Local Municipality, employing a quantitative research approach. The study used 300 small-scale sugarcane farmers which were randomly selected. The Recursive Bivariate Probit Regression model was applied to assess the access to credit by farmers and its influence on the adoption of ICT. The results from the Recursive Bivariate Probit Regression .model showed that access to credit , education and extension support with coefficient had a positive and significant influence on the adoption of ICT, while marital status and non-farm income had a negative and significant influence. On the other hand, gender and marital status had a positive and significant relationship with access to credit while age and non-farm income showed a negative and significant relationship. The study secondly assessed the impacts that determinants of ICT and credit accessibility have on the food security of small-scale

sugarcane farmers. The two-step generalized linear square model with a control function was used to assess the combined effect of ICT adoption and access to credit on household food security in terms of HFIAS. HFIAS revealed that out of the total sample size, 86.7% of the small-scale farmers were food insecure while 13.3% were food secure. Age of the household head and low income had a negative and significant contribution to the food insecurity status. The results also showed that Seed cane and transportation costs decreased food security among small-scale farmers. In the last objective, the study employed the Zero-efficiency stochastic frontier approach to assess efficiency among small-scale sugarcane farmers. The results show that farmers received high efficiency (40%) at 0.71-0.90 efficiency scores while they received low efficiency (15%) at 0.51-0.70 efficiency score. Age, gender, household size and seed cane age had a positive and significant influence on farmers' efficiency. On the other hand, education and non-farm income had a negative and significant influence on farmers' efficiency.

An improvement in the factor that affect small-scale farmers' production can lead to improvement in access to credit and adoption of ICT which in turn improves farm income and food security. Small-scale farmers need to be encouraged to get some education on how to adopt ICT and access credit. More training and workshops need to be conducted to teach and train farmers on the requirements needed to apply for formal credit. Moreover, they need to be trained on how to adopt modern information technology. This can help them to produce more efficiently and generate more income. Extension workers need to provide advisory support to small-scale farmers that need agricultural access to credit.for agricultural activities.

Keywords: Access to credit, Information Communication Technology (ICT), Small-scale farmers, Sugarcane production, Food security, Recursive Bivariate Probit Regression, Zero efficiency stochastic frontier approach

DECLARATION 1 - PLAGIARISM

I, Nkosingiphile Samuel Zulu, declare that:

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Author's contribution to publications that form part of the dissertation.

.Publication 1-chapter 4

Zulu N.S; Ngidi M, S, C; Ojo T, O and S.I Hlatshwayo. Determinants of access to credit and information and communication technology and its effect on income of sugarcane small-scale farmers in Ndwedwe local municipality, KwaZulu Natal Province, South Africa. (Paper in press,).

Publication 2- chapter 5

Zulu N.S; Ngidi M, S, C; Ojo T, O and S.I Hlatshwayo. The Determinants of Information Communication Technology (ICT) Adoption and Access to Credit Market and Its Effect on Food Security of the Sugarcane small-scale farmers in Ndwedwe local community, KwaZulu-Natal Province, South Africa. (Under preparation to be submitted in a journal).

Publication 3- chapter 6

Zulu N.S; Ngidi M, S, C; Ojo T, O and S.I Hlatshwayo. Analysis of efficiency among sugarcane small-scale farmers in South Africa: a zero-efficiency stochastic frontier approach. (Under preparation to be submitted in a journal).

ACKNOWLEDGEMENTS

I would like to express my gratitude to everybody who contributed towards this dissertation. It would not have been possible without your input, time, and support. Your help is really appreciated. My first and foremost thank you goes to Dr Mjabuliseni Ngidi, my supervisor. I would like to thank you for your guidance, mentoring and evaluations throughout this study. You really helped me to structure my opinions; I would not have managed without your support. Continue with the good work and may God be with you always. I would also like to thank Dr Ojo, Temitope Oluwaseun, for believing in me, you gave me all the hope l needed. I will not forget my immediate supervisor, Dr Simphiwe Hlatshwayo. I would like to thank KwaZulu-Natal Department of Agriculture and Rural development for financial supports.

I would like to direct appreciation to the respondents who took their time to complete my questionnaire in detail. I am truly grateful for that; it is your support that made it easier for me to compile this dissertation. It would have been an uphill battle to complete this study without your enthusiasm to work together with me, I would also like to extend my gratitude to my fellow colleagues for assisting me with gathering data, the Ndwedwe mission ,Nhlangano and Sonkombo sugarcane satellite office as well as scientists from the South African Cane Growers Association for data analysis, extension officers from the KwaZulu-Natal Department of agriculture and Ndwedwe Local Municipality especially the GIS Department. I would also thank Tongaat Huletts and South African farmers development Asoosiotion (SAFDA) for Ndwedwe Development information supports.

My sisters, parents, and wife, I would like to acknowledge you for supporting me through your words of encouragement. The University of Zululand Geography and Environment Department, I am very grateful for the technical backing that you provided with regard to the final map outcome of the study areas. I remain extremely thankful for the strength and hope that God-almighty has given me and for giving me the wisdom and strength to sail through — you made the entire plan of my dissertation possible.

Thank you all very much.

DEDICATION

To my late Dad and late Mum, who believed in me and inspired me to aim high. To my wife Euvone, Daughters Aneliswa and Queen, and Sons Qhawe, Prince, and Anele, together we are a family.

To my sisters Cleopatra and Zandile, who encouraged me to aim high.

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ACRONYMS AND ABBREVIATIONS

AUC	American University in Cairo
AVC	Agriculture Value Chain
CA	conservative Agriculture
CSAT	Climate Smart Agriculture
DAFF	Department of Agriculture Forestry and Fisheries
AU	African Union
AUDA	African Union Development agency
CASP	Compréhensive Agriculture Agricultural Support Programme
DARD	Department of Agriculture and Rural Development
FAO	Food and agriculture Organisation
FO	Farmer Organisation
GDP	Gross Domestic Product
HFIAS	Household food insecurity access scale
SASA	South African Sugar Association
SACU	Southern African Customs Union
SDGS	Sustainable Development Goals
GIS	Geographical information system Department
ICT	Information Communication Technology
KZN	KwaZulu-Natal
KZNDAEA	KwaZulu-Natal Department of Agriculture and Environmental Affairs
MAFISA	Micro Agricultural Finance Institution of South Africa
NDP	National Development Plan
NDoH	National Department of Health
NEPAD	New Partnership for Africa's Development
PA	Precision Agriculture
RFID	Description, Radio Frequency Identification
RBVP	Recursive bivariance Probit
SDGs	Sustainable Development Goals
SSGs	Small-Scale Growers

SPSS	Statistical Software for Social Sciences
STATS SA	Statistics South Africa.
USAID	United States Agency for International Development
STATS SA	Statistics South Africa
UAF	Umthombo Agricultural Finance
UN	United States
UNDP	United Nation Development Programme
VLFs	Very Low Food Security
SPF	Supplementary Payment Fund

CHAPTER 1: INTRODUCTION

1.1 Background of the study

Small-scale farmers require access to production credit through ICT uses, in order toincrease their productivity and to develop the agricultural sector as a whole. According to the Department of Agriculture Forestry and Fisheries, (2016), about 70% of the poor population in South Africa live in rural areas, and these areas are characterised by high levels of poverty and unemployment(Fan and Rue, 2020). According to Fan and Rue (2020) by 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day.

Sustainable development goals one is projecting that by 2030, to eradicate poverty for all people everywhere currently measured as people living on lessthan $1,25/day by 2030, and ensuring that men and women in particular the poor and the vulnerable , have equal rights to economic resources as well access. And also Access to basic services , ownership and control over land and other forms of property, inheritance, natual resources, appropriate new technology and financial services , including micro finance (Fan and Rue, 2020). The public sector is not a major investor, but its role can be catalytic High percentage of investments in agriculture tend to be made by private sector agents, especially by the farmers themselves. Public investments in agriculture, related infrastructure, and research and development only represent a fraction of total investment in the sector in low-income countries. More than 90 percent of the estimated 570 million farms worldwide are family farms (FAO, 2014). In low-income countries, the vast majority of these farms are less than 5 ha in size. Many small-scale farmers tend to face major barriers accessing the finance needed for investment in improving productivity and adopting sustainable farming practices. They usually have limited financial literacy, collateral and credit history, and few other sources of income (FAO, 2016).

There are number of Investment in agriculture in low-and middle-income countries, this include on farm investment in agricultural capital, government investment , public spending on agricultural R&D, official development assistance and provate direct investment. Governments can support and play a catalytic role in stimulating pro-poor investments, by securing producers' property and tenure rights, and developing rural infrastructure and public services. Public investment in public goods and services such as institution building, agricultural extension, productivity-enhancing research, rural transport, health, education and social

protection will be fundamental to creating an environment favourable to pro-poor investment. A positive recent trend is the emergence of partnerships between the public sector, private sector and communities, which promote agriculture and rural development, poverty reduction, food security and improved nutrition. Also needed are incentives to private banking institutions (including cooperatives) to increase their rural coverage. The creation of employment opportunities in infrastructure development and the public procurement of agricultural products generated by small-scale farmers can also help to stabilize incomes and provide opportunities for low-income rural people to acquire productive assets and inputs, such as land, equipment, fertilizers and seeds. Agricultural investments are considered high-risk given the weakness of production to weather and other climatic hazards. This applies particularly to low-income countries, where infrastructure, processing capacity, and cold storage and transportation may be poorly developed. This limits farmers' options to reduce the impacts of seasonality and uncertain weather conditions on incomes and local price stability. Improving infrastructure, building resilience, and strengthening risk-coping mechanisms (e.g. through social protection and agricultural insurance) will be essential to help farmers and agricultural investors hedge against the risks inherent in agricultural production. More in general, private investments in agriculture will be influenced through broader agricultural and food price policies. Governments around the world provide incentives to farmers and agribusinesses in order to increase agricultural production, influence input costs, supplement farm incomes and achieve other social, economic and environmental objectives, such as landscape preservation, water conservation, poverty reduction, and climate change mitigation and adaptation. Much of the existing production support, worldwide, involves subsidies on inputs, such as fertilizer and energy, particularly fossil fuels, or direct payments to farmers. The OECD countries spent US$211 billion in agricultural production support in 2015, while in the non-OECD countries for which data are available, this support reached US$352 billion in the same year (OECD, IEA, NEA and ITF, 2015).

From the perspective of sustainable development, such support measures may have unintended impacts on the environment. For example, input subsidies may induce inefficient use of synthetic fertilizers and pesticides and increase the emission intensity of production. Almost half of all agricultural subsidies provided by governments of OECD countries in 2010–2012 were classed as 'potentially most harmful to the environment' because they induced greater demand for chemical fertilizers and fossil fuels, which lead to more GHG emissions (OECD, IEA, NEA and ITF, 2015). Such policies influence the magnitude and the nature of investments

in agricultural sectors and food systems. Making support conditional upon the adoption of practices that lower emissions and conserve natural resources would be one way of aligning agricultural development and climate goals. Policies in areas such as nutrition, food consumption, food price support, natural resources management, infrastructure development and energy, may similarly need to be reset (FAO, 2016).

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These people are subject to constrained income because the rural economy cannot fully provide for self-employment opportunities. Growth in the agricultural sector has been hindered by different factors, such as high costs of production, uncoordinated policies, and natural risks such as climate variability. Small-scale farmers can contribute significantly to creating employment opportunities and improve household food security for the poor in rural areas (Mango *et al* 2018).

Therefore, in order to ensure long-term food security, there is needs to be a significant increase in the productivity levels of small-scale farmers (DAFF, 2016). Sugarcane farming is one of the most important agricultural activities in South Africa. Sugarcane is mostly grown in three provinces, namely Mpumalanga, the Eastern Cape and KwaZulu-Natal (KZN). According to the South African Sugar Association (SASA) (2016), the annual income generated by the sugar industry is estimated to be R8 billion, with a nominal gross domestic product (GDP) of R2.4 billion. This means that the industry contributes 0.5% to 0.7% to the GDP. A majority of the people working in the agricultural sector is employed in the sugar industry in South Africa, both directly and indirectly.

Approximately 79 000 workers are employed by the industry directly through sugarcane production and processing and 350 000 workers are indirectly employed through other support services such as input suppliers (SASA, 2016). Therefore, one can argue that sugarcane farmers and sugar mills contribute significantly to the economic survival of rural communities and towns. A study by Maloa (2001) concluded that sugarcane farming areas and milling towns in South Africa have lower levels of unemployment. The per capita income in these towns is also higher than in other towns and farming areas. According to SASA (2016), approximately 29 130 registered sugarcane growers and six milling companies are responsible for the manufacture of sugar.

The sugarcane growing areas are operated by 14 sugar mills. As a major crop grown in the KZN and Mpumalanga provinces, sugarcane generates approximately 50% of farming income from field crops in these provinces. Sugarcane production for the entire industry per season stands at 2.3 million tons. However, during the 2015/2016 season, the industry recorded a decline of 1.6 million tons in sugarcane production (SASA, 2016). This may be attributed to different factors, such as the recent drought, which affected mostly the central and eastern parts of South Africa and was declared the worst drought since 1992. The sugar industry in South Africa seems to be shrinking, and this is a matter of concern, given its importance.

The main purpose of the study is to determine the impact of access to credit and information communication technology (ICT) on small-scale sugarcane farmer's food security status in Ndwedwe local municipality of iLembe.

The study has contributed to the literature a several aspects. First, the study analyse the impact of ICT adoption on access to credit.The recursive bivariate probit(RBP) model to address the

selection bias issue that usually occurs when farmers self-select themselves as ICT adopters or non-adopters. The propensity score matching(PSM)approach have employed by previous studies to mitigate selection bias associated with ICT adoption(Minah, 2022; Shimada & Sonobe, 2021). However the PSM approach is unable to mitigate selection bias issues arising from unobserved factors. Secondly we explore whether there exist heterogenous effects of ICT adoption on access to credit between male and female-headed households and among geographical locations.

Previous studies have employed a propensity score matching (PSM) approach to mitigate selection bias associated with ICT adoption (Minah, 2022; Shimada & Sonobe, 2021). However, the PSM approach is unable to mitigate selection bias issues arising from unobserved factors. Second, we explore whether there exist heterogeneous effects of ICT adoption on access to credit between male- and female-headed households and among geographical locations. Current studies have confirmed that a gender devide exist in ICT adoption (Leng et al., 2020; Nikam,). Therefore, the impact of ICT adoption on access to credit might be heterogenous between male- and female- headed households.

Furthermore, the institutional arrangements, socioeconomic conditions , ICT infrastructure condtions and resource endowments differ globally, so it is worth investigating whether there are heterogenous regional effects of ICT adoption. Third, we explore the joint effects of ICT adoption and access to credit on household income. Previous studies have either examined the effects of ICT adoption, Leng et al., 2020; Ma & Zheng, 2022) or analyzed the effects of access to credit (Osabohien et al., 2022).

However, given that farmers may make joint decisions in their efforts to adopt ICTs and acquire credit, modeling the separate effects of ICT adoption and access to credit on household income would generate biased and inconsistent estimates. Fourth, we further estimate the impact of ICT adoption and access to credit on farm income and business income. This estimation enables us to intuitively understand whether farmers have used the ICTs and acquired credit to invest in income-generating farm and off-farm activities. Finally, we estimate an unconditional quantile regression (UQR) model to check whether the impacts of ICT adoption and access to credit on household income are homogenous or heterogeneous. From a policy perspective, policymakers are usually interested in understanding how ICT interventions and credit market development in rural areas affect the unconditional distributions of an outcome such as household income

According to SASA (2016), the total area under cane was 419 465 ha in the 2006/2007 season and this decreased significantly to 370 336 ha in the 2015/2016 season. Records show that there was also a major decline in small-scale sugarcane production during the same period. In the 2006/2007 season Small-Scale Growers (SSGs) produced a total of 2 030 443 tonnes of cane and this decreased to 1 410 472 tonnes in the 2015/2016 season (SASA, 2016).

1.2 Problem statement

Small-scale farmers of Ndwedwe local municipality, KwaZulu-Natal experienced lower sugarcane productivity due to poor education, limited resources, poor access to credit, poor infrastructure, high inputs costs and food insecurity and poor makerts information. Inadequate market information, poor infrastructure, technical inefficiencies, and high input costs are also major causes of low productivity among small-scale farmers (Madzokere *et al* 2018). The high number of SSGs in African developing countries still lack access to formal finance to increase agricultural production (Masuku, 2017).

Masuku (2017), further states that Credit provision is essential for rural development and for the growth of the economy. According to Masuku (2017) credit allows small-scale farmers to purchase production inputs easily, and thus contributes to sustainable growth in agriculture. And also Small-scale farmers are also able to adopt improved agricultural technologies through access to credit, hence increasing the production of their agricultural enterprises. According to Ntshangase 2016, the uncertainty in agricultural production has made it much more difficult for formal institutions to give credit to small-scale farmers for large-scale investments. This credit constraint issue has affected agricultural growth and poverty eradication measures by small-scale farmers in rural areas.

Small-scale sugarcane farmers in rural areas of South Africa still lack the necessary inputs and access to formal financial markets to obtain credit. Some do not have guaranteed markets for their produce, have limited production land, and suffer high transaction costs in production(Ntshangase 2016).

Initially, small-scale farmers ventured into sugarcane production with hopes of attaining substantial returns to enhance their food security status. However, attracted by the perceived profitability of sugarcane farming, many small-scale farmers transitioned from their traditional cash and food crop enterprises to solely focusing on sugarcane production. (Hurly et al ,2015). Consequently, these farmers allocated the majority of their land to sugarcane cultivation,

practicing monoculture as their primary farming method, which led to a notable decline in food crop production.

While sugarcane production was expected to provide sufficient income for small-scale farmers to purchase food, the reality of monoculture farming has resulted in inadequate earnings over time, intensifying food insecurity among these farmers,with no financial resources to improve such depreciated net farm earnings.

In the rural areas of KZN, small-scale sugarcane farmers are faced with a major constraint of increasing productivity, partially caused by lack of access to formal credit. Hence, there is continued research into identifying better measures that can improve small-scale sugarcane farmers' access to formal credit (Hurly *et al* ,2015).

Moreover, the extended maturity period of sugarcane plants in South Africa, spanning between 18 to 24 months, further composites the food insecurity situation, as households must wait for an extended period before their primary source of income materializes.

Several studies (Kuwornu *et al*., 2012; Saqibe *et al.,* 2016; Chandio *et al.,* 2016; *Chandio et al.,* 2021) have explored the impact of credit accessibility on agricultural production, while others have focused into the role of information accessibility in farmers' production, Saleni et al., (2021) some studies have concentrated on the food security of small-scale sugarcane farmers; Bahati *et al*., (2022), state that nevertheless, there is a scarcity of empirical investigations examining the combined influence of ICT and credit accessibility on the food security of small-scale sugarcane farmers.

In spite of the critical significance of credit access, Ndwedwe sugaracne rural households often encounter challenges in obtaining credit or securing the required amount, primarily due to diverse constraints. These obstacles encompass the absence of credit markets and services, limitations in regional financial institution structures, insufficient collateral, and the existence of information asymmetry (Benami and Carter, 2021; Kehinde and Ogundeji, 2022). Information asymmetry, in particular, stands out as a substantial hindrance. Adopting information and communication technologies (ICTs), such as computers and mobile phones, emerges as a viable solution to mitigate information asymmetry in the current digital era.

Many studies have been carried out in an attempt to deal with the issue of access to formal credit and adoption of ICT in a developing economy. These include supplier-led approaches to credit, which have not been successful; the developing world is still in search of improved alternatives to enhance access to formal credits by small-scale farmers (Stiglitz, 2002) and (Meyer, 2015). Many studies argued that in order to promote rural economic development, there has to be a change in the lending terms of financial markets in the rural areas and also access to ICT. Additionally, access to credit contributes to the smoothing of household consumption patterns (Kumar *et al.*, 2020), aiding in managing short-term non-delinquent expenses like sickness prevention and treatment and children's education (Kandulu *et al*., 2019). Beyond these benefits, access to credit has the potential to empower rural women by enabling them to acquire productive assets.

The study has contributes to the literature a several aspects. First, the study analyse the impact of ICT adoption on access to credit.The recursive bivariate probit(RBP) model to address the selection bias issue that usually occurs when farmers self-select themselves as ICT adopters or non-adopters. The propensity score matching(PSM)approach have employed by previous studies to mitigate selection bias associated with ICT adoption(Minah, 2022; Shimada & Sonobe, 2021). However the PSM approach is unable to mitigate selection bias issues arising from unobserved factors. Secondly we explore whether there exist heterogenous effects of ICT adoption on access to credit between male and female-headed households and among geographical locations. Previous studies have employed a propensity score matching (PSM) approach to mitigate selection bias associated with ICT adoption (Minah, 2022; Shimada & Sonobe, 2021). However, the PSM approach is unable to mitigate selection bias issues arising from unobserved factors. Second, we explore whether there exist heterogeneous effects of ICT adoption on access to credit between male- and female-headed households and among geographical locations. Current studies have confirmed that a gender devide exist in ICT adoption (Leng et al., 2020).Therefore, the impact of ICT adoption on access to credit might be heterogenous between male- and female- headed households Furthermore, the institutional arrangements, socioeconomic conditions , ICT infrastructure condtions and resource endowments differ globally, so it is worth investigating whether there are heterogenous regional effects of ICT adoption. Third, we explore the joint effects of ICT adoption and access to credit on household income. Previous studies have either examined the effects of ICT adoption (Li et al., 2020).

However, given that farmers may make joint decisions in their efforts to adopt ICTs and acquire credit, modeling the separate effects of ICT adoption and access to credit on household income would generate biased and inconsistent estimates. Fourth, we further estimate the impact of ICT adoption and access to credit on farm income and business income. This estimation enables us to intuitively understand whether farmers have used the ICTs and acquired credit to invest in income-generating farm and off-farm activities. Finally, we estimate an unconditional quantile regression (UQR) model to check whether the impacts of ICT adoption and access to credit on household income are homogenous or heterogeneous. From a policy perspective, policymakers are usually interested in understanding how ICT interventions and credit market development in rural areas affect the unconditional distributions of an outcome such as household income.

In spite of the considerable positive impact that the adoption of Information and Communication Technology (ICT) has on the ability of small-scale farmers to access credit,small-scale farmers encounter challenges in both accessing and embracing ICT and credit, thereby affecting their capacity to generate a sustainable income. Numerous sugarcane small-scale farmers from local level,Provincial level and national, , South Africa confront significant hurdles encompassing technical, economic, and social issues. The conditions and terms outlined in formal credit arrangements pose difficulties for farmers to comply with credit specific formal credit mandates that small-scale farmers possess reliable collateral, yet many farmers lack land ownership, and those who do own small plots (1.5 hectares).

The information embedded in formal credit processes is often overly intricate for farmers to comprehend and involves extensive administrative requirements. Moreover, ICT adoption and credit access have ability to optimize anticipated household welfare and food security among small-scale farmers. However, there is a dearth of previous studies exploring the joint impacts of ICT adoption and credit access on household food security in South Africa,

Given this research gap, this study aims to identify the factors influencing credit access and ICT adoption and quantify the impact of ICT and credit accessibility determinants on the income and food security of small-scale sugarcane farmers in Ndwedwe local Municipality, ilembe district of KwaZulu Natal province, South Africa.

1.3 Significant of the study

The study provide insight on the impact access to credit and ICT adoption has on small-scale sugarcane farmers' food security. The study also identifies the factors that affect adoption of ICT and access to credit and their effect on small-scale farmers' income. Additionally, the study assesses the efficiency among sugarcane small-scale farming and provide factors that affect efficiency among small-scale sugarcane farmers. The study is significant because the results and recommendations from this study will benefit different stakeholders in the field of agriculture and research. Small-scale farmers will be provided with feedback on where they can improve their sugarcane productivity. The understanding of determinants and the impact credit and ICT have is crucial as it could help small-scale sugarcane farmers to identify all the factors that limit their productivity. The study will also help to provide evidence-based information to policymakers and government in order to design relevant policies and strategies for empowering rural livelihoods, specifically the small-scale sugarcane farmers.

1.4 Study objectives

The overall objective of this study was to determine the impact of access to credit and information communication technology (ICT) on small-scale sugarcane farmer's food security status in Ndwedwe local municipality of iLembe.

The specific objectives were to:

- To establish relationship between small-scale farmers` access to credit and information and Communication technology on the income and food security of small-scale sugarcane farmers in Ndwedwe Local Municipality.
- To assess the impact that ICT and credit accessibility have on the food security of small-scale sugarcane farmers.
- To assess efficiency among small-scale sugarcane farmers in Ndwedwe local municipality using the Zero efficiency stochastic frontier approach.

1.5 Research questions

- What are the factors that affect adoption of ICT and access to credit and their effect on small-scale farmer's income and food security?

- Does ICT and access to credit have impact on the food security of small-scale sugarcane farmers?
- What is the efficiency among small-scale sugarcane farmers?

1.6. Definition of terms

Information and Communication Technology- diverse set of technological tools and resources used to transmit, store, create, share, or exchange information.

Credit- the ability of a customer to obtain goods or services before payment, based on the trust that payment will be made in the future.

Food security- The United Nations Food and Agriculture Organization (FAO) currently uses the following definition: Food security occurs when all individuals have physical, financial, and social access to adequate, secure, and nutritious food that serves their nutritional requirements and food preferences. South Africa adopted the FAO definition of food security.

Small-scale farmers- is the farmer who farms using mainly family members for labour and for whom the farm produces household food and excess for cash income.

1.7 Organisation of the study

This study has got seven chapters, including this introductory study. Chapter 2 provides review of the literature which include description of small-scale sugarcane production, challenges faced by small-scale farmers in sugarcane production, factors that influence small-scale sugarcane productivity, the concepts and state of food security in South Africa, factors that influence the food security status of small-scale sugarcane farmers. Chapter 3 presents research methodology which include description of the study, Data collection, Data analysis and results and discussion. The remaining chapters consist of three studies, each answering specific objectives concerning the impact of ICT and access to credit on sugarcane small-scale farmers food security. The last chapter presented the conclusions and policy implications of the research findings and associated recommendations for further research. The following stipulates the integral aspect of the study.

CHAPTER 4: The effect of access to credit and information and Communication technology on the income of small-scale sugarcane farmers in Ndwedwe Local Municipality.

CHAPTER 5: Determinants of Information Communication Technology (ICT) Adoption and Access to Credit Market and Its Effect on Food Security status of the small-scale Sugarcane farmers in Ndwedwe local community, KwaZulu Natal Province, South Africa.
CHAPTER 6: Analysis of efficiency among small-scale sugarcane farmers in South Africa: a zero efficiency stochastic frontier approach.

CHAPTER 7: Conclusions and Recommendations: Finally, the study presented conclusions and policy implications for the study.

1.8. References

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CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

A review of the literature on the theory and the relating to the impact of access to credit and ICT adoption on food security of small-scale sugarcane farmers is presented in this section. A description of small-scale farming, and small-scale sugarcane agricultural constraints are also presented in this section. The state and concepts of food security in South Africa and the contribution of small-scale sugarcane farming to food security are also presented. This chapter also includes determinants of access to credit and ICT adoption and its impact on small-scale income and food security status. The chapter concludes with a review of the analytical techniques of the study and conceptual framework.

2.2 The description of small-scale sugarcane production

Globally, sugarcane is the largest crop by production quantity; sugar is produced in 120 countries. Global production exceeds 165 million tons a year. The sugarcane is produced in 120 contries resulted to be largest crop by production quantity. Sugarcane production global excedds 165 millions tons a year. The dependent of sugarcane production are 2% of population on employment, business, education ,and training. The industry is a calalyst for economic growth and development (SASA,2022).. A significant contributor to the national fiscus and concentrating in rural areas in Soth African sugarcane industry. The 5.1 billion in value sugarcane production in the South Africa is constituted by the sugarcane industry.

The sugarcane industry has been proven by economic impact over decade to be so significant that rural areas and towns such as Tongaat in KwaZulu Natal and Malelani in Mpumalanga were established based on the business of growing sugarcane and supplying of sugar (SASA,2022). However, numerous challenges is facing by Sugarcane farmers , from planting and growing sugarcane, accessing Mill, low productivity , accessing markets and seeds varieties, making payments to the farmers, amongst other challenges. These challenges are mostly felt by small-scale sugarcane farmers whose productivity was adversely affected by social unrest and looting in july 2021. There was lost in KZN of 84,5 million and threatened thousands of rural jobs in the sugar industry because of the social unrest and looting in july 2021 (Dlamini ,2021).

It is reported by South African Cane Growers that mills in KZN rejected 135222 tons of damaged cane due to social unrest amounted to 84.5millions. Canegrowers revealed that more than 38000 tons belonged to small-scale growers, who were on risk on not recovering from revenue losses because they had no insurance (Dardagan, 2021). The small-scale farmers counld not effectively compete with large scale sugarcane farmers prior to the looting and social unrests. The socioeconomic devide between small-scale and large scale farmersc widened by the social unrest and looting that took place in July 2021 , and will take investment and relief funds to aid small-scale growers to gain competitive and comparative advantage versus large scale growers. According to Zulu *et al* .(2019) the decline in sugarcane production by small-lscale sugarcane growers amplified dependency on government social grants and bank loans, resulting SSGs to be facing with mounting dept and the challenge of reviving their economies.. Deadly spree of violence and looting overwhelmed the South African province Gauteng and KwaZuluNatal, in july 2021, during which Business were looted, and infrastructure set alight. Nearly 330 people were murdered during the deadly extravaganza.

The KZN government subsequently declared a state of disaster to divert funds toward recovery (Duma, 2021). The remainders of vandalism and burning still remain as some of the infrastructures such as shopping malls are still being rebuilt in KZN and Gauteng. Affecting markets of other agricultural produce such crops and vegetables. During the looting period, poverty, and unemployment, were at a record high of 34.9% and even higher at 46.6% among the youth, and this high unemployment was said to be one of the motivating factors for the unrest that exploded and subsequently crippled the already dwindling South Africa's economy (Stats SA, 2021). South African farmers were hit hard by the unrest and looting as trucks carrying produce and sugarcane deliveries from agricultural loading zones and whole salers were prevented from delivering to markets and mills therefore, threatening food supply. There are different methods of sugarcane production world wide.

The sugarcane producers has two methods of production which include seeds and stem cutting methods. Seeds are rare to plant and required a special condition. The sugarcane is propagated primarily by planting of cuttings called seed cane. This is an immature stalk used for planting, the stalk of seed cane used to have two or more buds. The seed cane is treated to ensure its viability and its true to type. Seed cane stalk can be cut into smaller sections with 5 to six buds. Seed cane used for sugarcane production, the growing points, are allocated in nodes along the , the cane stalk, which can be planted horizontally or vertically in the farrows, ensuring the use of moist but not waterlogged farrows, allowing buds sprouting in one to two weeks and grow

into a new plant. The fertilization (fertilizers mixture and straight fertilizers use) can be used according to soil test. The seed cane can be variety to be used in accordance with the climatic requirements of crop or seed cane

The global significance of sugarcane stems from its widespread utility in daily activities and industrial applications, contributing to both nutritional sustenance and economic development (South African Sugar Association (SASA), 2011). Sugarcane serves as a crucial industrial crop in subtropical and tropical regions worldwide, with approximately 28.8 million hectares under cultivation across more than 50 countries. This cultivation effort yields a total harvest of about 1.69 billion tonnes annually, spanning over 90 countries, as outlined by SASA (2014).

The sugar sector represents a multifaceted industry integrating agricultural activities related to the cultivation of sugarcane with the subsequent processing stages encompassing the manufacture of raw and refined sugar, syrup, and various byproducts (South African Sugar Association, 2014). Recognized for its pronounced emphasis on fostering socio-economic advancement within rural settings, the sugar industry is acknowledged for its role in orchestrating rural resources, generating employment opportunities, facilitating income generation, and bolstering the infrastructure of transportation and communication networks (Sibiya and Hurly, 2011),and Garside and Bell (2007) assert that while sugarcane production offers certain advantages, the sugar industry is confronted with numerous obstacles, particularly when it come to impacting small-scale sugarcane farmers.

These challenges encompass a decline in crop yields, diminishing numbers of farmers engaged in sugarcane cultivation, and reduced post-harvest income. Furthermore, the adverse effects of drought exacerbate these issues, leading to decreased productivity and subsequent declines in industry earnings over time. The plight of small-scale black farmers is particularly severe due to their lack of adaptive strategies. The diminishing yields of sugarcane farmers have become a source of distress for the South African sugar industry (Garside and Bell, 2007). Moreover, the substantial reduction in the number of small-scale sugarcane farmers, plummeting from approximately 57,000 in the early 2000s to fewer than 14,000 by 2011, remains largely unexplained (Dubb, 2013). Singh *et al.* (2008) emphasize that it is predominantly small-scale sugarcane farmers whose numbers have dwindled, and they suggest that ameliorating challenges hindering their yield could alleviate this situation. Despite occupying nearly 20% of the total cane cultivation area and operating within a distinctive regulatory framework on

communal lands, small-scale sugarcane farmers contribute less than 12% to the annual production across the three main sugarcane-producing regions of South Africa.

The preliminary findings of a survey conducted in Mauritius and South Africa in 2009 by Eweg *et al*. (2009) highlighted several factors contributing to reduced yields among small-scale sugarcane farmers. Poor re-plant rates and weed infestation were identified as significant contributors to this decline. Additionally, the study noted that low levels of education among these farmers resulted in inadequate crop husbandry practices. Eweg *et al*. (2009) further reported that small-scale sugarcane farmers perceived weeds as the primary agronomic constraint, emphasizing the need for improved weed management practices. The importance of addressing weeds control in practices among smallscale sugarcane farmers in South Africa, as weeds are regarded as another factor contributing to yield deterioration highly considered (Zulu,2019). Moreover, the use of herbicides among these farmers requires attention to enhance crop protection practices.

Zulu (2019) states that the sugar industry is confronting a problem of sugarcane production deteriorating and small-scale sugarcane farmers experiencing most of the decline. The yield decline experienced from sugarcane production adversely affected the South African sugar industry where there is a huge decrease in sugar productivity, farm returns, and foreign earnings. According to South African Farmers Development Association (2017) farmers struggle to cope with rising input and labour costs required for sugarcane planting as they cannot afford them which ultimately influences the progression and performance of farmers. The government has made several efforts to address the decline in sugarcane production

This trend has significantly impacted the industry's performance and progression, necessitating measures to mitigate the effects of increased input costs (Mandla *et al*.2011). Mandla *et al.* (2011) also underscored the complex relationship between small-scale farmers and financial institutions, upon which they rely entirely for working capital to support their sugarcane fields. Additionally, various other factors contribute to the decline in production by small-scale farmers in KwaZulu-Natal, including low productivity, financial constraints, drought, small farm sizes, inadequate infrastructure, limited education, and a scarcity of skilled labor (Zulu, 2019).

2.3 Challenges faced by small-scale farmers in sugarcane production.

South African small-scale farmers confront numerous challenges in the agricultural sector when compared to their commercial counterparts. These difficulties hinder their development and ability to overcome their insecurities regarding food (DAFF, 2012). Moyo (2014) asserts that small-scale farmers have trouble accessing markets and farming inputs due to high transaction costs and incomplete information. They typically work from publicly owned and government-owned land without a title deed. Because of this, they are unable to make investments in proper farm infrastructure, which could result in crop failure and lower productivity (Moyo, 2014). Lack of access to adequate roads limits farmers' capacity to transport inputs, produce, and obtain information, according to DAFF (2012).

This makes it more difficult for them to enter potentially profitable markets. High transaction costs are another factor impeding small-scale farmers'growth, and these can often be linked to inadequate infrastructure in South Africa's remote rural areas. This could affect the ability to obtain accurate information and lead to institutional issues like the absence of formal markets (DAFF, 2012). Small-scale farmers typically lack reliable markets in which to sell their produce in rural areas.

This among others forces them to sell their produce at their farm gates and at neighbourhood markets, where they get little money for their goods. On the other hand, the small-scale farmers would have made more money if these goods had been sold in markets with more competition.

In addition, DAFF (2012) listed a major obstacle that South African small-scale farmers must overcome, this include a shortage of human capital. Most of them are illiterate and lack technological skills. The lack of appropriate financial and marketing expertise impedes their capacity to satisfy the quality requirements established by food processors and fresh produce markets. Moyo (2014) claims that a shortage of essential production inputs like capital and water affects the financing of agricultural production and irrigation infrastructure. Small-scale farmers who lack basic inputs also exhibit inconsistent production and supply their products to fresh produce markets. The public and private sectors must provide a supportive framework to address all of these issues. To lower transaction costs, the government should step in and solve the issues arising from market failure as well as create the necessary infrastructure and institutions. In turn, this would boost agricultural growth and productivity overall, boosting income and ensuring food security. Small-scale farmers' uneven production and delivery of their goods to fresh produce markets is another effect of their lack of basic inputs. It will take

a supportive framework from both the public and private sectors to address all these issues. To mitigate transaction costs, the agricultural development stakeholders such as government,non-government sectors ,and Private agencies should step in and address market failure issues by creating appropriate institutions and infrastructure. Food security and income growth would result from this increase in agricultural productivity and growth overall.

2.4 Factors that influence small-scale sugarcane productivity.

The decline in small-scale sugarcane yields poses a significant concern for the South African sugar industry (Parsons, 2003; Eweg, Pillay and Travailleur, 2009; Eweg *et al*., 2009; Sibiya and Hurly, 2011). While various factors have been subjectively attributed to reduced yields, no comprehensive study has specifically addressed the crop husbandry or agronomic production constraints perceived by small-scale sugarcane farmers. Preliminary findings from a survey conducted in Mauritius and South Africa suggest that poor re-plant rates and low levels of education contribute to inadequate crop husbandry practices among small-scale sugarcane farmers (Eweg *et al.,* 2009; South African Cane Growers Association, 2011). Furthermore, small-scale sugarcane farmers identify weeds as the primary agronomic constraint, indicating the urgent need for research and extension efforts to enhance crop protection practices (Eweg *et al.,* 2009; SACGA, 2011). Recent publications have focused on improving weed management practices among emerging sugarcane farmers, underscoring the recognition of weeds as a significant constraint (Smit *et al*., 2010; Gillespie *et al*., 2012). Agronomic constraints, including high input costs, are paramount concerns for small-scale sugarcane farmers (Armitage *et al*., 2009). Eweg *et al*. (2009) suggest that the high costs of fertilizers may be a major limiting factor for small-scale sugarcane farmers, possibly resulting in insufficient fertilizer application. Given that small-scale sugarcane farmers often engage in diversified agricultural activities alongside sugarcane cultivation, effective communication among extension and support stakeholders is crucial to address their multiple constraints (Molomo, 2012; Zulu *et al*., 2019). Collaboration and coordination among stakeholders are essential to tackle challenges such as high input costs and weed control effectively.

2.5 The concepts and state of food security in South Africa

While South Africa is commonly perceived as food secure, both in terms of its domestic production of staple foods and its ability to import nutritious food, this perception primarily applies at a macro level (FAO, 2008; Masipa, 2017). However, Hart *et al.* (2018) and

Mkhawani *et al*. (2016) contend that at the household level, particularly among rural residents, food insecurity remains a significant challenge. To address this issue, the Department of Agriculture, Forestry, and Fisheries (DAFF) has been actively promoting the development of agricultural projects aimed at creating employment opportunities and generating household income (Hart *et al*., 2018; DAFF, 2018).

Statistics South Africa (2011) reports that nearly 4.75 million South African households are living below the poverty line, contributing to food insecurity. Sekhampu (2018) further highlights that approximately 14 million people in South Africa are vulnerable to food insecurity. Altman and Ngandu (2011) identify extensive unemployment, low wage levels in comparison to the rising cost of living, and high household dependency ratios as key factors contributing to food insecurity in South Africa. Achieving food security necessitates the consistent availability of adequate quantities of appropriate food (Altman and Ngandu, 2011). Food security, as defined by the United States Agency for International Development (USAID) (2010) and Deitchler *et al.* (2010), is the condition where all individuals have consistent physical and economic access to sufficient food to meet their dietary requirements for a healthy and productive life. This definition aligns with the South African Government's Bill of Rights, as outlined in Section 27(1) (b) of the South African Constitution, Act 108 of 1996, which asserts that everyone has the right to access adequate food (Zama et al., 2018). Furthermore, individuals must possess sufficient income or alternative means to procure or exchange for food.

Statistics South Africa (2011) reveals that many households in South Africa face challenges in purchasing food, primarily due to limited income-generating opportunities, particularly prevalent in rural areas. Since 1994, food security has been a national priority in South Africa, as emphasized by the Food and Agriculture Organization (FAO) (2008). The FAO (2008) acknowledges South Africa as predominantly food secure, with the capacity to produce enough staple foods domestically or import them as needed to fulfil the basic nutritional needs of the population. Notably, research endeavours concerning the assessment of household food security status have been undertaken across various provinces in South Africa. However, these studies often focus on specific areas within provinces, potentially leading to incomplete representations of the overall food security landscape. Misselhorn and Hendriks (2017) observe that the causes and impacts of food insecurity vary significantly from one location to another and from one household to another. Consequently, findings from one area may not accurately

reflect the food security situation for diverse population groups across defined regions, as argued by Govender et al. (2017).

The KwaZulu-Natal Department of Agriculture and Environmental Affairs (KZNDAEA) (2005) underscores that KwaZulu-Natal (KZN) boasts relatively high agricultural potential compared to other provinces, which attributed to favourable climatic conditions, soil quality, and water accessibility. With approximately 6.5 million hectares of available farming land, 18% of which is suitable for arable farming and 82% for extensive livestock production, KZN stands as a key agricultural hub. The South African National Treasury (2018) estimates that KZN hosts around 8,000 commercial farmers and approximately 400,000 rural farming families engaged in small-scale farming activities. Notably, commercial agriculture in KZN significantly contributes to South Africa's agricultural output, accounting for 90% of the nation's agricultural output and 37% of its food exports (Misselhorn and Hendriks, 2017). Moreover, according to the National Department of Agriculture (1998), many households in KZN participate in limited homestead-based food production, serving as a vital source of livelihood. Despite the province's considerable agricultural potential, a significant portion of land remains either underutilized or overexploited, presenting challenges to maximizing agricultural productivity and sustainability.

Remarkably, commercial agriculture in KZN plays a pivotal role in South Africa's agricultural sector, contributing 90% of the nation's agricultural output and accounting for 37% of national food exports (Misselhorn and Hendriks, 2017). Despite this significant agricultural presence, a considerable number of households in KZN participate in limited homestead based food production, which serves as a vital source of livelihood, as highlighted by the National Department of Agriculture (1998).

However, despite its agricultural potential, KZN faces significant challenges, particularly concerning high levels of unemployment and household food insecurity, as noted by Altman et al. (2013). To address these challenges, various intervention programs have been implemented in KZN since 2007, aimed at mitigating food insecurity and creating employment opportunities (D'Haese et al., 2013). These programs include the Comprehensive Agricultural Support Programme (CASP), Livestock Programme, Mechanization Programme, Mushroom Programme, Women, Youth, and People with

Disabilities Programme, Indigenous Nguni Livestock Programme, Rural Development Programme, Impact Partnership, and Land Care Projects. The overarching goal of these

intervention programs is to improve food security among households while simultaneously fostering job creation within the province.

The programs mentioned underscore the government's commitment to achieving food security for all in South Africa. However, despite the country's tradition of evidence-based decision-making, as highlighted by Misselhorn and Hendriks (2017), there is a lack of accessible evidence to the public regarding the effectiveness of implemented national food security programs. This lack of transparency regarding program outcomes limits the ability of both the public and civil society organizations to assess the success of these initiatives in achieving their objectives.

Without detailed reports on program performance, it becomes challenging to determine the extent to which these interventions contribute to rural growth, poverty alleviation, and food security. This lack of evidence also hampers efforts to identify both the opportunities and constraints associated with program implementation. As a result, it is difficult to tailor support to households effectively without a clear understanding of the programs' impact and effectiveness. Therefore, greater transparency and dissemination of information regarding program outcomes are necessary to ensure informed decision making and improve the effectiveness of interventions aimed at addressing food security challenges in South Africa. Despite concerted efforts, food security remains a pressing issue in the poorest areas of KwaZulu-Natal (D'Haese *et al*., 2013; Masuku *et al.*, 2017). Research by D'Haese *et al.* (2013) confirmed persistently high levels of experience-based food insecurity, despite some respondents acknowledging improvements in dietary diversity and access to resources attributed to agricultural support programs and government income transfers.

In response to the unsatisfactory outcomes of previous food security interventions, the Department of Agriculture, Forestry, and Fisheries (DAFF) introduced the "One Home One Garden" food security intervention program in 2009. This initiative aimed to establish household food security stability by promoting food production for consumption, with the long-term goal of generating surplus for sale at local markets such as the KwaZulu-Natal Dube Trade Port near the King Shaka International Airport (Ngema, 2018).

The program targeted the estimated 580,000 food-insecure households in KZN, distributing seeds and fertilizers to households as part of the "One Home One Garden" intervention. The program received positive reception from stakeholders, with over 650,000 beneficiary households provided with seeds to cultivate vegetables, maize, and beans. Additionally,

approximately 30% of the most deprived households received implements and fertilizer starter packs, with over 34,000 packs distributed.

In addition to promoting vegetable production for household consumption, the program offered agricultural training and financial advice to cooperatives. Furthermore, the South African government continues to support rural farmers by providing garden inputs, infrastructure, training, and mentoring to enhance household production through a province-wide food production campaign promoting household gardens.

2.6 Factors that influence the food security status of small-scale sugarcane farmers.

Although the nation of South Africa is considered to be a food-secure country according to South African Government plans on food supply, food insecurity still presents significant challenges at a household level (Altman *et al.*, 2009). Despite the creation of jobs and food production interventions in the respective Country, South Africa, the unavailability of and unaffordability of food are reported as being the main causes of food insecurity in the local communities (Daff ,2013).

The National Food Consumption Survey in 2005, about 50% of South African households experienced hunger, 28.2% were at risk of hunger and only 20.2% were found to be food secure. In rural settlements, approximately 58% of households were reported to be experiencing hunger and food insecurity, compared to urban settlements (42%) (Stats SA, 2019). It was revealed by Government reports that the pervasiveness of hunger in South Africa was most severe in the Eastern Cape, Northern Cape and Limpopo, with 66.7%, 65.3% and 63.2%, respectively, whereas the Western Cape presented the lowest percentage, with 29.3% (DAFF, 2013a; Stats SA, 2019).

It was also found that, in the country's provinces that are greatest involved in agricultural activities, namely Limpopo, KwaZulu-Natal and the Eastern Cape, only Limpopo presented the lowest number of people suffering hunger (Stats SA, 2019). De Klerk *et al*. (2004) estimated that nearly 35% or more than 14 million of South African population are vulnerable to food insecurity and about 1.5 million children under the age of six years have been reported to be stunted and malnourished. The National Department of Health (NDoH) indicated that in 2016, approximately 27%, 3%, 6% and 13% of South African children under five years of age were stunted, wasted, underweight and overweight, respectively (NDoHet al., 2019), and that the prevalence of lost children nationally was as high as 6.5% and 6.3% in the Gauteng and

KwaZulu-Natal Provinces, respectively. Rural areas have been found to have the highest rate of underdeveloped children (24.5%), compared to 18.5% in urban areas (DAFF, 2013a).

Apart from hunger, poverty also creates a great challenge for many poor and vulnerable South African households, which hinders their access to adequate, safe, and nutritious food (Stats SA, 2012). Nearly 80% of South African households were unable to afford a food basket that costs R262 per person a month (Labadarios et al., 2008). Food insecurity is higher in the rural areas, as 85% of the households cannot afford even the average dietary energy costs, and between 2006 and 2015, approximately 25.2% lived below the poverty line (Stats SA, 2019).

Studies by the Department of Agriculture and Rural Development (DARD) have reported that KwaZulu-Natal has the second-highest agricultural potential in the country, when compared to the other provinces (DARD, 2015). About 20% of the households are involved in agricultural activities as their main source of food and income (DARD, 2019). However, their social conditions are getting worse, due to their increasing hunger, poverty, and unemployment. Approximately 3.5 million people in the province struggle to access nutritious food; therefore, they are vulnerable to several forms of food insecurity (DARD, 2015).

Many households rely on government social grants to access adequate, safe, and nutritious food; even though they may be employed, many of them earn an income that ranges between zero and R3 185 per month, which is not sufficient for their household requirements (Kateneksza et al., 2012). KwaZulu-Natal is reputed to have the highest rate of inadequate access to food, which increased slightly from 23.4% to 24.5% in 2017 and 2018, respectively, compared to the country's record of 20.2% (DARD, 2020). Households are unable to generate an income and produce their own food; therefore, they borrow money from their neighbours and relatives as a strategy to cope with their hunger and food insecurity, during stress periods (D'Haese, 2013).

It is stated by FAO, 2019, the sugarcane production farmers in Ethiopia grow sugarcane significantly and its lower variety of food crops as compared to subsistence farmers, while the income they receive is insufficient to cover their food production gap putting them at relatively high risk of food insecurity.

In KwaZulu-Natal Illovo's small-scale sugarcane farmers also grow crops such as maize, bananas and yams for their own consumption, to ensure their food security (FAO, 2012). In South Africa, SASA (2014) states that although income from sugarcane production can be used

to buy food, due to the high transport costs, the income is poor, leading to food insecurity by small-scale sugarcane farmers of KwaZulu-Natal. It was furthermore noted by SASA (2014) that the distance from iLembe local Municipalities including Ndwedwe and Maphumulo to millers in Maidstone and Gledow reduces the profits for small-scale sugarcane farmers, resulting in low income to buy food.

2.7 The factors that affect the adoption of information communication technology and access to credit on small-scale farmers.

The 2030 Agenda for Sustainable Development, established by the United Nations (UN) in September 2015, delineates 17 Sustainable Development Goals (SDGs) spanning social, economic, and environmental domains (SDSN, 2015). Small-scale agriculture plays a vital role in fostering sustainable food security and contributes to three SDGs: eradicating poverty (SDG1), achieving zero hunger (SDG2), and promoting sustainable consumption and production (SDG12) (FAO, 2015). In 2013, the African Union (AU) adopted Agenda 2063, with Goal 5 focusing on modernizing agriculture to enhance productivity (AUC and AUDA-NEPAD, 2020). South Africa's National Development Plan (NDP), initiated in 2012, envisions agriculture as a means to generate employment opportunities by expanding irrigated agriculture, utilizing underutilized land, and facilitating commercial production (NAHF, 2017).

A key objective is to strengthen the Agriculture Value Chains (AVCs) of small-scale farmers and support their transition to commercial farming (AUC and AUDA-NEPAD, 2020). While digital technologies have the potential to revolutionize agriculture, many successful initiatives have not scaled up as anticipated (Deichmann *et al*., 2016). Thus, it is crucial to recognize the multidisciplinary nature of stakeholders involved and establish robust institutions and governance frameworks to ensure that digital technology is effectively harnessed to empower marginalized communities. To achieve this objective, various factors must be considered to ensure that digital technology reaches communities seamlessly. And indeed, understanding various economic, political, and social factors are crucial for effective digital technology interventions in agriculture. Economically, digital technology can lead to positive outcomes by reducing costs and increasing productivity and profitability for small-scale producers (El Bilali and Allahyari, 2018; Joiner and Okeleke, 2019). Facilitating connections between small-scale producers and markets can further reduce transaction costs within their Agriculture Value Chains (AVCs).

Politically, the state plays a pivotal role in Global Value Chains (GVCs), influencing AVCs of small scale farmers through its roles as a facilitator, regulator, producer, and buyer (Horner and Alford, 2019). Understanding and leveraging these political dynamics can significantly impact the success of digital interventions in agriculture. Social factors also significantly influence the adoption of digital technologies in agriculture. In Africa, demographic pressures, and climate change pose challenges to small-scale farmers' livelihoods, while urbanization and economic growth create new markets for fresh and processed foods (El Bilali and Allahyari, 2018). Access to credit is particularly vital in both rural and urban agricultural areas, as it improves agricultural production, alleviates poverty, and supports household consumption (Kehinde and Ogundeji, 2022; Osabohien, Mordi, and Ogundipe, 2022). Credit enables farmers to invest in productivity-enhancing inputs, expand their businesses, manage household expenses, and invest in education and health (Ejemeyovwi, Osabuohien, and Bowale, 2021; Kumar, Mishra, Sonkar, and Saroj, 2020; Li, Lin, and Gan, 2016; Felkner, Lee, Shaikh, Kolata, and Binford, 2022; Kandulu, Wheeler, Zuo, and Sim, 2019). Understanding and addressing these multifaceted factors are essential for the successful implementation and impact of digital technology interventions in agricultural development.

Access to credit is not only essential for rural households' economic empowerment but also plays a crucial role in empowering rural women by enabling them to purchase productive assets. For instance, credit allows women to acquire durable goods and services tailored to their needs, such as sewing machines, farm machinery, and relevant services to maintain farm production, particularly when men migrate for better salary opportunities (Basumatary, Chhetri, and Rajesh, 2022; Datta and Sahu, 2021; Paudel, Gartaula, Rahut, and Craufurd, 2020).

However, despite its importance, rural households often face difficulties in accessing credit due to various constraints, including the lack of credit markets and services, regional financial arrangements, collateral requirements, and information asymmetry (Akudugu, Egyir, and Mensah-Bonsu, 2009; Benami and Carter, 2021; Kehinde and Ogundeji, 2022; Kofarmata and Danlami, 2019; Li, Ma, Mishra, and Gao, 2020). Information asymmetry, in particular, poses a significant obstacle, increasing the risks of moral hazard and adverse selection among borrowers, thus restricting their participation in credit markets and access to adequate loan amounts (Akudugu *et al.,* 2009; Kofarmata and Danlami, 2019).

In the digital age, the adoption of Information and Communication Technologies (ICTs) offers promising solutions to reduce information asymmetry and improve access to credit for rural households. ICT-based analytical tools can enhance market understanding, efficiency, and effectiveness in dealing with information asymmetry and moral hazards, benefiting both borrowers and lenders (Asongu, le Roux, Nwachukwu, and Pyke, 2019). Studies have shown that ICT adoption contributes to farm economic performance, increases household income, and facilitates rural development by improving market access and information dissemination (Ogutu, Okello, and Otieno, 2014; Ma, Grafton, and Renwick, 2020; Niebel, 2018; Spielman, Lecoutere, Makhija, and Van Campenhout, 2021).

Moreover, ICT adoption enables mobile money usage, reducing borrowing costs and enhancing financial accessibility for rural households (Kim, 2022; Lashitew, van Tulder, and Liasse, 2019; Munyegera and Matsumoto, 2018). However, further research is needed to explore the joint effects of ICT adoption and access to credit on rural households' welfare and decision-making processes, highlighting the potential synergies between these two factors in maximizing household economic empowerment and well-being.

2.7.1 Governance and institutional implications for policy development on digital technologies

The widespread adoption of digital technology is permeating every aspect of Agriculture Value Chains (AVCs) among small-scale farmers globally. With this trend comes a growing recognition of the importance of governance and institutional support to facilitate the integration of digital technology into the practices of small-scale farmers. These digital tools have the potential to empower small-scale farmers by revolutionizing their VCs into collaborative digital models characterized by enhanced flexibility, agility, and sustainability. However, the effective selection and implementation of appropriate digital solutions require collaborative efforts, as localized, isolated approaches often fall short.

To kick start a comprehensive approach to implementing digital technology in AVCs of small-scale farmers, it is imperative to identify the necessary governance and institutional policies. These policies should serve as guiding frameworks to steer digital adoption toward achieving its objectives. Such measures will not only enable small-scale farmers to tap into the untapped potential of their existing capabilities but also lead to increased productivity and enhanced sustainability. To realize these goals, it is essential to establish the requisite skill sets, processes,

and tools for successful digital adoption, thereby fortifying AVCs of small-scale farmers to be more resilient, efficient, and effective. In order to achieve these objectives, digital adoption policies should focus on initiatives aimed at preparing small-scale farmers for the digital era. With this perspective in mind, this section delves into the governance and institutional factors that influence the adoption of digital technology in AVCs of small-scale farmers.

2.7.2 The impacts of ICT' in Extension Service Delivery

Dissemination of knowledge and Technology are strategic goals for the successful agricultural extension (Zulqarmain et al., 2020). Different forms of information communication technologies (ICT) are used to disseminate agricultural information to farmers. Umar et al. (2015) stressed the role of technology in improving productivity in agriculture. The technology was seen as an important tool for agricultural production. Agricultural extension operations main focus is to provide adequate and valuable knowledge to reassure end-users to follow what will ultimately lead to the growth of agricultural production (Hassan et al., 2019; Ramli et al., 2019).

.There are significant regional gaps in the diffusion of Information and Communication Technology (ICT) referred to as "Global Digital Divide," which is a major concern for policymakers worldwide. Ali *et al.* (2018) and Muktar *et al.* (2019) lamented that to disseminate knowledge or information packages, the agriculture extension must avoid the limited mindset of communicating technology packages. If this can be done, the extension could become more diversified, Use ICT's, more knowledge-intensive and demand-driven, and therefore more relevant in meeting the information needs of farmers.

The importance of ICTs has long been recognized in the development process and access to ICTs has also been one of the objectives of Millennium Development Goal No. 8, which highlights the advantages of emerging technologies, particularly ICTs, in reducing poverty (Ali *et al.* ,2018) ; Muktar *et al.* 2019). In this regar/d,noted that agricultural extension depends to a large extent on the exchange of information between farmers and a wide range of other actors, in particular front-line extension staff, who are direct links between farmers and other actors in the Knowledge and Information System for Agriculture (AKIS). (Ali *et al*. 2018). According to Ali *et al*. ,(2018) ; Muktar *et al*. (2019) ICTs have the potential to increase the capacity of farmers to meet demands; collective learning; sharing time-sensitive information, such as market prices and outbreaks of diseases; improving the effectiveness of extension

programmes and structures; involve farmers in assessing their own needs; promoting brainstorming by multiple stakeholders; creating innovative technologies for development; promoting business and credibility.

2.8 Impact of adoption of information communication technology and access to credit on small-scale farmer's income

Access to credit plays a crucial role in enhancing agricultural production and reducing poverty in rural regions of developing and emerging economies. Credit facilitates liquidity and enables farm households to procure inputs that enhance productivity, such as improved seeds, fertilizers, and pesticides. Moreover, credit supports investments in both farm and non-farm businesses, thereby contributing to economic growth (Ejemeyovwi, Osabuohien, and Bowale, 2021). Additionally, it helps smooth household consumption patterns and enables households to cope with unforeseen expenses related to sickness prevention and treatment, as well as children's education (Kumar, Mishra, Sonkar, and Saroj, 2020; Li, Lin, and Gan, 2016; Felkner et al., 2022; Kandulu et al., 2019). Furthermore, access to credit can empower rural women by enabling them to acquire productive assets, such as sewing machines, washers, and farm machinery, which are essential for maintaining farm production, particularly when male members migrate in search of better employment opportunities (Basumatary, Chhetri, and Rajesh, 2022; Datta and Sahu, 2021; Paudel, Gartaula, Rahut, and Craufurd, 2020).

Despite its significance, rural households often face challenges in accessing credit due to various constraints, including limited availability of credit markets and services, institutional arrangements of regional financial institutions, lack of collateral, and information asymmetry (Akudugu, Egyir, and Mensah-Bonsu, 2009; Benami and Carter, 2021; Kehinde and Ogundeji, 2022; Kofarmata and Danlami, 2019; Li, Ma, Mishra, and Gao, 2020). In particular, information asymmetry presents a major obstacle, hindering rural households from effectively participating in credit markets and obtaining the necessary loan amounts. Akudugu *et al.* (2009) and Kofarmata and Danlami (2019) conducted research in Ghana and Nigeria, respectively, and identified that information asymmetry increases the risks associated with borrowers' moral hazard and adverse selection. This situation hampers rural households' ability to participate in credit markets and obtain the necessary loan amounts. Thus, reducing information asymmetry between borrowers and lenders is crucial to improve farm households' access to credit.

Embracing information and communication technologies (ICTs) such as computers and mobile phones can mitigate information asymmetry in the digital era. ICT based analytical tools enable both borrowers and lenders to better comprehend market risks and enhance their efficiency in addressing potential information asymmetry and moral hazards (Asongu, le Roux, Nwachukwu, and Pyke, 2019).

Numerous studies have demonstrated the positive impacts of ICT adoption on farm economic performance, rural household income, and overall progress (Ogutu, Okello, and Otieno, 2014; Leng, Ma, Tang, and Zhu, 2020; Ma, Grafton, and Renwick, 2020; Niebel, 2018; Spielman, Lecoutere, Makhija, and Van Campenhout, 2021). For instance, Ogutu et al. (2014) revealed that ICT-based market information services enhance the utilization of purchased seeds, fertilizers, and labor productivity in Kenya. Similarly, Ma e*t al*. (2020) found that ICT adoption, particularly smartphone usage, increases farm income, off-farm income, and overall household income in rural China. Additionally, ICT facilitates mobile money usage, enabling basic financial transactions via smartphones, thereby reducing borrowing costs (Kim, 2022; Lashitew, van Tulder, and Liasse, 2019; Munyegera and Matsumoto, 2018).

Although limited, some studies have explored the relationship between ICT adoption and rural households' financial accessibility. Notably, Asongu *et al.* (2019) analyzed panel data from 162 banks across 42 African countries and demonstrated that ICT adoption decreases loan prices while increasing loan quantity. However, there is a lack of research on the joint effects of ICT adoption and access to credit on farmers' expected household welfare. In South Africa, farmers typically access credit through contractual agreements with lenders.

2.8.1 Access to credit in the sugar industry through engagement in agreements

Small-scale sugarcane farmers who engage in contractual agreements with other players in the industry, such as the sugar mill, have better chances of accessing credit compared to those who do not. Umthombo Agricultural Finance (UAF), under the finance division of SASA, caters for the financial needs of SSGs. According to SASA (2016), UAF provides retention savings facilities and loan administration for the growers. Each individual grower who is contracted to the sugar mill and UAF has two accounts, namely the savings account and a loan account. UAF uses the savings accounts to retain some of the growers' money when the mill pays out the grower (SASA, 2016). Hurly *et al.* (2015) noted that money withdrawn from the savings accounts helps the grower maintain the crop the following season, and it is carefully monitored that it is used for the right purpose. UAF also provides loan facilities to small-scale farmers

through the Micro Agricultural Finance Institution of South Africa (MAFISA) fund (which is a government fund under the DAFF). According to Hurly et al. (2015), the role of UAF is to act as a financial intermediary by screening the farmers and approving the loans on behalf of MAFISA. A total value of R14.9 million was allocated to small-scale sugarcane growers as loans by the fund during the 2013/2014 season.

Ntshangase (2016) observed that farmers who are contracted to the sugar mill receive money from the mill equivalent to R3 500 per hectare once their cane reaches four months. This money is for compensating the growers for the production inputs used during planting and to encourage them to produce more so that the mill has more cane to process. Hurly et al. (2015) further noted that growers who delivered cane to the mill in the previous season receive a pay-out called the supplementary payment fund (SPF) from the industry in March each year. This money is usually from profits made by the sugar industry from selling sugar to the international market (Hurly *et al.,* 2015).it is very important to identify impact of adoption of information communication technology and access to credit on small-scale farmers food security.

2.9 Impact of adoption of information communication technology and access to credit on small-scale farmers food security

2.9.1 Impact of ICTs for Food Security in Africa

ICTs have garnered significant global attention, with their role in the development process emphasized by researchers such as Kim *et al.* (2010), who, in a World Bank publication, argue that broadband penetration has a direct impact on GDP in low- and middle-income countries. They assert that for every 10 percent increase in broadband penetration in these countries, there is a corresponding 1.38 percent increase in GDP. While recognizing the economic benefits of broadband technology, Kim *et al.* (2010) caution that the success of ICT innovation is influenced by economic and political factors. Thus, it is essential to acknowledge that the success rates of ICT innovations may vary based on the specific environment in which they are implemented. Given these varying conditions, an ICT innovation that succeeds in one country may fail in another, underscoring the importance of avoiding one-size-fits-all ICT solutions and instead customizing each solution to its respective environment.

Despite limited research on the role of ICTs in Africa, particularly in sectors such as service delivery (Wakabi *et al.,* 2015), existing studies indicate that ICT-based innovations are rapidly

advancing, largely due to the phenomenon of technological leapfrogging. Notably, the utilization of geospatial data is becoming increasingly prevalent across Africa. Organizations like the Gates Foundation are facilitating access to emerging technologies by supporting initiatives such as the STARS project (Spurring a Transformation for Agriculture through Remote Sensing). The primary goal of this project is to enhance agricultural practices in the Sub-Saharan African region by leveraging remote sensing technologies. Specifically, targeting small-holder farmers in Sub-Saharan Africa and South Asia, the project aims to equip them with crucial information to improve farming practices. Despite the availability of geospatial data, a key challenge lies in disseminating this information to farms in real-time to enable informed decision-making that can positively impact production or enhance crop resilience. In Kenya, where agriculture plays a pivotal role, there is a significant demand for extension services. With an estimated 5000 extension officers, the country is unable to meet this demand and has thus adopted innovative approaches to address the issue. Recently, Kenya introduced e-extension services as a solution to overcome the challenge of staffing shortages. Leveraging relatively on high mobile phone and Internet penetration rates, the country utilizes technologies such as WhatsApp and other messaging platforms as part of the e-extension project to communicate with farmers on a large scale (BiztechAfrica, 2014).

2.9.2 ICTs for Food Security in South Africa

Small-scale farming in Africa is vital for ensuring food security among communities (World Bank, 2008), with limited resources being a common characteristic among small-scale farmers. The emergence of Information and Communication Technologies (ICTs) offers opportunities to enhance production levels by providing essential agricultural information, including market access and marketing details, to small-scale farmers (Munyua and Adera, 2009). The global food price crisis of 2007/2008 exacerbated food insecurity in South Africa, particularly affecting provinces like KwaZulu-Natal (Jacobs, 2010), leading to an increased need for interventions to address food insecurity. ICTs have been recognized as a solution to transfer agricultural information to smallholder farmers in South Africa, aiding them in improving production and resilience to climate shocks (Okello *et al.*, 2010). In South Africa, emerging ICTs such as Geographic Information Systems (GIS) are being utilized for precision agriculture (PA), particularly for irrigation purposes tailored to specific soil types (Munyua and Adera, 2009). Moreover, Radio-Frequency Identification (RFID) technology is employed in the livestock industry to track animal origins, in line with European Union traceability standards (Munyua and Adera, 2009). A major challenge regarding ICTs in South Africa has been the

lack of an integrated national ICT policy. This problem was identified by earlier authors (Van Audenhove, 2003) who noted that this situation resulted in the intertwining of programmes and policies. The lack of an integrated policy is also evident from the number of ICT initiatives, the overlap in initiatives and the number of actors and stakeholders involved (Van Audenhove, 2003). This situation has continued, and ICT policy currently is being influenced by the different initiatives being developed by the various government departments. The recently published National Integrated ICT Policy Green Paper by the Department of Communications (2014) is a positive move towards meeting the challenge of coordination and implementation of ICT based innovations.

2.9.3 ICTs for Food Security in KwaZulu-Natal

The potential for ICTs as a tool for information exchange between solution providers and problem holders has been acknowledged by a number of authors. In a study on the dissemination of information on climate change to rural women mussel harvesters in KwaZulu-Natal, Jiyane and Fairer-Wessels (2012) acknowledge the importance of ICTs in the transfer of information. The authors also acknowledge the importance of indigenous knowledge in creating resilience to climate change and identify the mobile phone as a possible ICT innovation to use to transmit information. The Wishvast Network is an example of an ICT innovation that has been implemented in order to draw out the full potential of the mobile phone through the creation of groups that are of common interest. This innovation also allows members to increase the awareness of their products and services through advertising to group members with similar interests (Jiyane and Fairer-Wessels, 2012). This ICT innovation can have a significant positive influence on the farming activities of the women mussel harvesters in KwaZulu-Natal through the provision of weather information. Gumede *et al*. (2009) in their study, identify the radio, television, mobile phone, and the landline in that order as available ICTs in the region. The study revealed that adults in these communities were of the view that they do not need to know about ICTs as they had believed them to be for the younger generation.

2.10. Models and framework underpinning the study

2.10.1 Recursive Bivariate Probit Regression (RBP) model

The Recursive Bivariate Probit (RBP) model employs a recursive simultaneous-equation framework, enabling an endogenous variable in one equation to serve as an exogenous variable

in another equation (Wang *et al*., 2021). This model effectively addresses endogeneity concerns arising from both observed and unobserved factors, allowing for the estimation of direct marginal effects of ICT adoption on access to credit and vice versa. Addai *et al*. (2022) applied the RBP model to investigate the determinants of membership in farmer organizations (FO) and their impact on the adoption of farm technologies by rice farmers in Ghana. Their findings indicated that FO membership was positively influenced by off-farm income, asset value, the location of the farmer organization, and the farmer's location in the Upper West region, but negatively affected by male gender, age, and total livestock units owned. Additionally, the adoption of machinery was positively influenced by FO membership and the respondent's male gender, while being negatively influenced by years of schooling, farm size, farm distance, and the farmer's location in Ghana's Upper East and West regions. Li *et al*. (2021) utilized the recursive bivariate probit (RBVP) model to assess the impact of early marriage on the utilization of maternal health services across five sub-Saharan countries: Burkina Faso, Guinea, Mali, Niger, and Chad. Their findings indicated that women who married before the age of 15 were 17 percentage points less likely to utilize prenatal services, while those who married before the age of 16 experienced a reduction in likelihood by 9.6 percentage points. However, there was no statistically significant decrease in maternal health care utilization observed for women who married at the age of 17 or older. Similarly, Olawuyi and Mushunje (2020) employed a bivariate probit model to analyze the factors influencing farmers' decisions regarding the adoption of conservation agriculture (CA), as well as to identify the factors driving farmers' choices in acquiring information and using CA practices. Their results indicated that decisions related to information acquisition and CA adoption were jointly determined by farmers, reflecting a positive and robust correlation parameter, rho, in the estimated model.

2.10.2 Household food insecurity access scale (HFIAS)

The Household Food Insecurity Access Scale (HFIAS) was developed to address the complexities associated with food insecurity problems, as highlighted by Coates et al. (2007), Swindale and Bilinsky (2007), and Bilinsky and Swindale (2010). Comprising nine questions related to food security, these inquiries are categorized into three groups. The first category focuses on the anxiety and uncertainty regarding food supply, the second category examines insufficient food quality (including variety and specific items), and the final set of questions explores the impact of food deficiencies, encompassing inadequate food intake and its physical consequences. Functioning as a subjective rural assessment tool, HFIAS measures respondents'

perceptions of their household food security based on the food consumed in the preceding four weeks (Headey and Ecker, 2013). HFIAS is widely employed in numerous studies on food security (Ndobo *et al*.,2013; Gebreyesus et al., 2015; Awodele and Olajide, 2020; Gewa et al., 2021)

Awodele and Olajide (2020) employed the Household Food Insecurity Access Scale (HFIAS) to measure the extent to which households were food secure in the Patigi Local Government Area of Kwara State, Nigeria. The food security index showed that 77 percent were moderately food secure, and about 66 percent of households' skipped meals because of insufficient funds to buy food. The food security status of households worsened with an increase in household size; women aged 35-39 years experienced a high degree of food insecurity. Ndobo *et al.* (2013) employed HFIAS to determine the extent to which food insecurity prevails in households in South African townships. The results showed that 49% of the households were vulnerable to food insecurity. Food insecurity was more prevalent in female-headed households (63.8%) than in male-headed households (42.9%).

In their study, Gewa *et al.* (2021) employed the Household Food Insecurity Access Scale (HFIAS) to evaluate the food insecurity status of households in rural Kenya, with mothers serving as the main respondents. Their findings revealed that engaging in poultry keeping, cereal/grain cultivation, vegetable production (both traditional and non-traditional), and having greater crop diversity were all significantly linked to lower levels of household food insecurity.

Meanwhile, Roy *et al*. (2022) conducted research on household food insecurity and the dietary diversity of women of reproductive age in rural areas of northwest Bangladesh. They utilized cross-sectional data gathered from 252 smallholder households to assess household food insecurity using the Household Food Insecurity Access Scale. Their results indicated that a majority of families experienced mild food insecurity (51.2%), followed by moderate insecurity (27.4%). Additionally, households reported feeling anxious about food insecurity for more than six months per year, with a Food Security Index score of 2.10 out of 4.00.

2.10.3 The two-step generalized linear square model.

The two-step generalized linear square model with control function is not commonly employed in this area of study. However, in this research, it was utilized to evaluate the combined impact of ICT adoption and access to credit on household food security as measured by the Household Food Insecurity Access Scale (HFIAS). Similarly, Joher *et al.* (2006) investigated the influence

of institutional holdings on managerial ownership and debt policy within an integrated framework using the two-step generalized linear square model. Their findings indicated a significant effect of institutional ownership, acting as an effective control mechanism, on both managerial ownership and corporate debt policy, as hypothesized. These findings suggest that institutional holdings play a vital role in shaping managers' strategic management decisions and mitigating agency conflicts.

Furthermore, Fatma and Chichti (2011) employed the three-stage least square simultaneous model to examine the efficacy of ownership structure and debt policy as mechanisms for resolving agency conflicts between shareholders and managers, particularly regarding the issue of overinvestment and the limitation of free cash flow problems. The results indicated that debt policy serves as a primary governance mechanism for mitigating the risk of free cash flow, while managerial ownership was found to reduce the level of agency costs associated with free cash flow. However, increased ownership concentration was associated with an elevated risk of free cash flow.

2.10.4 The Zero Inefficiency Stochastic Frontier (ZISF) production model

Abdulai and Abdulai (2016) utilized a zero-inefficiency stochastic frontier model to analyse allocative efficiency, scale economies, and the main determinants of efficiency among maize farmers in Zambia. Their study successfully accounted for both fully efficient and inefficient firms in the estimation process. The findings indicated the presence of scale economies, with the zero-inefficiency stochastic frontier model demonstrating better prediction of scale efficiency compared to the stochastic frontier model. Additionally, inefficiency was found to be influenced by factors such as education level, access to extension services, distance to markets, and access to credit.

Similarly, Kumbhakar et al. (2013) employed the zero-inefficiency stochastic frontier model to accommodate both efficient and inefficient firms in their sample. They developed the corresponding log-likelihood function and conditional mean of inefficiency to estimate observation-specific inefficiency and discussed testing for fully efficient firms.

Liu *et al.* (2017) identified fully efficient farmers and estimated the technical efficiency of inefficient farmers using the Zero Inefficiency Stochastic Frontier Model (ZISFM). Their results revealed that 13% of sampled farmers were fully efficient, supporting the validity of their approach. The mean technical efficiency was estimated at 91%, suggesting that rice

production could be increased by 9% through resource reallocation. Education positively impacted technical efficiency, while farmers using transplanting methods showed relatively higher technical efficiency compared to those using manual or mechanical direct seeding methods.

Ngango and Hong (2022) investigated the relationship between farm size and technical efficiency in maize production in Rwanda using the zero-inefficiency stochastic frontier method. They found that the average technical efficiency of maize farms was estimated at 0.64, indicating that maize output could be enhanced by approximately 36% without increasing input usage. Additionally, their results demonstrated a positive relationship between farm size and technical efficiency for maize production in Rwanda.

2.11. Theoretical framework

The development of a theoretical framework is shaped by the presence of relevant theories for a specific study and the goals of that study. The essential criteria for a practical theoretical framework include its utility, validity, and the presence of a comprehensive dataset to ensure adequate representation of small groups within the clusters (Pienaar, 2013; Hair *et al*., 2014; Kajombo *et al.,* 2014). Small-scale farmers, known for their diversity, operate within a constantly changing environment. Thus, this study embraced the Theory of Productive Efficiency, which centres on the notion of optimizing behaviour, whether from the perspective of producers or consumers (Kokkinou, 2010). This theory posits that producers strive to optimize both technically and economically. Technically, producers aim to minimize the wastage of productive resources, while economically, they seek to address allocation issues related to prices. However, not all producers are able to effectively address both types of optimization challenges in all situations. Performance at the firm or industry level is gauged by the ratio of outputs to inputs, providing a relative measure of performance applied to production factors (Korres, 2007). This performance depends on variations in production technology, the efficiency of the production process, and the environmental context in which production takes place (Korres, 2007). In this study this theory was chosen because small-scale sugarcane farmers are faced with number of challenges that affect their production efficiency. Many of the farmers operate in small plots of land, poor infrastructure, lack of agricultural extension services , lack of access to credit, lack of information technology; and poor farming and management practices. Most of the farmers use their traditional methods instead of adopting modern technology to produce their crops. The lack of information technology among farmers

prevents them from accessing formal credit and prevent them from getting viable information in the output and input market. These constraints affect farmers' productivity which in turn affect their ability to generate more income and improve their food security.

2.12. Conceptual and empirical framework

A conceptual framework serves as a valuable tool for researchers to illustrate the progression of the phenomena they are investigating (Camp, 2001). It becomes particularly useful when there is no definitive definition available to clarify the phenomena being studied (Akintoye, 2015). In such instances, researchers utilize the framework to conceptualize or depict the study. In this particular study, a variety of research methodologies have been employed to address the specific objectives. The conceptual framework presented in this study demonstrates that small-scale sugarcane farmers are influenced by numerous factors, including socio-demographic, farm-related, and socio-capital factors. It is conceptualized that these various factors have an impact on both access to credit and the adoption of ICT by small-scale farmers. The positive influence of these factors on access to credit ultimately leads to enhanced ICT adoption, which in turn contributes to higher sugarcane productivity. This increased productivity results in higher income levels, consequently improving food security. Figure 2.1 illustrates the interrelationship among the critical variables examined in the study.

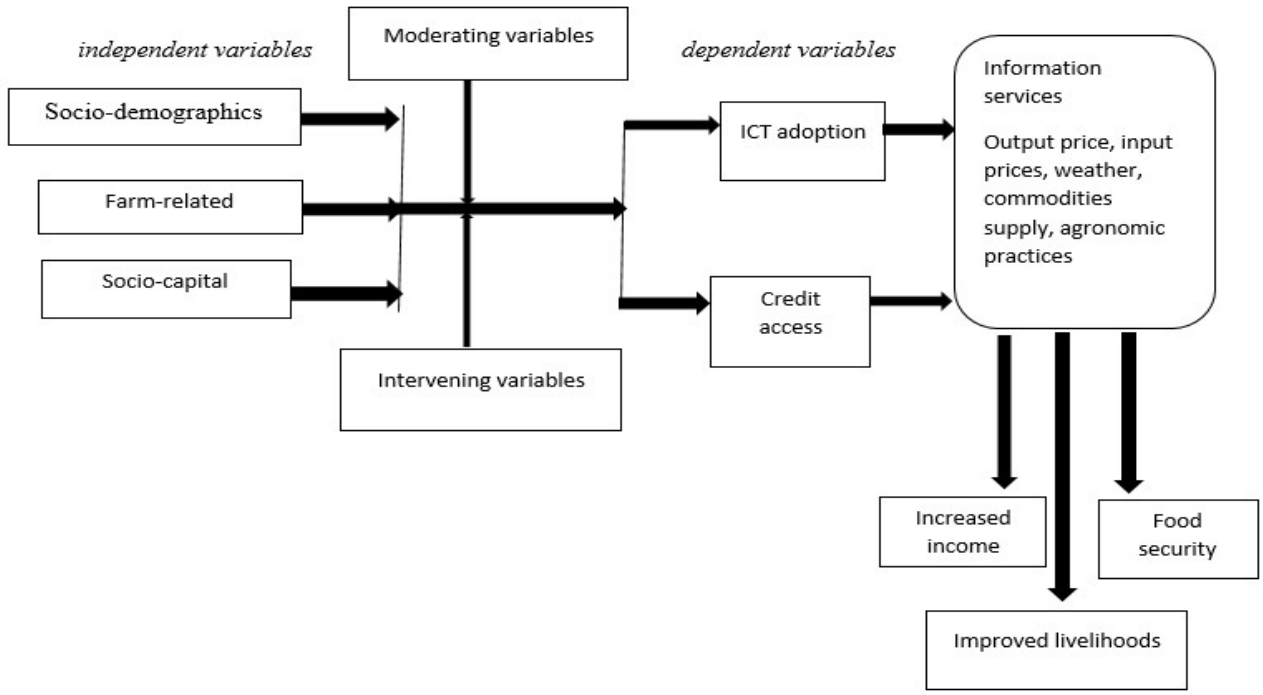

Figure 2.1: Illustration of the Interrelationship among the Critical Variables in The Study (conceptual framework).

Descriptive statistics were employed to present the socio-economic and demographic characteristics of small-scale sugarcane farmers. These statistics included average, standard deviations, frequencies, and percentages, providing insights into the various factors influencing access to credit and ICT adoption among small-scale farmers. To fulfil the objectives of the study, several econometric models were utilized. For the first specific objective, the Recursive Bivariate Probit (RBP) model was utilized. This model addresses the issue of endogeneity stemming from both observed and unobserved factors, enabling the estimation of the direct marginal effect of ICT adoption on access to credit and vice versa. Additionally, a two-stage selectivity-corrected Ordinary Least Squares (OLS) model was employed to assess the unbiased impacts of ICT adoption and access to credit on the income of small-scale farmers.

In the first stage, the two equations for ICT adoption and access to credit were jointly estimated using a Seemingly Unrelated Bivariate Probit (SUBP) model. The SUBP model concurrently estimates equations for ICT adoption and access to credit. The second objective aims to identify the factors that influence access to credit and adoption of ICT among small-scale sugarcane farmers, and to measure the impact of these determinants on their food security.

Initially, the Household Food Insecurity Access Scale (HFIAS) was utilized to gauge the food security status of these farmers, focusing on their ability to access food over a four-week period. Subsequently, a two-step generalized linear square model with a control function was employed to evaluate how ICT adoption and access to credit collectively influence household food security, as measured by HFIAS. Given the interconnected nature of ICT adoption and credit access, a simultaneous equations approach was chosen, with ICT adoption and access to credit serving as dependent variables in a two equation model. The third objective involved assessing the efficiency of small-scale sugarcane farmers in South Africa using the Zero-Inefficiency Stochastic Frontier approach. This approach utilized the Zero Inefficiency Stochastic Frontier (ZISF) production model to estimate the cost efficiency of individual firms within the study area.

The study is anchored in the Theory of Access, which posits that individuals may possess the right to access a particular resource but may lack the ability to utilize it productively due to structural and relational barriers such as technology, capital, knowledge, authority, labor, social relations, market mechanisms, and identity (Hlatshwayo et al., 2023). Ribot and Peluso (2003), as cited by Mutea (2020), delved into access by examining two variables: the "bundle of rights" and the "bundle of powers." This perspective emphasizes that access extends beyond mere entitlements to encompass the capability to derive benefits from resources (Ribot and Peluso, 2003). Consequently, the theory suggests that bundles of powers, alongside rights-based access mechanisms, influence how resource users gain control and sustain benefits (Mutea, 2020).

In the context of this study, the Theory of Access provides a robust framework for exploring the interplay between credit accessibility, Information Communication Technology (ICT), and the income of small-scale sugarcane farmers.

While these farmers have the right to access credit and ICT, their ability to effectively utilize these resources is constrained by various factors.

These constraints include a lack of information, suboptimal farming and management practices, inadequate infrastructure, limited agricultural extension services, and restricted access to land. The disconnect between the entitlement to access credit and ICT and the capacity to derive benefits from them hinders small-scale farmers from maximizing their income potential.

2.13 References

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CHAPTER 3:

RESEARCH METHODOLOGY AND DATA ANALYSIS

3.1 Introduction

This chapter focuses on the selection of the study area, description of Ndwedwe Local Municipality data collection method, research designs, and data analysis method employed in this study At the beginning of the chapter, the study area (Ndwedwe Local Municipality of iLembe District Municipality) was described to provide brief background information about the area where the study was conducted, and data collected. Tlhe chapter also provides a bit of information on the models that were used in this study.

3.2 Section of the study area

The study was carried out in the Ndwedwe Local Municipality of iLembe District Municipality of KwaZulu-Natal., The selected villages are Ndwedwe mission, Nhlangano and Sonkombo from five villages, the other two villages being Mona and Ntaphuka villages which are not part of my study.

These villages were selected because they are mostly occupied by small-scale farmers who are involved in the production of sugarcane. The sample chosen through simple random sampling techniques, where sample chosen with the assistance from extension workers. Secondly, these small-scale sugarcane farmers produce and deliver sugarcane in the same sugar mill.

The selected areas also have the same agro-climatic conditions that are suitable to produce sugarcane, rainfall in these areas is predominantly during summer months, (October–December while in winter they receive less rain and also they are affected by drought. Figure 3.1 is a map indicating the location of the study sites : Ndwedwe Mission, Nhlangano, and Sonkombo in Ndwedwe Local Municipality.

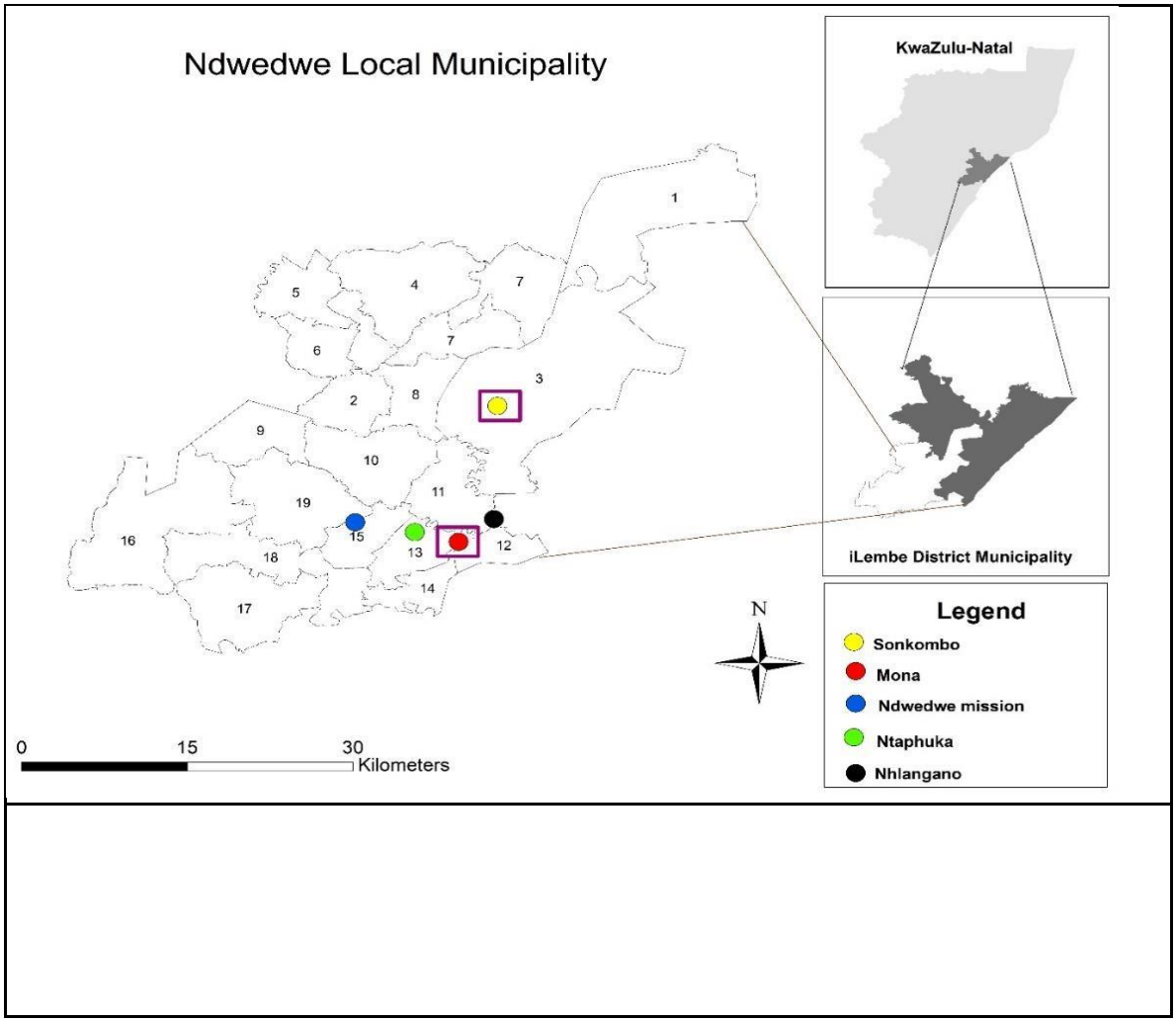

Figure 3.1: The Map of The Location of Study Sites in Ndwedwe Local Municipality

3.1 Description of Ndwedwe Local Municipality

The annual precipitation ranges from 700mm to 1,100mm (Sibiya and Hurly, 2011). According to the Ndwedwe Local Municipality IDP (2021) the villages are situated in the south part of Ndwedwe Local Municipality, with an optimum temperature for crop growth of 24°C to 30°C. The mean summer temperature for growth in Ndwedwe Local Municipality is 19°C.

3.3 Data collection method

The research adopted a quantitative approach and employed a simple random sampling technique to select respondents, ensuring that each member of the population had an equal chance of being included in the sample.

A questionnaire containing both open-ended and close-ended questions was utilized to collect data, focusing on the challenges and factors influencing sugarcane productivity among small-scale farmers in Ndwedwe Local Municipality, KwaZulu-Natal. The questionnaire covered demographic information, socio-economic characteristics, as well as institutional and production factors affecting sugarcane farming. To ensure accessibility and cultural relevance, the questionnaires were translated into the local IsiZulu language, the primary language spoken in the study area. The questions in the questionnaire are designed to generate data that is intended to answer your research questions. Ethical clearance approval was obtained from the university research ethics committee before commencing the research, and the study adhered to the university's research procedures and ethical guidelines. Face-to-face interviews were conducted to administer the questionnaires (interview schedule) to the respondents.

The questions were derived from previous studies or literature The questions structured in such way that it`s understandable by repondents applied,and the questions were more academic with specialised technical language. The both research and questionnaire questions were informed by theory or prevous research.as it is common with research in research discipline. The research questions informed by previous theory described as dedustive research, with deductive, research theory is significant factor. Provided that you acknowledge your sources, and the questions are adapted to your specific research question, this is not cheating; you are using questions that have already been ‘piloted’ and making it easier to compare your research with previous research and to make a clear claim about what is new in your findings (Bryman and Bell, 2011). You question to meet the requirements of statistical analysis, your question should has smart. To execute the questionnaire development process the following steps adhered to :Identify research aims and the goal of questionnaire, Define target respondents, Develop questions, Choose question type, design question sequence and overall layout and Run a pilot to check questions validity.

3.4 Research design

3.4.1 Sample size and sampling techniques

The sample size comprised 300 small-scale sugarcane farmers from three villages Ndwedwe Mission, Nhlangano, and Sonkombo. This sample size was considered adequate, representing 30% of the population, as recommended by statistical guidelines (Neuman, 2007). While this sample size may seem small, it was sufficient to achieve reasonable statistical power given the accessible nature of the study in terms of time and cost. From each village, approximately 200 small-scale sugarcane farmers were identified, and every fifth member from the list of farmers who delivered sugarcane to the mill was randomly selected as a respondent. The population size in small-scale sugarcane development of Ndwedwe local municipality was 1000 farmers. This systematic random sampling approach ensured that each member of the population had an equal chance of being selected, contributing to the scientific rigor of the study. The villages selected for the study—Ndwedwe Mission, Nhlangane, and Sonkombo were purposively chosen due to their similar agro-climatic conditions and the predominance of sugarcane cultivation as the primary crop enterprise. This purposive selection facilitated a focused investigation into sugarcane farming practices within the municipality. Again, the sample size of 300 farmers was deemed adequate for statistical analysis, ensuring the representativeness of the findings while considering the logistical constraints of the study.

3.5 Method of data analysis

The quantitative data were analysed using STATA statistical software (version 13), Excel, and Statistical Software for Social Sciences (SPSS) version 27. The descriptive statistics were performed to summarise the key socio-economic characteristics of the sampled small-scale sugarcane farmers. It was performed to show mean averages, standard deviation, and percentages of the factors affecting access to credit and adoption of ICT among small-scale farmers. The adoption of ICT and access to credit is influenced by factors that include age, gender, employment status, fertiliser costs, extension support, non-farm income, fertiliser time, land tenure system and seed cane age. To meet the objectives, the study used various econometric analytical tools. To **meet the first specific objective** of the dissertation, the recursive bivariate probit (RBP) regression model was used, which addresses the endogeneity issues from both observed and unobserved factors, and it can estimate a direct marginal effect of ICT adoption on access to credit and vice versa. However, the specification of the RBP model, where econometric analysis was applied, is discussed in detail in chapter 4 to avoid

repetition of information. To meet second objective, the Household Food Insecurity Access Score (HFIAS) was employed in this study to analyse and measure the food insecurity status level of the small-scale farmers, this method also used by Masuku, (2017), to measure the Status of household food security in rural areas at uThungulu District, KwaZulu Natal, South Africa. It was used to measure the access component of household food insecurity based on the food consumed in the four previous weeks. The two-step generalised linear square model with control function was used to assess the combined effect of ICT adoption and access to credit on household food security interms of HFIAS. The third objective assessed efficiency among small-scale sugarcane farmers in Ndwedwe area, using the Zero-efficiency stochastic frontier approach. The Zero inefficiency Stochastic Frontier (ZISF) production model was employed to estimate the firm-level cost efficiency of the farmers in the study area. The detailed model specification for the analytical tools is provided in Chapter 5 and 6 to avoid the repetition of information.

3.6. Ethical Considerations

Prior to the commencement of data collection, ethical clearance was sought and received from the Human Social Sciences Research Ethics Committee (see Appendix C). After receiving ethical clearance, questionnaires (Appendix B) were administered immediately, and participation for interviews were sent. All data collection tools were accompanied by the informed consent (Appendix A) which was to be signed as an acknowledgement that the participant's participation was free and consensual. All responses/ raw data were kept strictly confidential and encrypted within researcher's databases. Secondary data collected through literature review was also duly acknowledged.

3.7. References

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CHAPTER 4

Determinants of access to credit and information and communication technology and its effect on income of small-scale sugarcane farmers in Ndwedwe local municipality, KwaZulu Natal Province, South Africa.

ABSTRACT

Access to credit and information and communication technology (ICT) are the most valuable resources in improving small-scale sugarcane farmer's practices. These two resources make the life of small-scale farmers easier financially, socially, and economically. Despite the significant contribution of credit and ICT on sugarcane production, small-scale farmers are faced with difficulties to access them which affect their ability to generate sustainable income. This study sought to assess the factors that affect adoption of ICT and access to credit; and their effect on small-scale farmer's income. A multistage sampling procedure was employed to select 300 small-scale farmers. The results showed that about 77% of small-scale farmers had access to credit and more than 80% of the farmers adopted ICT. The results from recursive bivariate probit (RBP) regression model showed that access to credit, education and extension support had a positive and significant influence on adoption of ICT, while marital status and non-farm income had negative and significant influence. On the other hand, gender and marital status had a positive and significant relationship with access to credit while age, education and non-farm income showed a negative and significant relationship. A selectivity corrected ordinary least square regression model was used to estimate the synergetic effect of ICT adoption and access to credit on income of small-scale sugarcane farmers. The results showed that gender, marital status, extension, government support and transportation cost had a positive and significant influence on farmer's income, while education, employment status and non-farm income had a negative and significant influence. The study concludes that socio-demographic factors such as gender, marital status, extension support, government support, and transportation cost positively contribute to farmers`ncome. On the other hand, education, employment status, and non-farm income negatively affected farmer's income. There is a need to educate small-scale farmers on ICT and access to agricultural credit. Extension workers need to provide advisory support to small-scale farmers that need agricultural access to credit.

Keywords: small-scale farmers; access to credit; ICT adoption; income; sugarcane; recursive bivariate probit.

4.1 Introduction

Agriculture is the mainstay of South Africa's economy and supports the livelihoods of a large part of the population. This attributed to the fact that agriculture is the main source of food and income, it provides employment to about 70% of the South African rural households (Poole, 2017). Agriculture is also a source of raw materials for industries, which market manufactured goods, and contribute 10% to South African's foreign exchange earnings (International Trade Administration, 2023). South African agriculture consist of a considerable number of small-scale farmers, who produce various types of cash crops and food crops including maize, beans, and vegetables for subsistence (Mkuhlani et al., 2020). Sugarcane is among the cash crops that are largely grown by small-scale farmers to generate income. It is one of the industrial crops that is regarded as an essential crop worldwide due to its extensive use in the day-to-day lives of people and its industrial use intended for dietary and economic sustenance (South African Sugar Association (SASA), 2012). The sugarcane sector contributes significantly to South Africa's GDP through its solid socio-economic development that focus on job creation, resource organization, income generation, and the development of transport and communication networks (Aliyu *et al*., 2018). The sector generates approximately R6 billion in direct annual revenue from exports to the rest of the world and the regional block of the Southern African Customs Union (SACU) (Thibane *et al.,* 2023). Even though the sector contributes significantly, it needs some massive capital and financing. small-scale sugarcane farmers in South Africa are faced with low ability to adopt Information Communication Technology (ICT) which helps to provide necessary information on how to access credit and this in turn affect their ability to finance their production and generate income.

Access to credit and ICT are the valuable resources in improving small-scale sugarcane farmers' practices. Asongu *et al.* (2019) stated that ICT provides fundamental tools that assist both lenders and borrowers to have a better understanding on the market risks, credit terms and conditions and also it improves their competence in dealing with possible information asymmetry and moral hazards. Siyao (2012) outlined that access to information technology is a significant resource for socio-economic development as it empowers households to make informed decisions for achieving improved livelihoods. Olorunda and Oyelude (2008) also

stated that access to information is key for planning, decision making and the execution of programmes. Nowadays, agriculture has dependent more on modern technology, therefore it is important for farmers to have access to technical and scientific information to make relevant decisions (Salehi *et al.,* 2021). ICT can also improve the competitiveness of sugarcane farmers across the various sectors of the agricultural supply chain (Shikuku, 2019). With these being said, it cannot be disputed that sugarcane farmers with access to proper ICT are being able to access formal credit and vice versa.

Access to credit is a state in which small-scale farmers have the ability to tap into particular sources of capital that will enable them to obtain optimal inputs, such as improved seed cultivars or genetics, fertiliser, machinery (Motsoari *et al.,* 2015). It is a financial help that enable small-scale farmers to accomplish cash requirements of the primary agricultural inputs that are used in production (Abdallah, 2016; Adjognon et al., 2017; Afrin *et al.,* 2017). Manganhele (2010) reported that experiences in many developing communities proved that access to credit could accelerate the adoption of new technologies. Several studies indicated that most of the farmers in developing countries including South Africa are resource-deficient and faced liquidity constraints with buying necessary inputs, therefore, access to credit is more essential to them (Saqib *et al.,* 2016; Chandio *et al.,* 2018, Saqib *et al.,* 2018). In addition, access to credit has a significant contribution to growth and development of the rural economy, therefore secure and timely accessibility of formal credit can bring a productive change from subsistence to commercial (Saqib *et al.,* 2018).

Despite the significant contribution that adoption of ICT has on the ability of small-scale famers to access credit, small-scale farmers are faced with difficulties to access and adopt ICT and credit which affect their ability to generate sustainable income. Most of the small-scale sugarcane farmers in South Africa are faced with severe challenges that include technical, economical, and social issues (Thibane *et al.,* 2023). The policies or terms and conditions included in formal credit are difficult for farmers to adhere to. For instance, formal credit requires small-scale farmers to have reliable collateral while most farmers do not own land and others own very small sizes of land (1.5 hectares) (Salehi *et al*., 2021). The information included in formal credit are sometimes too complex for famers to understand and requires lot of administration. Chandio *et al*. (2021) stated that in most cases formal credit policies fail to address the small-scale farmers' needs for a loan, also, they are not compatible with farm and personal objectives.

With regards to information technology, small-scale farmers do not adopt adequate information. Shanthy (2011) outlined that ICT typically involves a 'top-down' approach where people in the top can be researchers, government or policy makers provide information with innovations that are sophisticated and provide them to extension services to deliver to farmers without any training. Therefore, farmers become reluctant and rely more on their traditional knowledge and informal lenders which are not adequate to sustain the production processes.
An improvement in access to credit and ICT adoption will improve small-scale farmers' agricultural production, which will have an implication on farm income. It is, therefore, important to understand all the factors that affect the ability of small-scale farmers to acquire ICT and formal credit in order to provide interventions that will enhance farmers' capabilities and improve their agricultural performance.

Several studies (Kuwornu et al.,2012; Saqibe *et al*., 2016; Chandio *et al.,* 2016; Chandio *et al.*,2021) have been conducted on the influence of access to credit on farmers production, others focused more on role of access to information on famers' production(Shanthy, 2011; Siyao, 2012; Saleni *et al.,* 2021). However, there is a dearth of empirical research that has been conducted on the combined effect on ICT and access to credit on small-scale sugarcane farmers' income. Against this backdrop, the study presented the following aims (i) to determine the factors that affect access to credit (ii) to determine the factors that influence ICT (iii) to quantify the effect of both ICT and access to credit on small-scale sugarcane farmers' income in KwaZulu Natal province, South Africa.

4.2 Analytical framework

Following data collection, the gathered information underwent a process of cleaning, recording, and analysis utilizing the Statistical Package for the Social Sciences (SPSS) Version. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were employed to portray the socio-demographic characteristics of the sampled respondents. In the context of small scale farmers, there exists a crucial decision-making process regarding the utilization of Information and Communication Technology (ICT), often referred to as self-selection. However, this decision is influenced by various socio-economic, institutional, and unobservable factors, potentially leading to an endogeneity issue regarding the ICT adoption variable in econometric estimation.

When examining the impact of a binary endogenous treatment variable, such as ICT adoption, on a binary outcome variable, like access to credit, previous studies have proposed various approaches. These include the endogenous switching probit (ESP) model and the Recursive Bivariate Probit Regression (RBP) model. In this study, the RBP model was employed to address the endogeneity issue arising from both observed and unobserved factors. Additionally, it enabled the estimation of the direct marginal effect of ICT adoption on access to credit, and vice versa.

The RBP model entails estimating two equations. One equation describes the probability of access to credit (Equation 1), while the other explains the relationship between ICT adoption and households' credit access (Equation 2)

$$I_i * = \ _iX_i\xi_iIV_i + \tau_i, I_i = \begin{cases} 1, if\ I_i > 0 \\ 0, otherwise \end{cases} \quad (1)$$

$$c_i * \alpha_iI_i + \beta_iX_i + \ _i, C_i = \begin{cases} 1, if\ C_i * > 0 \\ 0, otherwise \end{cases} \quad (2)$$

where I_i is a latent variable representing the probability that a household I adopts ICTs, which is determined by the observed binary variable I_i (I_i =1 for ICT adopters and I_i =0 for non-adopters); $C_i *$ refers to a latent variable that represents the propensity of credit access, which is determined by the observed binary variable Ci (Ci = 1 for credit users and Ci = 0 for non-users); X_i is a vector of exogenous variables; IV_i refers to an instrumental variable (IV), which is used for RBP model identification; $_i$, ξ_i, α_i and β_i are parameters to be estimated; τ_i and $_i$ are error terms.

The synthesized valid instrumental variable IV was used in this study as it represents the average number of other ICT adopters (i.e., except for the sampled household) within the same county (Zheng *et al.*2021). The synthesized IV is expected to affect a household's ICT adoption decision, but not affect access to credit directly. Statistically, a Pearson correlation analysis was conducted to test the validity and effectiveness of the IV.

Modeling the joint effects of ICT adoption and access to credit on small-scale sugarcane farmer's income

To explore the combined impacts, the study hypothesized that household income could be modeled as a function of ICT adoption, access to credit, and a set of explanatory variables. The equation representing the regression for household income can be reformulated as follows:

$$Y_i = \gamma_i I_i + \delta_i C_i + \varphi_i X_i + \omega_i \quad (3)$$

where Y_i refers to household income; I_i , C_i, and X_i are variables; γ_i, δ_i , and φ_i are parameters to be estimated; ω_i is an error term. γ_i and δi are the parameters in Equation 3 representing the effects of ICT adoption and access to credit on household income, respectively. Equation 3 can be analyzed using an ordinary least squares (OLS) regression model. However, it's important to note that the ICT adoption variable (I_i) and the access to credit variable (Ci) are both potentially endogenous in Equation 3. This is because farmers themselves decide whether to adopt ICT or not, as well as whether to use credit or not, leading to a self-selection bias. Previous research (Kumar *et al*., 2020; Li *et al.,* 2020) has highlighted the endogeneity issues associated with access to credit variables. Failure to account for these endogeneity issues could result in biased estimates of the joint effects of ICT adoption and access to credit on household income. Drawing from previous research (Ma *et al.,* 2018; Wooldridge, 2015), this study utilized a two-stage selectivity-corrected ordinary least squares (OLS) model to accurately gauge the effects of ICT adoption and access to credit on the income of small scale sugarcane farmers. In the initial stage, a seemingly unrelated bivariate probit (SUBP) model was employed to jointly estimate the equations for ICT adoption and access to credit. Unlike the recursive bivariate probit (RBP) model, the ICT adoption variable was excluded from Equation 2 in the SUBP model to prevent any potential reverse causality issues between ICT adoption and access to credit.

The outcomes derived from the SUBP model were then utilized to predict variables for the endogenous factors. Subsequently, in the second stage, these predicted variables for ICT adoption and access to credit, which effectively control for endogeneity concerns, were substituted for the original variables in Equation 3. This facilitated the estimation of the selectivity-corrected OLS model, thus enabling a more precise analysis of the relationship between ICT adoption, access to credit, and small scale farmers' income:

$$Y_i = \ _i I'_i + \lambda_i C'_i + \varphi_i X_i + \omega_i \quad (4)$$

where Y_i and X_i are variables defined below; I_i and C_i are predicted ICT adoption variable and predicted access to credit variable, respectively; $_i$, λ_i, and φ_i are parameters to be estimated; ω_i is an error term.

Definition of variables

Y_1= Access to credit

Y_2= Adoption of ICT

Y_3= Income

X_1= Sex of household head (male =1, female = 0)

X_2 = Age of household head (years)

X_3 = Household size (persons)

X_4 = Farm size (hectares)

X_5 = Level of education (years)

X_6 = Sugarcane income of household head

X_7 = Quantity of own production (kilogram)

4.3. The study area, sampling, and data collection technique

The study area, sampling, and data collection technique are the same as in chapter three.

4.4 Results and discussion

4.4.1 Demographic results

Table 4.1 shows the different socio-demographic factors that affected the adoption of ICT and access to credit by small-scale farmers. The descriptive results showed that about 77% of small-scale farmers had access to credit while 23% did not have access to credit. This means that more farmers were able to use the resources they owned as collateral to acquire loans (Chandio *et al.,* 2016). The results also revealed that more than 80% of the farmers adopted ICT while 20% did not. This means that most of the farmers were able to adopt information that helped them to boost their production. The current study was dominated by female farmers who amounted to 66% in total, while male farmers were only 34% in total. This is not surprising as smallholder agriculture is mainly dominated by females who provide labour and mainly involved in production side (Hlatshwayo et al., 2022). Regarding marital status, the results showed that most (34%) of the farmers were married followed by 25% of farmers who were widowed. Only 6% of the farmers were divorced.

Table 4.1: Socio-demographic Factors of Small-scale Sugarcane Farmers in Ndwedwe Local Municipality

Variable	Percentage (%)
Access to credit	
Yes	77
No	23
Adoption of ICT	
Yes	80
No	20
Gender	
Male	34
Female	66
Marital status	
Single	21
Married	34
Widowed	25
Divorced	6
Living with partner	14
Educational status	
No formal education	27
Primary school level	37
Secondary level	22
Tertiary level	14
Employment status	
Unemployed	57
Employed temporal	33
Employed permanent	10

Non-farm income	
Salaries	2
Old age pension	41
Disability grant	4
Child support grant	28
Foster care	12
Business	13

Most (37%) of the farmers had primary education while only 14% has tertiary education. This implies that most of the farmers had grade R to grade 7. About 27% of the farmers had no formal education, meaning that they were using their traditional and indigenous knowledge in production. The results showed high rate (57%) of employment percentage among small-scale farmers. This shows that most of the small-scale farmers were unemployed, and they depended more on the production of sugarcane as source of income. When it comes to non-farm source of income, more than 41% of the small-scale farmers depended on old pension grant as a main source of income. These results are consistent with many previous studies who reported that most of the small-scale farmers depend on old pension grant as source of income and end up neglecting farming (Sinyolo *et al.*, 2016; Sinyolo *et al.*, 2017; Hlatshwayo *et al.*2022).

4.4.2 Empirical results

4.4.2.1 Factors influence ICT and access to credit.

Table 4.2 represents the results of the factors influencing the adoption of ICT and access to credit. The results showed that access to credit had a positive and significant influence on ICT adoption among small-scale sugarcane farmers. The model predicts that a 1% increase in the amount of access to credit will increase ICT adoption by 1.591 percent.

This implies that farmers with access to credit were also able to access information technology and be updated with all the required production information. The results were in line with those of Weng *et al.* (2023) who found a positive relationship between access to credit and use of the internet. The authors explained that access to credit and information technology such as the Internet can effectively reduce the transaction costs caused by information transmission and

search, and increase the willingness of farmers to use morden technology. Tchamyou *et al.* (2019) also found a positive relationship between access to credit and ICT. The authors concluded that access to credit and ICT makes the lives of farmers easy and saves them time.

Table 4.2: Factors That Influence ICT and Access to Credit- Recursive Bivariate Probit Regression

Model						
Variable	Coefficient	Std. err.	P-value	Coefficient	Std. err.	P-value
Information Communication Technology				Access to credit		
Access to credit	1.591	0.293	0.000***			
Age	0.006	0.015	0.675	-0.043	0.009	0.000***
Gender	0.393	0.321	0.220	0.828	0.197	0.000***
Marital status	-0.182	0.104	0.080*	0.280	0.068	0.000***
Education	0.380	0.183	0.038**	-0.501	0.097	0.000***
Employ status	-0.087	0.250	0.729	-0.016	0.143	0.913
Nonfarm income	-0.205	0.113	0.069**	-0.174	0.082	0.033**
Extension Support	1.003	0.277	0.000***	0.168	0.174	0.335
Government support	0.137	0.173	0.427	0.164	0.108	0.128
Seed cane Age	0.107	0.160	0.504	0.031	0.093	0.741
_cons ICT	-1.583	1.528	0.300			
_cons Access to credit	2.077	0.837	0.013			
/atanrho			-262.891	0.967		
			10.825			
Rho			-1	-1		

Notes: ***, **, * Indicate significance at 1%, 5%, and 10% level, respectively.

Marital status had a negative and significant influence ($p<0.05$) on ICT adoption. This means that married couple were unable to access ICT. The possible explanation might be that married people have lot of commitment in their personal lives, so they end up involved less in many social activities. These results are consistent with Sever (2016) who reported that married people with job and household responsibilities experiences a lot of pressure which affect their priorities when it comes to communication. Kari (2021) determined the role of marital status on the use of digital library services. According to Kari (2021), the study has implications on the management of library due to the evidence provided that may be useful to library professionals on how they can encourage women to make use of digital library services. The study found that single women utilized more of the digital library services than married women. The plausibility of this findings could be traceable to the fact that being married mainly affect decision making and responsibilities which affect social life. On the other hand, marital status showed a positive relationship with access to credit. This implies that married people were able to access credit than those who are not married. This is because married people have mor.e resources required to access credit than those who are not married. The result is similar to that of Ololade and Olagunju (2013) who found that not being married reduced the probability of having access to credit by 86.3%.

The current results showed that there was a positive and significant relationship between education and ICT adoption ($p<0.05$) among small-scale sugarcane farmers. This means that farmers who were educated were able to access and use ICT services. Szymkowiak *et al.* (2021) outlined that education plays a significant role in advancing the knowledge and skills of an individual. Goldie (2016) also emphasized that education provides scientific and technological advances that improve information and knowledge.

The results also revealed that there was a negative and significant relationship between education and access to credit. This means that farmers who are educated are using other forms of income to finance their agricultural production. On the contrary, Kiplimo *et al.* (2015) found that educational level had a positive effect on access to credit financial .services. Johnson and Morduch (2007) also reported that farmers with higher levels of education have more advantages to have secured collateral which enables them to access credit. Hussein (2007) also found results that are similar to this study and reported that educated farmers have the ability to access and understand information on credit terms and conditions which allow them to complete their application forms correctly.

Non-farm income had a negative influence ($p<0.05$) on both ICT and access to credit among smallholder farmers. This means that farmers who were relying on non-farm income were not able to access both ICT and credit. The results were contrary to those of Kiplimo *et al.* (2015) who found that farmers who were employed outside the farm were able to access credit. The authors explained that farmers were able to generate more income outside the farm and accumulate more assets that would be used as collateral when seeking credit services.

The results also revealed that extension support services had a positive and significant association with information technology of small-scale sugarcane farmers. This implies that small-scale farmers were getting more support from extension agencies that helped them access more information on their production. The results concur with that of Worsen *et al.* (2017) who found a positive relationship between extension services and access to formal credit. The study recommended that there is a need for extension services to help farmers in the expansion of financial markets that help in improving farmers 'welfare and efficiency.

The age of the household head had a negative and significant ($p<0.001$) influence on access to credit among small-scale farmers. This implies that as the age of small-scale farmers' increases access to credit decreases. The current results are consistent with Chandio *et al*. (2017) who found that age of households had a negative and significant effect on farmers' access to credit. The study therefore concluded that there is a need for institutional sources of credit to improve their loaning schemes to better suit the diversified needs of small farmers.

In contrast, Kehinde and Ogundeji (2022) found that age was among the socio-demographic factors that positively influenced productivity of those farmers who have access to credit. The authors reported that reported that as farmers get old, they acquire enough assets that will be served as collateral and be able to secure credit.

With regards to gender, the results showed that gender of household head had a positive and significant ($p<0.05$) association of access to credit. This means that women had the same access to credit as men do. This also mean that women were able to acquire sufficient credit that helped them to finance their production. The results concur with the results of Chandio *et al.* (2017) who found a positive relationship between gender and access to credit. Kehinde and Ogundeji (2022) found different results which showed that male farmers had better access to credit than their female counterparts. The authors further explained that females are not

generally involved in decision making, they are more involved in-house chores that hinder them from participating in many things.

4.4.2.2. Joint effects of ICT adoption and access to credit on small-scale Farmer's Income

Table 4.3 presents the joint effects of ICT adoption and access to credit on small-scale farmers' income. The variance inflation factor (VIF) was used to control endogeneity and assess how much the variance of an estimated regression coefficient increases when variables are correlated. In this study, all the variables show the mean VIF was 2.617. This means that multicollinearity was not a problem in the regression results. Access to credit and ICT adoption were the variables of interest in this objective, however, this is positive and shows a significant impact at 1% of small-scale farmer's income. This is significant at 1%. Both variables showed a negative sign with no significant influence.

The R-Square measure the "model quality" or the percentage of the variance of the results that is explained by the model. Concerning this dataset, the R-square accounts for about 84% of the variation of the dependent variable by the explanatory variables, suggesting that the model is fit to explain the variations to the dependent variable. The *F*-test is used in regression analysis to test the hypothesis that all model parameters are zero. It is also used in statistical analysis when comparing statistical models that have been fitted using the same underlying factors and data set to determine the model with the best fit. This F test uses the F statistics to explain the relationship between the dependent and independent variable. F-statistic 128.487 has a *p*-value of 0.000. Since our *p*-value (≤0.05), we reject the null

Table 4.3: The Effect of ICT and Access to Credit on Small-scale sugarcane Farmer's Income-Selectivity-corrected Ordinary Least Square Regression Model

Variable	Coefficient	Std. err.	P-value	VIF
e2				2.617
Gender	12.380	0.903	0.000***	1.371
Marital status	5.336	0.321	0.000***	1.29
Education	-8.493	0.542	0.000***	2.117
Employment status	-2.945	0.590	0.000***	1.156
Nonfarm income	-3.699	0.282	0.000***	1.498

Access credit	-0.221	1.089	0.840	1.738
ICT	-0.345	1.768	0.768	1.765
Extension Support	3.459	0.740	0.000***	1.031
Government support	2.322	0.477	0.000***	1.118
Seed cane Age	1.023	0.388	0.789	1.106
Low-income	0.290	1.051	0.783	1.727
Transport costs	0.000	0.000	0.018**	1.107
Mean VIF	1.49			
e2 (Residual ICT_ Access to credit)	-56.985	2.736	0.000***	
Constant	86.594	3.106	0.000	
Mean dependent var	55.897	SD dependent var	15.646	
R-squared	0.843	Number of obs	300.000	
F-test	128.487	Prob > F	0.000	
Akaike crit. (AIC)	1970.917	Bayesian crit. (BIC)	2019.066	

Notes: ***, **, * Indicate significance at 1%, 5%, and 10% level, respectively.

The results showed that the gender of the household head had a positive and significant ($p<0.001$) influence on small-scale farmer's income. This means that females were also able to utilize all the resources they had in farming and be able to generate more income. The results are similar to that of Abokyi *et al.* (2020) who also found a positive relationship between gender and income. On the contrary, Tolno et al. (2015) found that gender was significant and negatively related to farmer's income. In the same vein, Hailu *et al.* (2014) found that male-headed households had better farm income when compared to female-headed. The authors then explained that their findings are an important indicator of household decision-making whereby in a traditional setup, key decisions in a household are made by men.

Marital status showed a positive and significant influence on farmer's income at a 1% level. This means that as more farmers get married, they join their resources for production and ge/nerate more farm income. These results were opposed to those of Ojo and Baiyegunhi (2020) who found that marital status was statistically significant and negatively related to farmers' net income. The authors explained that married households have large family sizes which makes them use their net income in other activities than production.

On the other hand, the study showed that education had a negative and significant ($p<0.001$) relationship with farmer's income. This means that as farmers get more educated their level of participation in farming decreases which decreases their income. The plausible explanation is that educated people opt for other jobs that pay better than being involved in farming full-time. However, Serin *et al.* (2009) found that formal education and practical education in the form of utilizing expert consulting and training services also increase the productivity and income of farmers. Ao *et al*. (2021) also found that formal education was among the socio-demographic factors that had a significant positive impact on farming income levels. The study outlined that it is important to improve strengthen agricultural technical training of farmers and increase their level of education. The results also revealed that employment status and non-farm income had a negative and significant ($p<0.001$) on small-scale farmer's income. The farmers who were employed outside the farm were not using their off-farm income to finance their agricultural production to generate more farm income. In line with these findings, Odoh *et al.* (2020) found a low level of income generation from farm activities than non-farm activities. Odoh and Nwibo (2016) also found that in Nigeria non-farm sector is a major contributor to employment and income generation of rural households, contributing up to 63% of household income.

Agricultural extension services play a crucial role in boosting small-scale sugarcane productivity which in turn improve farm income and increase food security and rural livehoods. These services are provided by the government as an intervention to support small-scale farming. The current study revealed that extension support and government support had a positive and significant ($p<0.001$) influence on farmer's income. This means that small-scale farmers were receiving adequate support from extension services which increased their productivity and income.

The results of the current study are similar to those of Baiyegunhi *et al.* (2020), who found that the government extension program significantly contributed to an increase in the net farm

income of the participants. Amrullah *et al.* (2023) also reported that access to extension services plays an important role in agricultural income. The study suggested that the government needs to increase public investment in extension as it optimizes the potential impact on technology adoption and agricultural income, which also affects the distribution of the welfare of rural smallholder farmers.

The study showed surprising results on transport costs. Transportation **costs** had a positive and significant impact on farmer's income.The possible explanation is that some of the small-scale farmers had their own transport to use during production and they incurred fewer costs or the distance they travelled to suppliers was less and did not cost them so much

4.5 Conclusion and policy recommendations

The sugarcane sector contributes significantly to South Africa's GDP through its solid socio-economic development that focuses on job creation, resource organization, income generation, and the development of transport and communication networks. The aim of the study was to assess the factors that affect the adoption of ICT and access to credit and their effect on small-scale farmer's income. The study concludes that socio-demographic factors such as access to credit, education, and extension support had a positive contribution to the adoption of ICT, while marital status and non-farm income had a negative effect on the adoption of ICT. Gender and marital status had a positive contribution to access to credit while age, education, and non-farm income showed a negative and significant relationship. On the other hand, socio-demographic factors such as gender, marital status, extension, government support**,** and transportation cost showed an improvement in farmer's income, while education, employment status, and non-farm income had a negative influence. An improvement in these factors can lead to improvement in access to credit and adoption of ICT which in turn improves farm income. Smallholder farmers need to be encouraged to get some education on how to adopt ICT and access credit. More training and workshops need to be conducted to teach and train farmers on the requirements needed to apply for formal credit. Moreover, they need to be trained on how to adopt modern information technology. This can help them to produce more efficiently and generate more income. Extension workers need to provide advisory support to small-scale farmers that need agricultural access to credit.

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CHAPTER 5

The determinants of information communication technology (ICT) adoption and access to credit market and its effect on food security status of the small-scale sugarcane farmers in Ndwedwe local community, KwaZulu Natal province, South Africa.

ABSTRACT

Adopting Information Communication technology helps small-scale farmers to access credit thereby increasing their production. Therefore, alleviating the disproportionate burden of food insecurity in South Africa requires focused initiatives to assist small-scale farmers to adopt Information Communication Technology and be able to access credit. The aim of this study was to assess the impact that determinants of ICT and credit accessibility have on the food security of small-scale sugarcane farmers. A multistage sampling procedure was employed to select 300 small-scale farmers. The Household Food Insecurity Access Scale revealed that out of the total sample size, 86.7% of the small-scale farmers were food insecure while 13.3% were food secure. The marginal results showed that the gender of household head and marital status had a positive influence on the adoption of ICT and access to credit among small-scale farmers. The age of the household head, educational level, and land size showed a negative influence on the adoption of ICT and access to credit among small-scale farmers. The results from the two-step generalized linear square model showed that seed cane and transportation costs had a positive and significant contribution to the household food insecurity situation of small-scale farmers. On the other hand, the age of the household head and low income had a negative and significant contribution to the food insecurity status. Seed cane and transportation costs decreased food security among small-scale farmers. It is recommended that small-scale farmers are assisted on how to check the quality, and maturity of seed cane before planting. Researchers need to provide small-scale farmers with laboratory measures that will help farmers determine the quality of seed cane before production. Small-scale farmers need to be encouraged to use middlemen when it comes to the transportation of their produce. Middlemen will help farmers to transport their produce from the farm to end users at a certain price and that will help to decrease transportation costs.

Keywords: Small-scale farmers, food security, access to credit, ICT adoption, two-step generalized linear square mode

5.1 Introduction

Sugarcane holds a prominent position among cash crops in South Africa, contributing significantly to the country's agricultural and socio-economic development. The sugar industry plays a vital role in poverty reduction, employment generation, income enhancement, and the enhancement of food and nutrition security. Initially, small-scale farmers ventured into sugarcane production with hopes of attaining substantial returns to enhance their food security status. However, enticed by the perceived profitability of sugarcane farming, many small-scale farmers transitioned from their traditional cash and food crop enterprises to solely focusing on sugarcane production. Consequently, these farmers allocated the majority of their land to sugarcane cultivation, practicing monoculture as their primary farming method, which led to a notable decline in food crop production. While sugarcane production was expected to provide sufficient income for small-scale farmers to purchase food, the reality of monoculture farming has resulted in inadequate earnings over time, exacerbating food insecurity among these farmers. Moreover, the extended maturity period of sugarcane plants in South Africa, spanning between 18 to 24 months, further compounds the food insecurity situation, as households must wait for an extended period before their primary source of income materializes. To enhance household food security among small-scale sugarcane farmers, it becomes imperative for them to explore diverse income streams. This approach aims to mitigate reliance on a singular source of income, thereby contributing to a more resilient household economy. Household food security, as defined by FAO (2011), entails ensuring consistent access to sufficient food for sustaining a healthy and active lifestyle. This involves not only the availability of nutritionally adequate and safe foods but also a reliable capability to obtain acceptable foods through legitimate means, eliminating the need for emergency food supplies, scavenging, stealing, or other coping mechanisms (Babu *et al.*, 2014). In this context, both the availability and the ability to acquire food emerge as fundamental components crucial to achieving and maintaining household food security (Babu *et al.,* 2014). At the national level, South Africa is recognized for its overall food availability and the capacity to acquire food. However, when examining individual households, a substantial percentage (30–60%) of rural households faces food insecurity, as reported by Statistics South Africa (Stats SA) in 2021. Specifically, in 2020, approximately 9.34 million households, constituting 16% of the population, experienced severe food security challenges (United Nations Development Programme (UNDP), 2021). The prevalence of hunger was notable, with 20.6% of households encountering this issue in the same year (Stats SA, 2021). Household food security is intricately linked to income, given that a significant number of households depend on purchasing their food. Nevertheless, a

considerable 55.5% of South African residents live below the poverty line, with children, women, and the elderly comprising most of this demographic (Stats SA, 2019).

The household's ability to acquire food is influenced by all resources (tangible and intangible) available to a household. These resources serve as means for acquiring food through various means, including production, exchange, or transfer. A greater abundance of resources correlates with improved access to food. Furthermore, small-scale farmers find it necessary to explore alternative means for financing their production, with a key aspect being access to credit. The access to credit plays a pivotal role in enhancing agricultural production and alleviating poverty in rural areas of developing and emerging countries (Ma et al., 2023). Credit serves to enhance liquidity, enabling farm households to procure inputs that boost productivity, such as improved seeds, fertilizers, and pesticides. It also facilitates investments in both on-farm and off-farm enterprises (Ejemeyovwi *et al*., 2021; Osabohien *et al*., 2022). Additionally, credit contributes to the smoothing of household consumption patterns (Kumar et al., 2020), aiding in managing short-term non-delinquent expenses like sickness prevention and treatment and children's education (Kandulu *et al*., 2019). Beyond these benefits, access to credit has the potential to empower rural women by enabling them to acquire productive assets.

In spite of the critical significance of credit access, rural households often encounter challenges in obtaining credit or securing the required amount, primarily due to diverse constraints. These obstacles encompass the absence of credit markets and services, limitations in regional financial institution structures, insufficient collateral, and the existence of information asymmetry (Benami and Carter, 2021; Kehinde and Ogundeji, 2022). Information asymmetry, in particular, stands out as a substantial hindrance. Adopting information and communication technologies (ICTs), such as computers and mobile phones, emerges as a viable solution to mitigate information asymmetry in the contemporary digital era. ICT-based analytical tools can aid both borrowers and lenders in understanding market risks, thereby enhancing their efficiency and effectiveness in addressing potential information asymmetry and moral hazards (Asongu et al., 2019). Numerous studies have indicated that the adoption of ICT contributes to improved economic performance in farming (Ogutu *et al*., 2014), enhanced income for rural households (Leng *et al*., 2020; Ma et al., 2020), and the facilitation of rural development (Niebel, 2018; Spielman *et al.*, 2021). Consequently, it becomes crucial for farmers to make informed decisions regarding both ICT adoption and credit access simultaneously to optimize anticipated household welfare and food security. However, there is a dearth of previous studies exploring the joint impacts of ICT adoption and credit access on household food security.

Numerous studies (Kuwornu *et al.,* 2012; Saqibe *et al.,* 2016; Chandio *et al*., 2016; Chandio *et al.,* 2021) have explored the impact of credit accessibility on agricultural production, while others have focused into the role of information accessibility in farmers' production (Shanthy, 2011; Siyao, 2012; Saleni *et al.,* 2021). Some studies have concentrated on the food security of small-scale sugarcane farmers (Muthoni Thuo, 2011; Peter, 2011; *Bahati et al.,* 2022). Nevertheless, there is a scarcity of empirical investigations examining the combined influence of ICT and credit accessibility on the food security of small-scale sugarcane farmers. Given this research gap, this study aims to (i) identify the factors influencing credit access and ICT adoption and (ii) quantify the impact of ICT and credit accessibility determinants on the food security of small-scale sugarcane farmers in the in Ndwedwe local municipality in Ilembe of KwaZulu Natal province, South Africa.

5.2 Analytical framework

After data collection, data was cleaned, recorded, and analyzed using the Statistical Package for the Social Sciences (SPSS) Version. Descriptive statistics, such as means, standard deviations, frequencies, and percentages, was used to describe the socio-demographic characteristics of the sampled respondents. The food security assessment tool used to measure small-scale sugarcane farmers' food security status is the Household Food Insecurity Access Scale (HFIAS). The HFIAS was used to estimate the "access component of household food insecurity" by utilizing the data collected in four weeks (Coates et al.2007). According to Coates *et al*. (2007) this tool consists of nine questions that is about food access. The HFIAS score shows the level food security or insecurity occurrence among households in a period of a month before data collection. When computing the HIFAS score certain codes were used for each item that specify the frequency of occurrence for that household. The HFIAS score is between 0 and 27. A household with a high score may be facing food insecurity while, a household with a lower-than-average score may be considered food secure (ScottShaw and Escott, 2011).

The two-step generalised linear square model with control function as used by previous studies (Joher, *et al.,* 2006; Fatma and Chichti,2011) was used to assess the combined effect of ICT adoption and access to credit on household food security in terms of HFIAS. A simultaneous equations approach is deemed to be appropriate based on the interrelationships among the adoption of ICT and access to credit. This study uses a two-equation model with ICT adoption and access to credit as the dependent variables. The independent variable is the HFIAS. The

substitutability arguments suggest that adoption of ICT lead to more access to credit which have a positive effect on household food security. The model estimates parameters of the system when equations are exactly-identified or over – identified (Fatma and Chichti, 2011). The two-equation model is the improved version of single equation models employed in some recent studies that examine two depended on variables (Joher, *et al.,* 2006). For instance, the estimated coefficients are always larger in the ordinary least squares (OLS) model compared to the two-equation models. This supports the hypothesis that OLS estimates of coefficients have a positive bias in simultaneous equation models (simultaneity bias). Contrarily, two-equation estimated coefficients tend to have downward bias. In a system comprising of independent endogenous variables, the two-equation method is preferred over the ordinary least squares (OLS) method as the latter would lead to biased and inconsistent parameter estimates (Joher, *et al*., 2006).

The system of two simultaneous equations can be written as follows:

$$Y = Z\delta + \qquad (1)$$

As,

$$Y = \begin{pmatrix} Y_1 \\ Y_2 \end{pmatrix} = \begin{pmatrix} Z_1 & O & O \\ 0 & Z_2 & O \end{pmatrix} \begin{pmatrix} \delta_1 \\ \delta_2 \end{pmatrix} + \begin{pmatrix} 1 \\ 2 \end{pmatrix} \qquad (2)$$

As:

$Y' = (Y^1, Y_2)$ is vector of endogenous variables. δ represent the vector of coefficients of all explanatory variables and is an error term.

The specification of the simultaneous equations system is given as below with Vectors of the explanatory endogenous and exogenous variables of the equation of ICT adoption and access to credit:

$ICT\ ADT = \alpha_0 + \alpha_1$Age + $\alpha_2 Marital\ status + \alpha_3$Education + α_4 Employment status + α_5Gender + α_6Non-farm income + $\alpha_7$extension support + $\alpha_8$land tenure and size +U (3)

$Acce\ Credit = \beta_0 + \beta_1$Age + $\beta_2 Marital\ status + \beta_3$Education + β_4 Employment status + β_5Gender + β_6Non-farm income + $\beta_7$extension suppor + $\beta_8$land tenure and size + v

Table 5.1: The Explanatory Variable That Affect Adoption of ICT and Access to Credit among Small-scale sugarcane Farmers.

Variables names	Variable type and measurement
Age of the household head	Participant's age in years
Gender of household head	If the respondent is male, 1; otherwise, 0.
Marital status	If the participant is married, 1 is assigned; otherwise, 0 is assigned.
Education	Years of education (continuous)
Employment status	If the respondent is employed, 1; otherwise, 0.
Nonfarm income	If there is a person who works for income, 1; otherwise, 0.
Extension Support	If the participant had access to extension support, the answer was 1, otherwise it was 0.
Government support	If the participant had access to government support, the answer was 1, otherwise it was 0.
Seed cane Age	Seed cane age (continuously)
Land tenure system	If the participant had access to land tenure, the answer was 1, otherwise it was 0.
Land size	Farm or land size in hectors

5.3 The study area, sampling, and data collection technique

The study area, sampling, and data collection technique are the same as in chapter three.

5.4 Results and discussion

5.4.1 Demographic results

Table 5.2 represent various socio-demographic factors that affected the adoption of ICT and access to credit by small-scale farmers. The descriptive results showed that about 77% of small-scale farmers had access to credit while 23% did not have access to credit. This means that more farmers were able to use the resources they owned as collateral to acquire loans (Chandio *et al*., 2016). The results also revealed that more than 80% of the farmers adopted ICT while 20% did not. This means that most of the farmers were able to adopt information that helped them to boost their production. The current study was dominated by female farmers who amounted to 66% in total, while male farmers were only 34% in total. This is not surprising as small-scale agriculture is mainly dominated by females who provide labour and are mainly involved in the production side (Hlatshwayo *et al*., 2022). Regarding marital status, the results

showed that most (34%) of the farmers were married followed by 25% of farmers who were widowed. Only 6% of the farmers were divorced.

Table 5.2: Socio-Demographic Factors of Small-scale Sugarcane Farmers in Ndwedwe Local Municipality

Variable	Percentage (%)
Access to credit	
Yes	77
No	23
Adoption of ICT	
Yes	80
No	20
Gender	
Male	34
Female	66
Marital status	
Single	21
Married	34
Widowed	25
Divorced	6
Living with partner	14
Educational status	
No formal education	27
Primary school level	37
Secondary level	22
Tertiary level	14
Employment status	

Unemployed	57
Employed temporal	33
Employed permanent	10
Non-farm income	
Salaries	2
Old age pension	41
Disability grant	4
Child support grant	28
Foster care	12
Business	13

Higher percentage 37%) of the farmers had primary education while only 14% has tertiary education. This implies that most of the farmers had grade R to grade 7. About 27% of the farmers had no formal education, meaning that they were using their traditional and indigenous knowledge in production. The results showed high rate (57%) of employment percentage among small-scale farmers. This shows that most of the small-scale farmers were unemployed, and they depended more on the production of sugarcane as source of income. When it comes

to non-farm source of income, more than 41% of the small-scale farmers depended on old pension grant as a main source of income. These results are consistent with many previous studies who reported that most of the small-scale farmers depend on old pension grant as source of income and end up neglecting farming (Sinyolo *et al*., 2016; Sinyolo *et al.,* 2017; Hlatshwayo *et al*., 2022).

5.4.2 Occurrence of Food Insecurity by Household Characteristics Based on HFIAS Categories

The Household Food Insecurity Access Scale was used to determine food access 3w3eeeeeamong sugarcane small-scale farmers, the results revealed that among the total sample size 86.7% of the small-scale farmers were food insecure, and only 13.3% were food secure, suggesting that most of the small-scale farmers were facing difficulties to access adequate food. In terms of the HFIAS categories, the results showed that majority of small-scale farmers were moderately food insecure with 44.7%. Followed by 28.7% of farmers who were mildly food insecure. About 13.3% of sugarcane small-scale farmers were either food secure or severely food insecure. This shows that there is serious problem when it comes to accessing nutritious food in the study area. This is line with Ngidi *et al*. (2023) who found that about 10% of households experienced severe food insecurity in rural areas of Mpumalanga and Limpopo province, South Africa.

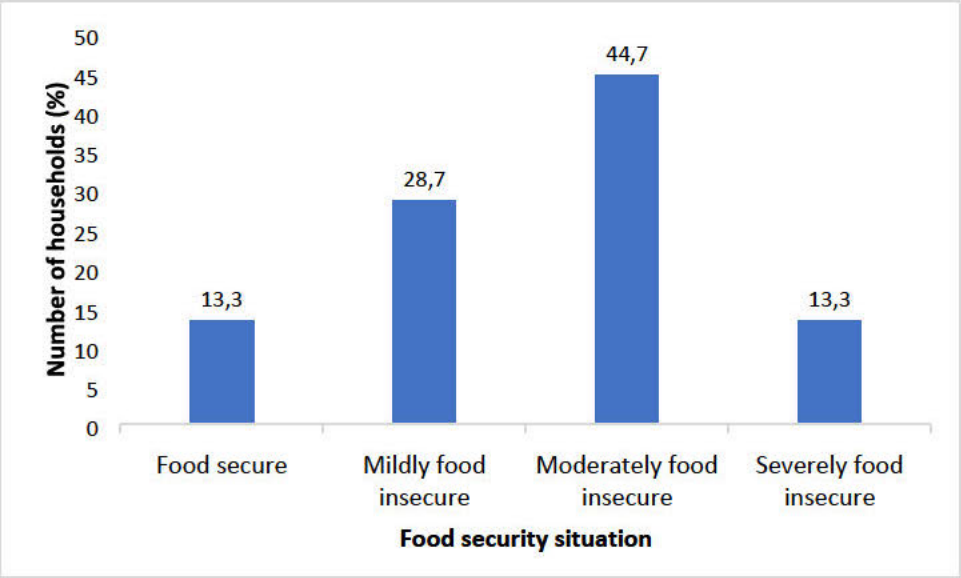

Figure 5.1: The Food Insecurity situation of Small-scale sugarcane farmers in Ndwendwe Local Municipality

5.4.3 Determinants of ICT and access to credit among small-scale sugarcane farmers

The results in Table 5.3 display various factors that affected small-scale sugarcane farmers' adoption of ICT and access to credit in Ndwedwe Municipality. The marginal analysis results showed that age of household head had a negative, statistically significant ($p < 0.001$) relationship with adoption of ICT and access to credit among small-scale farmers. The model predicts that a 1% increase in age is associated with decrease ICT adoption and access to credit. This means that as age of small-scale farmers increases the adoption of ICT and access to credit decreases. As small-scale farmers get older, they lack necessary skills and resources to adopt ICT and be able access formal credit. The results are contrary with Njogu *et al.* (2017) who found that as age of participants' increases, it increased the likelihood of farmers to use mobile banking technology to access credit. Kinyangi (2014) also found that age had positive and significant influence on the adoption of technology. The authors explained that as farmers get old, they use their investments and resources they have, to adopt technology that will help them to secure formal credit.

Table 5.3: Factors Influencing ICT Adoption and Access to Credit among Small-scale sugarcane farmers

	Probit			Marginal effect		
Variables	Coef.	St.Err.	p-value	dy/dx	St.Err.	p-value
Age	-0.045	0.009	0.000***	-0.013	0.003	0.000***
Gender	0.884	0.206	0.000***	0.252	0.056	0.000***
Marital status	0.288	0.085	0.001***	0.082	0.024	0.001***
Education	-0.543	0.110	0.000***	-0.155	0.030	0.000***
Employment status	-0.026	0.147	0.861	-0.007	0.042	0.861
Nonfarm income	-0.129	0.084	0.125	-0.037	0.024	0.123

Extension Support	0.147	0.164	0.370		0.047	0.370
				0.042		
Government support	0.161	0.112	0.151		0.032	0.150
				0.046		
Seed cane age	0.060	0.095	0.529		0.027	0.527
				0.017		
Land tenure system	0.189	0.240	0.430		0.068	0.428
				0.054		
Land size	-0.199	0.070	0.005***		0.020	0.004***
				0.057		
Constant	1.902	0.956	0.047**			
Mean dependent var	0.733	SD dependent var	0.443			
Pseudo r-squared	0.214	Number of obs	300..000			
Chi-square	74.622	Prob > chi2	0.000			
Akaike crit. (AIC)	297.327	Bayesian crit. (BIC)	341.772			

Notes: The dependent variable is the adoption of ICT and access to credit; ***, **, * Indicate significance at 1%, 5%, and 10% level, respectively.

The gender of the household head had a positive and significant at 1% significant level influence on the adoption of ICT and access to credit among small-scale farmers. The model predicts that a 1% increase in the marital status will increase ICT adoption and access to credit by 0.884 per cent. This means that women were also able to adopt ICT and be able to access credit. However, these results were opposed by Owusu *et al.* (2018) and Makate *et al.* (2019). Owusu *et al.* (2018) reported that most of the female farmers in rural areas of Ghana have limited or no knowledge of the adoption of ICT. Makate *et al.* (2019) found adoption of technology and access to credit was less pronounced in women farmer groups compared to their male farmer group counterparts. The authors stated that female farmers are often left out in different key policies and programs in agriculture which affects their ability to participate in many activities. The marginal results showed that the marital status of the household head showed a positive and statistically significant at 5% significant level and . associated with the adoption of ICT and access to credit among small-scale farmers. The model predicts that a 1% increase in the marital status will increase ICT adoption and access to credit by 0.288 per cent.

This means married couples were able to combine the skills, capital, and information they have, to be able to adopt ICT and access credit. The result is similar to that of Ololade and Olagunju (2013) who found that not being married reduced the likelihood of having access to credit. The authors explained that married people have more power to source necessary information and tools that will help them to acquire formal credit. On contrary, Kari (2021) found that single women adopted more of ICT than married women. The authors clarified that being married mainly affect decision making and responsibilities which affect their daily life.

High educational level is expected to increase the chances of farmers to adopt more ICT and be able to access credit. However, the results from this current study showed a negative and significant at 1% significant level with relationship between educational level of household head and ICT adoption and access to credit among small-scale sugarcane farmers. The model predicts that a 1% increase in education level associated with decrease ICT adoption and access to credit by per -0.543 cent. his means that farmers who were educated were not adopting ICT to access credit. The possible explanation is that educated farmers have different source of income, so they can finance their own production and they adopt ICT for other commitments. Ullah *et al*. (2020) contested the current results, they found that household head's education was significantly and positively associated with farmers' access to agricultural credits. The study explained that household head's level of education is an indicator of literacy and affects farmer awareness and understanding of credit sources.

Land size is significantly at 5% significant level and negatively associated with farmers' access to credit and adoption of ICT. The model predicts that a 1% increase in landsize should decrease ICT adoption and access to credit by -0.199 per cent.This means that as land size increases the probability of farmers' adoption of ICT and access credit decreases. This result is contradicting many previous studies (Nouman *et al*., 2013; Rasheed *et al*., 2016; Chandio *et al.*, 2017; Ullah *et al*., 2020) that found a significant positive effect of farm size on farmers' adoption to ICT and access to credit. These studies stated that land size is considered a symbol of social status, therefore, farmers with large farm sizes are more likely to have access to agricultural credits. However, Saqib *et al*. (2018) raised an important point that the key reason for the lack of access to formal credit sources among small-scale farmers is the high collateral requirements in the form of land and rarely available personal guarantees.

5.4.4 Combined effect of ICT and credit access on household food security_ two-step generalized linear square model with control function.

The study utilized the two-step generalized linear square model with control function to examine the impact of ICT adoption and access to credit on the food security of small-scale farmers, measured in terms of HFIAS. Table 5.4 displays the results of this model, depicting the severity of food insecurity among small-scale farmers who adopted ICT and had access to credit. Since the HFIAS variable rises with increased food insecurity severity, positive coefficients suggest a likelihood of more severe food insecurities, whereas negative coefficients suggest the opposite. Among the factors examined, the age of small-scale farmers who adopted ICT and had access to credit emerged as statistically significant at a 5% level, with a negative coefficient. This indicates that as the age of small-scale farmers increases, they experience less food insecurity (Table 2). This finding is inconsistent with the observations of Hlatshwayo *et al.* (2021), who noted that older farmers often make better farming decisions due to their accumulated experience, often investing retirement funds into farming ventures. Mango *et al.* (2014) also suggested that a farmer's age serves as a proxy for farming experience, with older farmers typically possessing greater knowledge of food security issues. Moreover, research by Mitiku *et al*. (2012) affirmed that as farmers' aged they accumulate more farming experience, become more risk-averse, and tend to diversify their production methods.

Table 5.4: The Effect of ICT and Credit Access on Household Food Security of small-scale sugarcane farmers.

Variables	Coefficient	Std.	P-value
HFIAS			
Age	-0.072	0.029	0.014**
Marital status	0.395	0.294	0.180
Educational level	-0.521	0.371	0.159
Employment status	0.829	0.525	0.114
Nonfarm income	-0.114	0.287	0.691
Smart precise Plant Nutrition	-1.568	0.833	0.673
Smart Crop rotation	-0.876	1.297	0.500
Smart CA farming	-0.856	1.102	0.437
Seed cane Age	0.975	0.329	0.003***
Low income	-4.887	0.803	0.000***
Transport costs	0.000	0.000	0.077*
_cons	11.359	2.675	0.000***
lnsigma2			

Resid_ICT_Credt	1.236	0.594	0.037
_cons	2.539	0.454	0.000
Wald chi2(11)	141.18		
Prob > chi2	0.0000		
Prob > chi2 0.0373			

Notes: The dependent variable is HFIAS***, **, * Indicate significance at 1%, 5%, and 10% levels, respectively.

Seed cane age had a statistically significant at 5% level positively related with household food insecurity of small-scale sugarcane farmers who adopted ICT and had access to credit, that is, as seed cane age increases at 5%, based on model predictions , small-scale farmers experience increases of food insecurity at 0.975. Ayele *et al.* (2014) stated that seed cane age affects the early growth performance of sugarcane plants. The authors found that seed cane ages of six to eight months showed superior growth when compared to seed cane ages of nine to ten months. Similarly, Yeshimebet *et al*. (2009); Mengistu (2013) submitted that, age of seed cane significantly affected the rate of sprouting, tiller, and stalk population which then affected the sugarcane yield. This means that an increase in the age of seed cane negatively affects the yield of sugarcane plants which consequently affects the food security of farmers that depend on sugarcane production.

Generally, it is expected that higher-income households are more likely to be food secure. Surprisingly, low income was significant at 1% level and negatively associated with the HFIAS of small-scale farmers, meaning household heads with low income were food secure. The plausible explanation might be that small-scale farmers who received low income from other engagements were also involved in sugarcane production to make extra income and improve their source of living. In contrast to these results, Taruvinga *et al*. (2013) reported a positive relationship between high income and food security statuses of households. It can be concluded that income leads to high demand for various foods that lead to food security. Gebre 2012) also found that households who are receiving more income had an improved food security status. These studies concluded that high income leads to high demand for several nutritious food groups that lead to improved food security.

The results showed that transportation costs had a significant level of 10% with positive association with the HFIAS of sugarcane small-scale farmers. The model predicts that a 10% increase in transport costs should increase food insecurity by 1%. This means that as transportation costs increased, farmers were experiencing food insecurity. Prasara-A and

Gheewala (2016) found that high transportation costs had a significant impact on sugarcane production. The study explained that the average distance between the farm and the selling point is relatively high which increases the transportation costs. Odhiambo (2017) also found that the distance from the farm to the sugar mill significantly affects the production costs. It can be said that transportation costs are part of the cost of the inputs that affect the production of sugarcane, their increase leads to more expenses and less profit which results in food insecurity.

5.5 Conclusion and recommendations

The access to credit and adoption of ICT does not only serve as an alternative means for financing the production of small-scale farmers also help in enhancing agricultural production which in turn improve households' food security. Despite the important role that credit and adoption of ICT play, rural households often encounter challenges in obtaining and securing credit due to diverse constraints. The aim of this study was to assess impact that determinants of ICT and credit accessibility have on the food security of small-scale sugarcane farmers. Age of small-scale and low income improved food security while seed cane and transportation costs decreased food security. It is recommended that small-scale farmers are assisted on how to check quality, maturity of seed cane before planting. Researchers need to provide small-scale farmers with laboratory measures that will help farmers to determine quality of seed cane before production. Small-scale farmers need to be encouraged to use middlemen when it comes to transportation of their produce. Middlemen will help farmers to transport their produce from the farm to end users at a certain price and that will help to decrease transportation costs.

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CHAPTER 6

The efficiency among small-scale sugarcane farmers in South Africa: A Zero Efficiency Stochastic Frontier approach

ABSTRACT

Efficiency of small-scale sugarcane farmers plays a pivotal role in shaping both economic prosperity and sustainable development. It is important to understand the factors influencing efficiency among small-scale sugarcane farmers as they remain a complex and multifaceted challenge. This study sought to assess efficiency among small-scale sugarcane farmers in South Africa using the Zero efficiency stochastic frontier approach. A multistage sampling procedure was employed to select 300 small-scale farmers. The results show that farmers received high efficiency (40%) at 0.71-0.90 efficiency scores while they received low efficiency (15%) at 0.51-0.70 efficiency score. The Zero inefficiency Stochastic Frontier results showed that age, gender, household size and seed cane age had a positive and significant influence on farmers' efficiency. On the other hand, education and nonfarm income had a negative and significant influence on farmers' efficiency. It can be concluded that age, gender, household size and seed cage age improved efficiency while education and non-farm income resulted to inefficiency. It is recommended that farmers who are educated are encouraged to use their education skills in order to advice on cost efficient inputs and output. Also, farmers need to be encouraged to use their non-farm income in farm production to produce more and generate income.

Key words: Efficiency, sugarcane, small-scale farmers, Zero-efficiency stochastic frontier approach

6.1. Introduction

Enhancing agricultural productivity is recognized as a key solution for advancing food security, diminishing poverty, and fostering economic growth in developing countries (Julien, Bravo-Ureta, and Rada, 2019). Over recent decades, agrarian policies in many developing countries have emphasized the promotion of agricultural technologies and efficient utilisation of limited resources to attain sustainable farm yields (Ali and Deininger, 2015). Typically, agricultural production across developing countries is largely dominated by small-scale farming (Julien *et al.,* 2019). In particular, South Africa, which is the most densely populated country in Africa, has an average landholding of only about 0.5-2 hectares per household (Food and Agriculture

Organization (FAO),2015). Additionally, smallholder farming in South Africa tends to be non-capital-intensive, as most operators do not employ farm machinery in their agricultural activities, resulting in low crop productivity Yusuf and Popoola, 2022.). Most of these small-scale farmers are involved in sugarcane production.

In the dynamic landscape of South Africa's agricultural sector, the efficiency of small-scale sugarcane farmers plays a pivotal role in shaping both economic prosperity and sustainable development (Martiniello and Azambuja, 2019). As a critical component of the nation's agro-industrial complex, the sugarcane industry stands as a significant contributor to the country's GDP and employment (Solomon, 2016). Efficiency helps in the economic planning of an industry by providing insight into the potential increase in output without requiring additional resources (Geng *et al*., 2010). However, understanding the factors influencing efficiency among small-scale sugarcane farmers remains a complex and multifaceted challenge. This study research into the field of agricultural efficiency, specifically focusing on small-scale sugarcane farmers in South Africa.

Against the backdrop of fluctuating global markets, climate change, and evolving agricultural policies, investigating the efficiency of small-scale sugarcane farmers becomes imperative for ensuring not only the economic viability of these enterprises but also the broader sustainability of the agricultural sector (Mnisi, 2019). By adopting a zero-efficiency perspective, this research seeks to go beyond conventional efficiency analyses and shed light on the factors that contribute to the complete absence of productivity in certain instances, offering a more refined and realistic portrayal of the challenges faced by small-scale farmers.

Zero-efficiency stochastic frontier approach is used to unpack the intricate web of variables that impact the efficiency levels within the production sector (Guha and Das, 2020). The stochastic frontier framework helps to distinguish between observed inefficiency and inherent randomness, providing a comprehensive understanding of the efficiency dynamics unique to small-scale sugarcane farming operations. By identifying and understanding the determinants of efficiency and inefficiency, the study aims to contribute to the development of targeted interventions and strategies that can enhance the resilience and competitiveness of small-scale sugarcane farming in South Africa. There are limited studies that have been conducted on small-scale sugarcane efficiency especially in South Africa. Ngombe and Kalinda (2015); Abdulai and Abdulai (2016) assessed efficiency among maize farmers in Zambia; Ngango and Hong, 2022 assessed the technical efficiency among maize farmers in Rwanda; Maurice *et al*., (2015) analyzed the cost efficiency in food crop production among small-scale farmers in

Nigeria. These studies were conducted in other part of Africa not in South Africa and they focused more on maize efficiency than sugarcane efficiency. It is therefore the aim of this study to assess efficiency among small-scale sugarcane farmers in South Africa using the Zero-efficiency stochastic frontier approach.

6.2 Analytical framework

Following the collection of data, the information underwent a process of cleaning, recording, and analysis through the utilization of the Statistical Package for the Social Sciences (SPSS) Version. Descriptive statistical measures, including means, standard deviations, frequencies, and percentages, were employed to depict the socio-demographic attributes of the respondents included in the sample. Following Kumbhakar et al. (2013); (Abdulai and Abdulai, 2016), the Zero inefficiency Stochastic Frontier (ZISF) production model was employed to estimate the firm-level cost efficiency of the farmers in the study area. The ZISF model is specified as follows:

$$ZISF \rightarrow Y_i = x'_i\beta + V_i \; with\; probability\; P, \quad _i = x'_i\beta + (V_i - \upsilon_i) \; with\; probability\; (1-p)$$

where Y_i represents the output of the farm i, x_i is a vector of inputs, β is a vector of unknown parameters to be estimated, p is the probability of a farm being fully efficient, and $(1-p)$ is the probability of a farm being inefficient. The composed error term in the ZISF model is given by $V_i - \upsilon_i[1 - 1(ui = 0)]$, where $p = 1(ui = 0)$.

kThe density function of the convoluted error term of the ZISF model is defined as

$$f(\ /x) = \frac{p}{\sigma_u} g\frac{}{\sigma_u} + (1-p)\left[\frac{2}{\sigma} g\left(\frac{}{\sigma}\right)\ G\left(-3\frac{\lambda}{\sigma}\right)\right]$$

where g and G are the normal probability density and normal cumulative distribution functions, respectively, $\sigma^2 = \sigma^2{}_u, and\ \lambda = (\sigma_u/\sigma\upsilon)$.

Regarding the estimation of inefficiency function in the ZISF model, we adopt the approach of Jondrow, Lovell, Materov, and Schmidt (1982) which postulates that the conditional density function of the inefficiency u given is zero with probability p and the truncated normal, N $+(\mu*, \sigma* 2)$ with

probability $1 - p$. This function is expressed as:

$$f(\mu/\ ) = \frac{g[(\upsilon - \upsilon,)/\sigma_*]}{\sigma_* G(-\varepsilon\lambda/\sigma)}$$

where $\mu * = -\varepsilon\sigma_u{}^2/\sigma^2$ and $\sigma_*{}^2 = \sigma_u{}^2\sigma\upsilon^2/\sigma_u{}^2$. From the above specification in Equation (6), the conditional mean estimator for inefficiency in the ZISF model is given by:

$$E(\mu/\ ) = (1-p)\frac{\sigma\lambda}{1+\lambda^2}\left[\frac{g(-\varepsilon\lambda/\sigma)}{G(-\varepsilon\lambda/\sigma)} - \frac{\varepsilon\lambda}{\sigma}\right]$$

Here, the measurement procedure entails the replacement of the unknown parameters by their maximum likelihood (ML) estimates and the error term should be replaced by its residuals$_i$. Besides, inefficiency in the ZISF model can be estimated by constructing the posterior estimates of inefficiency, expressed as

$$\tilde{u}_i = (1 - \acute{P}_i)\tilde{u}_i$$

where $p\check{\imath}$ denotes the posterior estimate of probability of full efficiency, written as

$$\acute{P}_i = \frac{\left(\acute{P}_i|\delta v\right)g(\acute{\varepsilon}_i|\delta v)}{\left(\acute{P}_i|\delta v\right)g(\acute{\varepsilon}_i|\delta v) + \left(1-\acute{P}_i\right)\left(\frac{2}{\delta}\right)g(\acute{\varepsilon}_i|\delta)G(\acute{\varepsilon}_i|\delta_0)}$$

These posterior estimates of inefficiency are influenced by farm and household characteristics.

To test for the zero inefficiency, we use the pseudo-likelihood ratio (PLR) test. The PLR test is represented as $PLR = -2(LN - LZI)$, where LN denotes the log-likelihood of the normal linear model estimated using OLS and LZI denotes the log-likelihood of the ZISF model. As noted by Kumbhakar *et al*. (2013), the PLR test has an asymptotic distribution that constitutes a 50:50 mixture of inefficient x^2_0 and fully efficient X^2_1 distributions. In testing for zero inefficiency, the rejection of the null hypothesis of full efficiency (i.e., $H0$: $p = 1$), indicates the presence efficiency in the ZISF model (Abdulai and Abdulai, 2016).

Stochastic cost frontier model

The traditional stochastic cost frontier model for farmer i is specified as

$$C_i = x_i'\beta + (v_i - u_i)\ for\ i = 1, \ldots\ldots, n$$

where C_i denotes a scalar of total cost of production, x_i is a $k \times 1$ vector of covariates of factor prices

and level of output, $\beta\ is\ k \times 1$ vector of parameters to be estimated, vi is the random term (white noise) assumed as $v_i \sim e\ i{:}\ i{:}\ d{:}\ N^{+}(0;\ \sigma^2{}_v)$, and ui is systematic error term accounting for inefficiency and assumed as $u_i \sim e\ i{:}\ i{:}\ d{:}\ N^{+}(0;\ \sigma^2{}_u)$, ; nonnegative half-normal (Aigner, Lovell, and Schmidt 1977). The non-negativity assumption of inefficiency ($ui \leq 0$) suggests that, both inefficient farms can be used ($ui > 0$Þ; and fully efficient farms ($ui = 0$). This phenomenon characterizes the farmers into regimes of fully efficient and inefficient farms, respectively. Following Kumbhakar, Parmeter, and Tsionas (2013), a ZISF model is formulated within the regime membership framework to account for both inefficient and fully efficient farms. The variables used in the analysis are presented in Table6.1.

Table 6.1: A Priori Expectations for The Explanatory Variables Used in The Models.

Independent Variable	Type of variable	Explanation	Hypothesis
Age	Continuous	In years	+/-
Gender	Categorical	1= Male 2= Female	+/-
Employment Status	Categorical	1=Unemployed 2= Temporary Employment 3= Permanent Employment	+/-
Fertiliser Costs	Continuous	In rands	+
Non-farm income	Categorical	1= Salaries and Wages 2= Old age pension 3= Child support grant 4= Foster care 5= Business	-
Access to credit	Categorical	1= Yes 2= No	+/-
Extension Support	Categorical	1= Yes 2= No	-
Smart Crop Rotation	Categorical	1= Yes 2= No	-
Fertiliser Time	Categorical	1=Yes 2= No	+/-
Land Tenure System	Categorical	1= Owned 2= PTO 3= Rented/ Leased	+/-
Seed Cane Age	Categorical	1= 11 to 15 months 2= DNK	+/-

6.3 The study area, sampling, and data collection technique

The study area, sampling, and data collection technique are the same as in chapter three.
Results and discussion

6.4 Results

6.4.1. Demographic results

Table 6.1 represent various socio-demographic factors that affected the adoption of ICT and access to credit by small-scale farmers. The descriptive results showed that about 77% of small-scale farmers had access to credit while 23% did not have access to credit. This means that more farmers were able to use the resources they owned as collateral to acquire loans (Chandio *et al.,* 2016). The results also revealed that more than 80% of the farmers adopted ICT while 20% did not. This means that high number of the farmers were able to adopt information that helped them to boost their production. The current study was dominated by female farmers who amounted to 66% in total, while male farmers were only 34% in total. This is not surprising as smallholder agriculture is mainly dominated by females who provide labour and mainly involved in production side (Hlatshwayo *et al.,* 2022).

Regarding marital status, the results showed that most (34%) of the farmers were married followed by 25% of farmers who were widowed. Only 6% of the farmers were divorced.

Table 6.2: Socio-Demographic Factors of Small-scale Sugarcane Farmers in Ndwedwe Local Municipality

Variable	Percentage (%)
Access to credit	
Yes	77
No	23
Adoption of ICT	
Yes	80

No		20
Gender		20
Male	34	
Female		66
Marital status		
Single		21
Married		34
Widowed		25
Divorced		6
Living with partner		14
Educational status		
No formal education		27
Primary school level		37
Secondary level		22
Tertiary level		14
Employment status		
Unemployed		57
Employed temporal		33
Employed permanent		10
Non-farm income		
Salaries		2
Old age pension		41
Disability grant		4
Child support grant		28
Foster care		12

Higher percentage (37%) of the farmers had primary education while only 14% has tertiary education. This implies that most of the farmers had grade R to grade 7. About 27% of the farmers had no formal education, meaning that they were using their traditional and indigenous knowledge in production. The results showed high rate (57%) of employment percentage among small-scale farmers. This shows that most of the small-scale farmers were unemployed, and they depended more on the production of sugarcane as source of income. When it comes to non-farm source of income, more than 41% of the small-scale farmers depended on old pension grant as a main source of income. These results are consistent with many previous studies who reported that most of the small-scale farmers depend on old pension grant as source of income and end up neglecting farming (Sinyolo *et al.*, 2016; Sinyolo *et al*., 2017).

6.4.2. Empirical results

Table 6.3 presents the coefficients and standard errors derived from the inefficiency model within the context of the ZISF model. The first-order terms associated with output and factor prices within the cost frontier of the ZISF model exhibit anticipated positive signs, except for the logarithm of herbicide costs. This suggests a linear association between the overall production cost and the variables of output and factor prices (Abdulai and Abdulai, 2016). As the total cost and its regressors are in logarithms and normalized by a single factor price, the first-order term coefficients within the cost frontier model can be interpreted as cost elasticities assessed at the sample mean, following the approach outlined by Farsi, Filippini *et al*. (2005). To illustrate, the coefficient associated with land price implies that an increase in the annual land rent will lead to an increase in the overall cost of sugarcane production. Furthermore, the factor price elasticity estimates derived from the ZISF model affirm the assumption that the cost function is homogeneous of degree one and that the factor prices minimizing cost is non-decreasing. To discuss the inefficiency variables, positive ZISF coefficient indicates a positive impact on full efficiency and vice versa. To keep it concise, only variables that demonstrate statistical significance at standard levels will be discussed.

Table 6.3: Zero Inefficiency Stochastic Frontier Model Expectation-Maximization Algorithm with Control Function

Variables	Coefficient	Std. err.	P>z
Cost factors			
Log of Land	0.002	0.001	0.090*
Log of Quantity of fertilizer	0.005	0.002	0.005**
Log of cost of Agrochemical	0.000	0.002	0.890
Log of cost of herbicides	-0.003	0.001	0.031**
Residual ICT _Credit	0.556	0.002	0.000***
Constant	0.491	0.008	0.000***
Inefficiency effects			
Age	0.001	0.000	0.000***
Gender	0.017	0.001	0.000***
Marital status	-0.010	0.000	0.000***
Education	-0.026	0.157	0.000***
Employment status	0.020	0.000	0.569
Nonfarm income	-0.032	0.000	0.000***
Household size	0.099	0.002	0.000***
Extension Support	-0.036	0.234	0.450
Seed cane Age	0.010	0.000	0.000***
Rho	0.989	0.010	0.000***
lnsigma_u	-2.654	0.214	0.000***
lnsigma_v	-6.102	0.039	0.000***
logist_probability	0.371	0.110	0.001***

Notes: ***, **, * Indicate significance at 1%, 5%, and 10% level, respectively.

The results showed that age of small-scale sugarcane farmers had a positive and statistical significant 1% level associated with the ZISF, indicating that an increase in the age of farmers reduce inefficiency. This means that as farmers get older, they allocate their resources professionally and avoid unnecessary costs. The findings were consistent with the results of Zalkuwi *et al*. (2010) for Nigeria. The authors found that as the age increases the cost inefficiency of the farmers' decreases. The authors explained that this is because farmers' age affects the production efficiency since farmers in different ages have different farm sizes. Zhang et al. (2019) also reported that older household heads with higher educational levels tend to have lower technical inefficiency cost.

Gender of sugarcane small-scale farmers was positive and statistically significant at 1%, associated with the ZISF, indicating that an increase in the gender of farmers reduce

inefficiency, suggesting that female farmers are relatively more efficient in sugarcane production. The results contradict Mango *et al.* (2015) who found that gender coefficient had a negative and significant impact on cost inefficiency in maize production. The authors reported that it implies that male farmers are relatively more efficient in maize production. The authors further explained that female farmers had relatively less access to productive resources which explains the imbalance in resource's access by gender.

The negative and statistically significant(1%) level relationship between marital status and efficiency in the ZISF model, suggests that farmers who are married were experiencing higher cost inefficiency. Kari (2021) supported this finding and reported that being married affect decision making and responsibilities of farmers which can increase their cost of living. On the other hand, Ng'ombe and Kalinda (2015) found that marital status increases the farm's efficiency, the authors explained that married households' heads advise each other on agricultural technologies and share valuable information.

Education of farmers showed a negative and significant at 1% level of association with the ZISF, indicating that higher levels of education increase inefficiency, decrease full efficiency . The possible explanation is that some people when they get educated, they demand lot of things and end up incurring lot of costs. These results contradict Ng'ombe and Kalinda (2015); Abdulai and Abdulai (2016) who found that higher levels of education reduce inefficiency and increase full efficiency. These studies reported that farmers who received tertiary education are more likely to be more technically efficient than other farmers. The reason might be that such farmers would more likely follow and apply the recommended principles at their farms and result in efficient resource use.

Non-farm income is statistically significant at 1% under the model distribution and had a negative coefficient. Its negative coefficient means that holding other factors constant, increase in non-farm income of a small-scale sugarcane farmers increases cost inefficiency. A plausible explanation is that small-scale sugarcane farmers that are involved in off farm income generating activities would allocate less time on farm practices but concentrate more on non-farm activities. This finding is consistent with the results by Chiona *et al*. (2014); Ng'ombe and Kalinda (2015). These studies found that off-farm income reduce efficiency, this is due to the less attention given to farm activities and increased participation in non-farm activities. Farmers who have various sources of income beside crop production are more likely to be

preoccupied with other income generating activities and hence pay less attention to important agronomical practices (Chiona *et al*., 2014).

The results showed that household size had a positive and significant association with the ZISF, indicating that an increase in the household size reduce inefficiency and increase efficiency. This is because an increase in household size increases labour and sharing of farm activities in small-scale farming which result to high production. However, this finding contradicts with several studies (Maurice *et al*., 2015; Abdulai and Abdulai 2016; Ngango and Hong, 2022) on inefficiency. These studies found that household size was not statistically significant at affecting technical inefficiency. They reported that this means that as the size of the smallholder farmers increases, it does not affect technical efficiency when holding other factors constant. Lastly, the findings revealed a positive and significant relationship between seed cane age and ZISF, meaning that as seed cane age increases increased efficiency. Mengistu (2013); Ayele *et al*. (2014) opposed this result by stating that seed cane age affects growth performance of sugarcane plant, sugarcane seeds at lower ages show a superior growth when compared to the older ones. Mengistu (2013) further explained that seed cane age affects the rate of sprouting, tiller and stalk population which negatively affect yield and efficiency.

Efficiency score for ZISF

The translog cost frontier estimates of the ZISF were used to estimate efficiency score. The density plots of efficiency cases are presented in Figure 2.The peakedness and tailedness of the ZISF plots suggest a relatively higher kurtosis. Balanda and MacGillivary (1988) cited by Abdulai and Abdulai (2016) highlighted that a rise in kurtosis is linked to the redistribution of probability mass from the distribution's shoulders to its center and tails.

This observation implies that the ZISF offers a more accurate prediction of score efficiency. The results show that farmers received high efficiency (40%) at 0.71-0.90 efficiency scores while they received low efficiency (15%) at 0.51-0.70 efficiency score. This means that were not at optimal operation. These findings were consistent with the results of Abdulai and Abdulai (2016) who found that farmers were not optimal in their scale of operations and that, a proportional increase in outputs led to a less than proportional increase in cost.

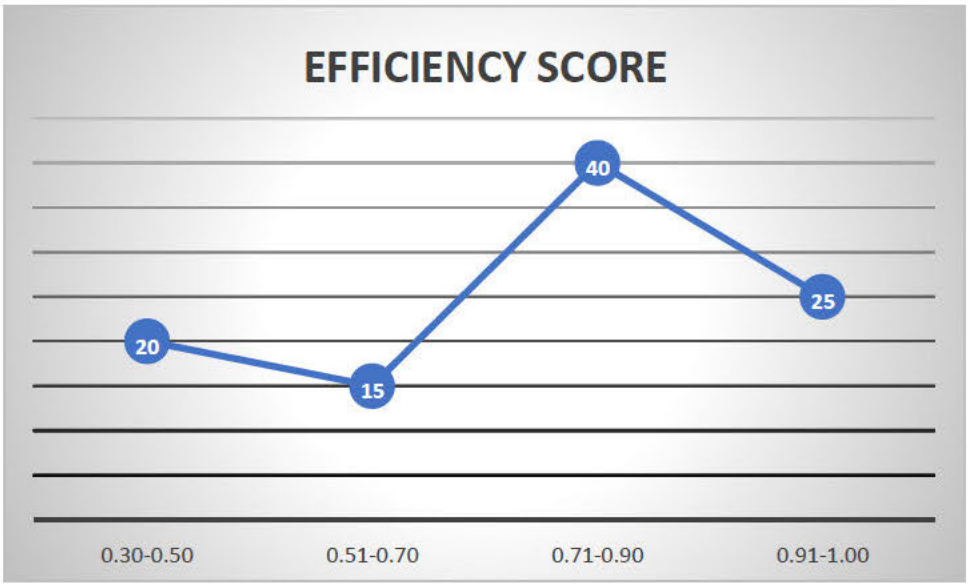

Figure 6.1 Distribution of Efficiency Score

6.5. Conclusion and recommendations

Efficiency helps in the economic planning of the farm by providing insight into the potential increase in output without requiring additional resources. However, efficiency is influenced by number of factors among small-scale sugarcane farmers remains. The aim of this study was to assess efficiency among small-scale sugarcane farmers in Ndwedwe local Municipalityk using the Zero-efficiency stochastic frontier approach. The results showed that age, gender, household size and seed cane age had a positive and significant influence on farmers' efficiency. On the other hand, education and non-farm income had a negative and significant influence on farmers' efficiency. It can be concluded that age, gender, household size and seed cage age improved efficiency while education and non-farm income resulted to inefficiency. It is recommended that farmers who are educated are encouraged to use their education skills in order to advice on cost efficient inputs and output. Also, farmers need to be encouraged to use their non-farm income in farm production to produce more and generate income.

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CHAPTER 7

CONCLUSION AND RECOMMENDATIONS

7.1. Conclusions

The sugarcane sector contributes significantly to South Africa's GDP through its solid socio-economic development that focuses on job creation, resource organization, income generation, and the development of transport and communication networks. The results from recursive bivariate probit (RBP) regression model showed that access to credit, education and extension support had a positive and significant influence on adoption of ICT, while marital status and non-farm income had negative and significant influence. On the other hand, gender and marital status had a positive and significant relationship with access to credit while age, education and non-farm income showed a negative and significant relationship. The results from a selectivity-corrected ordinary least square regression model. showed that gender, marital status, extension supports , government support and transportation cost had a positive and significant influence on farmer's income, while education, employment status and non-farm income had a negative and significant influence. Despite the important roles that credit and adoption of ICT play, rural households often encounter challenges in obtaining and securing credit due to diverse constraints. An improvement in these factors can lead to improvement in access to credit and adoption of ICT which in turn improves farm income. Age of small-scale and low income improved food security while seed cane and transportation costs decreased food security.

The Zero inefficiency Stochastic Frontier results showed that age, gender, household size and seed cane age had a positive and significant influence on farmers' efficiency. On the other hand, education and non-farm income had a negative and significant influence on farmers' efficiency. It can be concluded that age, gender, household size and seed age improved efficiency while education and non-farm income resulted to inefficiency.

The study further indicates that while these farmers have the right to access credit and ICT, their ability to effectively utilize these resources is constrained by various factors, the observed and unoserved factors.. The factors which consnpicous include constraints on a lack of information, suboptimal farming and management practices, inadequate infrastructure, limited agricultural extension services, and restricted access to land, and also disconnection between the rights to access credit and ICT and the capacity to derive benefits from them, hinders small-

scale farmers from maximizing their income potential resulting to food security for all sugarcane producers .

7.2. Recommendations and policy implications and Conclusion.

An improvement in the factors that affect small-scale farmers' production can lead to improvement in access to credit and adoption of ICT which in turn improves farm income and food security. Smallholder farmers need to be encouraged to get some education on how to adopt ICT and access credit. More training and workshops need to be conducted to teach and train farmers on the requirements needed to apply for formal credit. Moreover, they need to be trained on how to adopt modern information technology. This can help them to produce more efficiently and generate more income. Extension workers need to provide advisory support to small-scale farmers that need agricultural access to credit. The study suggested that the government needs to increase public investment in extension as it optimizes the potential impact on technology adoption and agricultural income, which also affects the distribution of the welfare of rural smallholder farmers. The study showed surprising results on transport costs.

It is also recommended that small-scale farmers are assisted on how to check the quality, and maturity of seed cane before planting. Researchers need to provide small-scale farmers with laboratory measures that will help farmers determine the quality of seed cane before production. Small-scale farmers need to be encouraged to use middlemen when it comes to the transportation of their produce. Middlemen will help farmers to transport their produce from the farm to end users at a certain price and that will help to decrease transportation costs. Lastly, it is also recommended that farmers who are educated are encouraged to use their education skills in order to advice on cost efficient inputs and output. Also, farmers need to be encouraged to use their non-farm income in farm production to produce more and generate income.

7.3. Limitations of the study and suggestions for further research

The study used only one province (KwaZulu Natal) and has been limited to only one local municipality that is Ndwedwe Local Municipality. Future studies can perform the same research across all nine provinces of South Africa where small-scale sugarcane farmers are located. The findings can be used to compare small-scale sugarcane farmers' challenges and

opportunities in their different working environments. The results will also be used to identify the area of improvement each province needs. The findings will also help develop a comprehensive report that will be submitted to policymakers, government, and other stakeholders for implementation.

APPENDICES

APENDIX A: CONSERT LETTER
UKZN HUMANITIES AND SOCIAL SCIENCES RESEARCH ETHICS COMMITTEE (HSSREC)

APPLICATION FOR ETHICS APPROVAL
For research with human participants

INFORMED CONSENT RESOURCE TEMPLATE

Note to researchers: Notwithstanding the need for scientific and legal accuracy, every effort should be made to produce a consent document that is as linguistically clear and simple as possible, without omitting important details as outlined below. Certified translated versions will be required once the original version is approved.

There are specific circumstances where witnessed verbal consent might be acceptable, and circumstances where individual informed consent may be waived by HSSREC.

Information Sheet and Consent to Participate in Research

Date:

Greeting: Hello,

My name is Mr. Nkosingiphile Samuel Zulu, a PhD student in Department of Agricultural Extension and Rural Resource Management at the University of KwaZulu-Natal (UKZN) in South Africa. My contacts are as follows: Phone: 0760462125; e-mail: 218088268@stu.ukzn.ac.za.

You are being invited to consider participating in a study that involves research on factors affecting productivity and food security of small-scale sugarcane farmers, Ndwedwe local Municipality of iLembe District. The aim and purpose of this research. Is to his study aims to determine the factors affecting the productivity and effect it has on food security of small-scale-sugarcane farmers in Ndwedwe Local Municipality of iLembe District.

The study is expected to enroll 300 participants in total, 100 in Nhlangano 100 in Ndwedwe mission area and100 in Sonkombo area. It will employ stratified design with probability proportional to size sampling of households from municipality and enumeration areas to draw a sample of 300 households from three villages in Ndwedwe local municiplity of iLembe. These villages will be sampled randomly among the five high-priority sugarcane intervention villages in the iLembe district which comprise Ndwedwe mission, Nhlangano, Ntaphuka and Sonkombo and Mona.

Three enumeration villages were randomly sampled from five villages of Ndwedwe local municipality. The local municipality and enumeration areas and population figures are those obtained from the 2018 South African Population census. Three villages were purposively selected because these villages were in the same local municipality with same weather condition and three selected villages with farmers who produce and deliver cane as a cash crop to the same sugar mill and within the sugarcane areas there are also crops including vegetables and grains crops. The face to face interview will be conducted with participants at their homes.

The duration of the interview if you choose to enroll and remain in the study is expected to be one hour. The study is funded by KZNDARD. The study will not involve any risks and/or discomforts. The study will provide no direct benefits to participants. However, the findings of the study are expected to provide the basis for reform process on sugarcane production. The findings of the investigation are also intended to provide decisive action to develop a more robust institution through which all sugarcane farmers are harmonized and work collaboratively with a common and shared end-purpose of achieving sustainable sugarcane development and food security.

In the event of any problems or concerns/questions you may contact the researcher at (0760462125) or the UKZN Humanities and Social Sciences Research Ethics Committee, contact details as follows:

HUMANITIES and SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Research Office,
Westville Campus
Govan Mbeki Building
PrivateBagX54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557- Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

Your participation is voluntary and your refusal to participate or to withdraw from the study carries no penalty or loss of any benefits. Participant will be told at the point of consent and at each survey point that they may either withdraw from the study or decline the opportunity to participate without any adverse action. In the event the participant shows some discomforts or emergency, the researcher will terminate the participant from the study.

This study has no cash or income-specific benefits provided to participants.

Your privacy will be protected to the maximum extent. If you have any questions, you can ask me, or Nkosingiphile Samuel Zulu or Dr Ngidi Mjabuliseni who is his supervisor. You can contact Mr

Nkosingiphile S Zulu on the following contacts: Phone:0760462125; e-mail: 218088268@stu.ukzn.ac.za. If you have any further concerns or questions about the research you may also call the supervisor of the research study at+27332605193 or email at ngidim@ukzn.ac.za.

Once the participants are recruited they will be assigned study ID numbers. Only the study investigator and the supervisors will have access to the data. Enumerators will have been trained on proper consenting procedures that include ensuring the participant is in a private location and in a place that they have voiced make them comfortable. Data will be cleared permanently from the database so to avoid it from being restored.

CONSENT (Edit as required)

I (Name) have been informed about the study entitled factors affecting productivity and food security of small-scale sugarcane farmers, Ndwedwe local Municipality of iLembe District by Nkosingiphile Samuel Zulu.

I understand the purpose and procedures of the study.

I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.The study has zero risks involved.

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher at (Phone: 0760462125; e-mail: 218088268@stu.ukzn.ac.za.

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

HUMANITIES and SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Research Office,
Westville Campus
Govan Mbeki Building
Private Bag
X54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557 - Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

Additional consent, where applicable I hereby provide consent to:

Audio-record my interview / focus group discussion YES / NO
Video-record my interview / focus group discussion YES / NO
Use of my photographs for research purposes YES / NO

_____ _____
Signature of Participant Date

_____ _____
Signature of Witness Date
(Where applicable)

_____ _____
Signature of Translator Date
(Where applicable)

APPENDIX B: QUESTIONNAIRE

Interview no….....

Date…….

Village……

Province……

District municipality……..…….

Local municipality……

APPENDIX A: SURVEY QUESTIONNAIRE

University of KwaZulu-Natal, College of agriculture, Engineering and science.

The impact of access to credit and information communication technology (ICT) on small-scale sugarcane farmer's food security status in Ndwedwe local municipality of iLembe.

PART A: DEMOGRAPHIC INFORMATION

1.In this section we will look at demographic factors affecting the food security status of small-scale sugarcane farmers in Ndwedwe villages (X or Tick (✓) and coding where appropriate)

1.1 Gender of respondent=Male= 1; Female is =2

1.2. Age of respond ent (specify in years)

1.3 Marital status Scale 1=Single 2=Married 3=Widowed 4=Divorced 5= Living with partner

1.4 indicate composition and total number of your household member living with you.

No of Females:	No of Males:	Total
1	2	=

1.5 What is the highest educational level the head of the household has completed?

1. No. Of formal education	Primary School Level	Secondary Level	Tertiary level	
1	2	3	4	

PART B: SOCIO-ECONOMIC CHARACTERISTICS

2. In section we will look at socio-economic factors, institutional factors and production challenges affecting sugarcane farmers. The sugarcane household who is more familiar may answer

(mark with X or Tick (✓) and coding where appropriate)

2.1. What is your employment status?

Unemployed	Employed Temporal	Employed Permanent	
1	2	3	

2.2. Please state the source of non-farm income available to your household by indicating the relative contribution of the following sources to your total income: (Total=100%).

Source of non-farm income	Yes	No
1.Salaries or wages		
2.Old age pension		
3.Disability grant		
4.Child support grant		
5.Foster-child grant		
6.Business		

2.3. Do you have access to credit in order to boast your farm?

1.Yes	2=No	

2.4. Do you receive extension Support to enrich your farm knowledge?

1.Yes	2=No	

2.5. If yes state most important practice (rank 1 as most important):

Practice	Rank	
Mulching		
Crop Rotation		
CA Farming		
Other (Specify)		

2.6. What do you think are the most important challenges you face in your sugarcane production (rank 1 as most important problem).

Challenge		Nature of challenge.	
1. Fertilisation time			
2.Inputs costs			
3.Livestock problem			
4.Transport costs			
5.Low income			
6.Late payment			
7.Harvesting problem			
8.Other(Specify)			

2.7. In the past 12 months did you practice climate smart agriculture in your farm extension in order to improve farming produce?

Yes=1	No=2

PART C. PRODUCTION INFORMATION

3.In section we will look at factors affecting small-scale sugarcane productivity and role played by other crops on food security status(Mark with an X or Tick (✓)

1.Sugarcane production information focus periods	2019	2020	2021
	Tons: Rands/ton:		Tons: Rands/ton:

3.1 What is size of household farmland in hectors?

3.2 What is your average sugarcane production trends with reference to three years period (tons/ha)?

3.3. What are production costs/ha which include:?

(i)Planting costs

(ii) Harvesting Cost

(iii)Transport costs

3.4. Land occupation type: what is your land tenure system in your farm (Mark with an X or Tick (✓)

3.Livestock production			
Tenure system	1.Owned	2.PTO	3. Rent/Lease

Type of agricultural production	
1.Sugarcane crops production	
2.Other crops (vegetables and grains)	

3.5.What types of agricultural production in your farmland (rank 1 as most important commodity).

3.6.Please indicate your feeling regarding your current level of production mark 1 as most important

(Mark with an X or a Tick (✓)

Sufficient for decent living	Just enough for basic good living standard	Just enough for basic improvement of my living standard	Sufficient extra income for doing basic expansion of my operations	Sufficient f significant susta operation c my expa
1.	2.	3.	4.	5.

3.7.Please provide the most important reasons for your answer 3.6.

COMMODITY AND REASONS THAT CURRENTLY INFLUENCING YIELD

1.	2.	

3.8.Please complete the following regarding your land and its cultivation (Mark with an X or Tick(✓) where appropriate)

Cane category(plant or ratoon[1]						
Topography[2]						
Soil type[3]						
[1].Cane category	Plant cane	2=R1	3=R2	4=R3	5=R4	6=Other(specify)
[2].Topography	1=flat	2=undulating		3=Slope		
[3].Soil type	1=Sandy soil	2=loamy soil		=3clay loamy	Other(specify)	

3.9. Labour: Please complete the following regarding your labour position per each activity. Who mostly does the following labour? (Mark with code1-4 after activities)

1.Land preparation		5.Hand weeding	
2.Planting		6.Harvesting and transport	

3.Fertilization				
4.Herbicides application				
[1]Labour	1=self	2=Household	3.Permanent hired labour	4=Part time Hired labour

3.11 what is topdressing fertilizers application rate	Kg/ha:	
3.12 what are costs of fertilizers (side dressing fertilizers):	Costs/ha:	

3.10. Choice of sugar cane variety. Please indicate the following regarding your choice of sugar cane variety decisions and practices.

(Mark with an X or Tick (✓)

[1] Who makes decision on variety choice	1 = self	2 = Milling co	3=Scheme admin	4= Extension	5=Other(specify):	
[2] What is the use of inspected seed cane in your farm [4] Age of seed cane	1=very often 1=<10 months.	2= regularly 2=11-15 months	3= Sometimes 3=>15 month s	4 = DNK / irregularly 4=DNK	5 =never	

3.10. Fertilizer use. Please indicate the following regarding your fertilizer use decisions and practices

(Mark with an X or Tick (✓) where appropriate)

[1]When do you analyse the soil potential to get better yield?	1=At planting only	2=In Ratoons only	3= Both	4 = Never

[2]Who Takes soil samples?	1=Yourself	2=Extension officer	3=Researchers		4=do not know	
[3]How strict do you Adhere to recommendations?	1=I commit to doing precisely as recommended	2=if my circumstances allow, I do what I can	3=only sometimes	4 = Never		
[4]When do you apply top-dress fertilizer on ratoon?	1=Immediately after harvest	2=Before crop is 3 months old	3=At anytime	5=wait for rain	6=when crop more 4moths	Other(specify)
[5]Who take decision to apply fertilizers	1 = Self	2 = Company or group	3 = Miller	4=Extension Officer	5=Contractor	

3.13

Weed control. Please indicate the following regarding your weed control decisions and practices' or Tick (✓) where appropriate)

[1] What is your impression of own practices?	Use following scale for farmer assessment: 1= totally disastrous; 2 = very poor; 3 =of low level; 4= reasonable level; 5= very good level.			
[2]What is method of weeding actually applied in field?	1 = Manual	2 = Chemical	3= Combination	4= No weeding 5= DNK
[3]What stage of weeds control?	1=Before germination above cane < 3 leaves	weed 2=When knee height	3=Cane late	4=Very 5= DNK
[4]Who performs weeds control have f (i)chemical	1 = Self	2 = Contractor	3 = family	labourer 4=some member 5 = if DNK difference:
(ii)Physical		s		

3.14.If you applies chemicals(herbicides) what is application rate?	Litres/ha/growing season:
3.15.What is Chemical costs/ha/day?	Costs/ha:
3.16.If physical weeds control what is labour costs (weeding):	Rands/ha:

3.17 as per type of agricultural production in subsection 3.4 do you still have interest to farm other crops as a part enterprise combination?

1.Yes	2.No

3.18 If yes in 3.17 do you think that the inclusion of other crops influence sugarcane production and food security?

Yes=1	No=2

3.19 If yes in 3.18; what is the main role played by other crop to the farmer indicate by 1 as most important (i) consumption: (ii)economic growth

:

(iii) cultural/customary practice ect:

3.20. Have you received government support on your farmland (mark with X or Tick (✓)

Yes=1	No=2

3.21If yes what type of support.

(1) infrastructure support (Roads, Fencing and Irrigation)

Yes=1	No=2

(2) Agricultural support (Seeds, Fertilizers, Agrochemicals and Mechanisation).

Yes=1	No=2

3.22 Please rate your satisfaction with Government quality support (mark with an X or Tick (✓) the correct answer.

Quality of Support given to farmers	Rate of government support

	Totally dissatisfied	Little dissatisfied	Moderately satisfies	Satisfied	Highly Satisfied
Quality of agricultural support (seeds,fertilizers,agrochemicals)	1	2	3	4	5
Quality of Infrastructure support(roads,fencing,irrigation)					
Quality of produce recieved					
The price you get from agricultural produce					
The productivity of your farm land					

PART

4.

FOOD

No	Question	Option	Code
1	In the past four weeks, did you In the past four weeks, did you Worry that your household Would not have enough food?	0 = No (skip to Q2) 1=Yes 0 = No (skip to Q2) 1=Yes	....__| ....__|
1a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks	....__|
2	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	0 = No (skip to Q3) 1=Yes	....__|
2a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks	....__|
3	In the past four weeks, did you Or any household member has To eat a limited variety of foods Due to a lack of resources?	0 = No (skip to Q4) 1 = Yes	....__|
3a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks)	....__|

SECURITY CHECK LIST QUESTION,

4.1 I will ask questions on analysis of the effect of productivity on food security status of small-scale sugarcane farmers in Ndwedwe villages ,If you answer Yes to the following questions, How often did this happen? 0= No; 1 = Rarely (once or twice in the past four weeks); 2 = Sometimes

(three to ten times in the past four weeks); 3= Often (more than ten times in the past four week

		3 = Often (more than ten times in the past four weeks	
4	In the past four weeks, did you Or any household member has To eat some foods that you Did not want to eat Because of a lack of resources To obtain other types of food?	0 = No (skip to Q5) 1 = Yes	….___|
4a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks	….___|
5	In the past four weeks, did you Or any household member has To eat a smaller meal than you Felt you needed because there Was not enough food?	0 = No (skip to Q6) 1 = Yes	….___|
5a	How often did this happen?	1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks	….___|

8	In the past four weeks, Or any household To sleep at night Because there was not Foo	1= Yes	
8a	How often did this	1= Rarely (once or twice in the past 2= Sometimes (three to ten times in the past four 3	1
9	In the past four weeks, Or household Whole day and night Eating anything Was not enough	0= No (questionnaire is 1=	1
9a	How often did this	1= Rarely (once or twice in the past 2= Sometimes 3= Often (more than ten times in the past four	1

APPENDIX C: ETHICAL CLEARANCE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

27 September 2022

Nkosingiphile Samuel Zulu (218088268)
School Of Agri Earth & Env Sc
Pietermaritzburg Campus

Dear NS Zulu,

Protocol reference number: HSSREC/00004462/2022
Project title: Factors affecting productivity and food security of small-scale sugarcane farmers in Ndwedwe local Municipality of iLembe District
Degree: PhD

Approval Notification – Expedited Application

This letter serves to notify you that your application received on 22 June 2022 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid until 27 September 2023.
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

HSSREC is registered with the South African National Research Ethics Council (REC-040414-040).

Yours sincerely,

[redacted]

Professor Dipane Hlalele (Chair)

/dd

Humanities and Social Sciences Research Ethics Committee
Postal Address: Private Bag X54001, Durban, 4000, South Africa
Telephone: +27 (0)31 260 8350/4557/3587 **Email:** hssrec@ukzn.ac.za **Website:** http://research.ukzn.ac.za/Research-Ethics
Founding Campuses: Edgewood Howard College Medical School Pietermaritzburg Westville