

FACULTY OF AGRONOMY AND FORESTRY ENGINEERING

EFFECT OF CREDIT ACCESS ON PRODUCTIVITY OF MAIZE-BASED CROPPING COMBINATIONS AMONG SMALLHOLDER FARMERS IN UGANDA

BY

Tabisa Kagoya

Supervised by

Prof. João Mutondo

A Dissertation Submitted to the Department of Agricultural Economics as Part of the Requirements for the Degree of Master of Science in Agricultural Economics from Eduardo Mondlane University

Maputo, October 2026

DECLARATION

I, Tabisa Kagoya, certify that this dissertation has never been presented for the purpose of acquiring a degree or in any other field and that it is the result of my individual labor. This dissertation is presented in partial fulfillment of the requirements for acquiring the degree of Master of Science in Agricultural Economics from Eduardo Mondlane University.

_____ _____

Tabisa Kagoya Date

ACKNOWLEDGEMENTS

I thank the Almighty God for His grace, strength, wisdom, and guidance throughout my academic journey. His faithfulness has sustained me through the challenges and enabled me to reach this important milestone.

I would like to express my sincere gratitude to my supervisor (Prof. João Mutondo) for the invaluable guidance, constructive feedback, patience, and support throughout this research. Your contribution has been instrumental in shaping this dissertation, and I am deeply grateful for your commitment to my academic development.

I am sincerely grateful to the World Bank and the Centre of Excellence for the scholarship that made my studies possible. Your financial support provided me with the opportunity to pursue this Master's degree, and I deeply appreciate the investment you have made in my academic and professional growth.

My sincere appreciation goes to Eduardo Mondlane University and the Faculty of Agronomy and Forestry Engineering for providing an enabling academic environment. I extend my gratitude to all the lecturers who taught me, shared their knowledge, and contributed to my academic and professional development throughout the programme.

To my brothers, Fred, Ken, and Elvis, thank you for your love, encouragement, and support throughout this journey. Your presence in my life has been a source of strength and motivation.

My deepest gratitude goes to my beloved husband, Jude, for his unwavering love, patience, understanding, and, most importantly, financial support throughout my studies. Your sacrifices and belief in me have meant more than words can express. Thank you for standing by me and helping me pursue this dream.

To my dear children, Johnpaul, Markfrancis, and Simon Peter, you are my greatest inspiration. The time spent away from you and the sacrifices made along this journey have not always been easy, but your love has continually motivated me to persevere. This achievement is not mine alone; it is also for you, and I hope it inspires you to pursue your own dreams with courage and determination.

Finally, I extend my heartfelt appreciation to everyone who contributed, directly or indirectly, to the successful completion of my studies and this dissertation. Your kindness, encouragement, and support are sincerely appreciated.

TABLE CONTENTS

LIST OF TABLES v
ABSTRACT vi
LIST OF ABBREVIATIONS vii
CHAPTER ONE: INTRODUCTION 1
1.1 Background 1
1.2 Problem statement 3
1.3 Objectives 4
1.3.1 Main objective 4
1.3.2 Specific objectives 4
CHAPTER TWO: LITERATURE REVIEW 5
2.1 Theoretical underpinning 5
2.2 Crop combination in smallholder farming 5
2.3 Role of credit on agricultural productivity 7
2.3.1 Credit and maize productivity 8
2.3.2 Determinants of credit access 11
CHAPTER THREE: METHODOLOGY 13
3.0 Introduction 13
3.1 The maize-based cropping combinations 13
3.2 Effect of credit access on maize productivity 13
3.2.1 Estimation of marginal effects 15
3.2.2 Description of the variables and their expected signs 16
3.2.3 Diagnostic tests 19
3.3 Data sources and type 21
3.4 Study design 21
3.5 Data management and cleaning 21
3.6 Limitations to the study 22
3.7 Ethical considerations 23
CHAPTER FOUR: RESULTS AND DISCUSSION 24
4.1 Maize-based cropping combinations 24
4.2 Effect of credit access on productivity across different maize-based cropping combinations 27
4.2.1 Marginal effects of access to credit by cropping combination 32
CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS 35

5.1 Conclusion 35
5.2 Recommendations and Policy Implications 36
REFERENCES 37
APPENDIX 51

LIST OF TABLES

Table 1 Description of variables and expected signs 17
Table 2 Maize-based cropping combinations 24
Table 3 Diagnostic and specification tests 27
Table 4 OLS regression results for maize productivity with interaction effects between credit access and cropping combinations 28
Table 5 Average marginal effects of access to credit on maize productivity 32

ABSTRACT

Agricultural credit enables smallholder farmers to invest in productivity-enhancing inputs, yet its benefits may differ across cropping systems. This study assessed the relationship between credit access and maize productivity among smallholder farmers in Uganda. It described common maize-based cropping combinations and examined how productivity responses to credit varied across them. The study used secondary data from the Uganda National Panel Survey (UNPS) 2019/2020 conducted by the Uganda Bureau of Statistics. The sample comprised 789 maize-producing households cultivating 1,046 maize plots. Descriptive statistics established the prevalence of cropping combinations. Ordinary Least Squares (OLS) regression, including interaction terms between credit access and cropping combinations, analysed differences in maize productivity. Average marginal effects estimated the association between credit access and productivity within each cropping system. Four combinations were identified: maize-only, maize-beans, maize-cassava, and maize-beans-cassava. Maize-only plots were most common, accounting for 43.59% of plots, followed by maize-beans at 35.56%, maize-beans-cassava at 11.66%, and maize-cassava at 9.18%. Credit access was positively and significantly associated with maize productivity on maize-only plots, corresponding to approximately 52.9% higher productivity. However, estimated effects for maize-beans, maize-cassava, and maize-beans-cassava plots were not statistically significant. Fertilizer use, farming experience, and location in the Eastern and Northern regions were also positively associated with productivity. The findings indicate that the productivity association of credit varies by cropping combination. The study recommends strengthening affordable agricultural credit and complementing financing with extension and agronomic support.

Keywords: Agricultural credit, maize productivity, cropping combinations, smallholder farmers, Uganda.

LIST OF ABBREVIATIONS

ACF	-	Agricultural Credit Facility
AME	-	Average Marginal Effect
FAO	-	Food and Agriculture Organization
GDP	-	Gross Domestic Product
LSMS-ISA	-	Living Standards Measurement Study – Integrated Surveys on Agriculture
NAADS	-	National Agricultural Advisory Services
OLS	-	Ordinary Least Squares
PDM	-	Parish Development Model
PMA	-	Plan for Modernization of Agriculture
RESET	-	Regression Equation Specification Error Test
SACCOs	-	Savings and Credit Cooperative Organizations
SSA	-	Sub-Saharan Africa
UBOS	-	Uganda Bureau of Statistics
UDB	-	Uganda Development Bank
UNPS	-	Uganda National Panel Survey
VIF	-	Variance Inflation Factor

CHAPTER ONE: INTRODUCTION

1.1 Background

Credit access facilitates the adoption of improved production technologies, such as the use of fertilizers, herbicides, and pesticides among smallholder farmers, which in turn improve agricultural yields (Chandio & Jiang, 2018). World over, the mean yearly rate of agricultural growth productivity has decreased between 2011 and 2021 from 1.93% to 1.14% respectively (Fuglie et al. 2024). Scholars attribute this decrease partly to the limited adoption of modern technologies that enhance productivity and the adverse impacts of climate change, which collectively have caused a decrease of 21% in agricultural productivity (Ortiz-Bobea et al. 2021).

Besides boosting yields, access to finance supports wider agricultural activities like crop production, livestock rearing, and raw material production, all of which are important for household nutrition and overall welfare improvement (Areebahoona et al., 2024). The importance of credit is considerably more noticeable in Sub-Saharan Africa because farmers experience institutional and structural barriers, such as high poverty levels, limited financial infrastructure, and the predominance of informal economies (Mothobi & Kebotsamang, 2024). Most of these nations rely on agriculture both directly and indirectly for their existence, making it the primary source of revenue and employment for the majority of households (Manoharan & Varkey, 2021).

In Uganda, agriculture is key to the national development agenda outlined in Vision 2040, which aims to transition the country into a competitive middle-income economy through agricultural growth and industrialization (FAO, 2024). Currently, the agriculture sector employs about 70% of the workforce, generates 42% of export earnings, and is responsible for roughly 24% of the Gross Domestic Product (GDP). It further supplies vital raw materials to domestic industries and supports rural development (Emong, 2023). According to UBOS, (2015), smallholder farmers constitute the largest segment of farming households in Uganda, mainly carrying out their farming activities on an average land holding of 1.6 hectares. They carry out many farming activities, such as crop cultivation, aquaculture, and livestock farming.

Among the cultivated crops, maize is particularly important because it functions as both a commercial crop and staple food (Midamba, 2022). Small-scale farmers contribute approximately 75% of maize production and 70% of marketable surplus, with the maize sub-sector supporting a

livelihood of about four million Ugandan farm households (FAO, 2018). Notably, maize is commonly cultivated in intercropping systems that combine maize with other additional crops such as beans, cassava, groundnuts, soya beans, bananas, and potatoes (Madembo et al., 2020). These maize-based cropping combinations serve multiple functions such as dietary diversification, cultural preferences, soil fertility management, and risk reduction under climate and market uncertainties (Filipponi et al., 2024).

Despite the importance of maize, its productivity in Uganda continues to be low compared to regional and global averages. The yields range between 1.5 to 1.8 metric tons per hectare (Midamba, 2022; Asea et al., 2023), which is below 2.1 metric tons per hectare of the Eastern Africa Region's potential (FAO, 2021). Dependency on rain-fed farming systems, limited availability of improved inputs, and difficulties obtaining finance are some of the contributing factors.

Access to finance is particularly important because it enables farmers to make timely purchases of seeds, fertilizer, labour, and pesticides, which collectively enhance productivity. However, Ugandan smallholder farmers still face uneven distribution and limited access to credit, with disparities arising from demographic characteristics, institutional settings, regional differences, and the growing effects of climate (Ferris et al., 2014).

These challenges have contributed to low productivity, food insecurity, malnutrition, and accelerated poverty rates within agricultural households (Nabuuma et al., 2021). For example, 21.7% of Ugandan households face severe food insecurity (Nahalomo et al., 2023), and approximately seven million Ugandans live in absolute poverty (UBOS, 2024). Expanding credit access has therefore become a policy priority, not only for raising agricultural productivity but also for empowering households to invest in long-term ventures, meet immediate consumption needs, and improve overall living standards (Lin et al., 2019; Mujeri, 2015).

Bocher et al. (2017) stated that households in Ethiopia that have access to credit experience enhanced food security and higher total food expenditures. Similarly, in Malawi, access to well-targeted credit has been linked to reduced welfare inequality (Makuluni & Dunga, 2022). This highlights the importance of credit in enabling households to achieve better consumption outcomes. Despite the recognized advantages of credit for both smallholder farmer households and

economic development, many agricultural households in Uganda, including those engaged in maize production, have limited access to credit and financial services.

A survey by FinScope (2018) and Economic Policy Research Centre, (2024), revealed that only 11% of the adult population in Uganda access formal agricultural credit. Due to this restricted coverage, smallholders lack the capacity to secure the required inputs such as machinery, seeds, and fertiliser, which reduces their potential for growth, productivity, and household food security.

Social and economic characteristics, for example, household size, age, education, gender, marital status, and asset ownership, influence access to credit. For example, households with greater wealth and education have a higher chance of being approved for loans because of their stronger collateral and greater financial awareness (Rasheed et al., 2016; Chandio and Jiang, 2018; Wadeya, 2022; Quach, 2016).

Although the Ugandan government has implemented programs such as the National Agricultural Advisory Services (NAADS) and the Parish Development Model (PDM) to improve financial inclusion (Areebahoona et al., 2024), productivity among smallholder farmers remains low. Maize is a major staple and commercial crop in Uganda and is commonly cultivated alongside other crops. What is particularly unclear is the role of credit within the different maize-based cropping combinations that dominate smallholder farming systems. Despite their agricultural and economic importance, the specific contribution of credit to the productivity of these maize-based cropping combinations is not well understood. Therefore, there is a clear need to examine how credit influences the productivity of maize-based cropping combinations among smallholder farmers in Uganda.

1.2 Problem statement

Although substantial literature shows that access to agricultural credit has the potential to improve productivity, household income, and food security, little is known about which specific cropping combination is most responsive to credit access in terms of productivity. The majority of previous studies have treated agricultural production in general as homogeneous (Zabatantou et al., 2023; Akudugu 2016; Saptia and Rusnani, 2024; Bhola, 2024; Chaiya et al., 2023), without distinguishing between the different cropping combinations commonly cultivated by smallholder farmers.

Yet, smallholder farmers in Uganda grow maize in combination with many other crops, such as beans, soybeans, groundnuts, potatoes, cassava, bananas, millet, coffee, and sorghum (Makate et al., 2025). Much as this diversity is well acknowledged, there is limited documentation of the specific maize-based cropping combinations that farmers commonly practice, and very few studies have examined how the productivity effects of credit vary across these combinations. Examining credit access within maize-based cropping combinations is important because farmers allocate credit to production activities according to the input and labour requirements of the crops they cultivate together.

These maize-based cropping combinations differ in input needs, labor requirements, and yield outcomes (Kaur & Sharma, 2025), suggesting that the productivity effect of credit is unlikely to be uniform. However, financial institutions and policymakers continue to provide agricultural credit to these farmers without evidence-based guidance on which specific cropping combinations generate the highest productivity gains.

This study, therefore, contributes new evidence by (i) documenting the maize-based cropping combinations commonly practiced by smallholder farmers in Uganda, and (ii) assessing which of these combinations are most responsive to credit access in terms of productivity. These contributions are expected to inform the design of more targeted and efficient credit programs aiming to maximize productivity and improve the well-being of rural households.

1.3 Objectives

1.3.1 Main objective

The main objective of this study is to assess the effect of credit access on productivity of smallholder farmers cultivating different maize-based cropping combinations in Uganda

1.3.2 Specific objectives

i. To describe maize-based cropping combinations commonly practiced by smallholder farmers in Uganda.
ii. To determine which maize-based cropping combinations are most responsive to credit access in terms of productivity.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical underpinning

The small farm production model proposed by (Carter, 1989) provides a direct theoretical explanation for how access to credit influences agricultural productivity among smallholder farmers. Carter (1989) used his model to identify three ways in which a smallholder farmer's production function could benefit from having access to financing.

First, when smallholder farmers have access to credit, they are better positioned to achieve efficient allocation of resources by purchasing the appropriate mix of agricultural inputs required for optimal production. For example, credit enables farmers to acquire productivity-enhancing inputs such as fertilizers, improved seeds, and pesticides in the quantities and at the times when needed. In this way, credit serves as a mechanism for improving the optimal allocation of resources across competing farm needs, hence influencing productivity.

Second, Carter (1989) argues that credit access improves technical efficiency by enabling farmers to adopt better technologies and production methods. This includes investments in more advanced tools and machinery, as well as high-yielding and disease-resistant seed varieties. Through such investments, farmers can shift the production frontier outward, effectively increasing output per unit of land or labour.

Third, access to credit enables farmers to expand the scale of production, either by hiring additional labour or cultivating larger land areas. This scale effect arises because financial liquidity reduces the immediate cash constraints that often limit the extent to which smallholder farmers can engage in more intensive or extensive agricultural practices.

Carter's model is further strengthened by (Feder et al., 1989), who emphasized that credit market imperfections are binding constraints in smallholder agriculture. When farmers lack access to credit, they are unable to invest sufficiently in key production inputs and improved technologies, which results in lower productivity.

2.2 Crop combination in smallholder farming

Smallholder farming systems across Sub-Saharan Africa are characterized by the widespread cultivation of multiple crops on the same plot (Wollburg et al., 2024). Rather than specializing in a single crop, farmers commonly adopt diverse crop combinations such as maize-beans, maize-

cassava, sorghum-groundnuts as strategies to address diverse livelihood objectives (Beillouin et al., 2019; Madembo et al., 2020). This pattern reflects structural realities of smallholder agriculture, such as limited landholdings, labour constraints, and restricted access to capital and external inputs (Ruben, 2024). Under such conditions, cultivating several crops concurrently provides a flexible and adaptive approach to managing production, consumption, and income needs (Bocher et al., 2017).

In Uganda, where the majority of smallholder farmers rely on less than two hectares of land (UBOS, 2015), crop diversification is particularly essential. It allows farmers to maximize productive use of scarce land while ensuring a steady supply of staple foods. Similar land-use dynamics are observed in other East and Southern African countries, where average farm sizes rarely exceed three hectares (Jayne et al., 2016), reinforcing the centrality of intercropping to smallholder agricultural systems across the region

The adoption of crop combinations is supported by both agronomic advantages and livelihood considerations. Agronomically, intercropping improves the availability and use of soil nutrients, enhances soil structure, and reduces vulnerability to pests and diseases (Mcauley et al., 2025). Cereal and legume combinations are especially beneficial because legumes fix atmospheric nitrogen, which enriches soil fertility and improves the yield potential of cereals grown alongside them (Kassie et al., 2018; Race et al., 2022). Differences in rooting depth, canopy structure, and nutrient uptake among intercropped species reduce intra-plant competition and support more efficient resource use (Brooker et al., 2015).

Further, the rationale for intercropping among smallholder farmers is also shaped by both ecological and socio-economic considerations. Economically, crop diversification provides an important risk management function. It enhances the production of crops that differ in maturity periods, market demand, and susceptibility to climatic stressors, hence farmers spread production and income risks throughout the growing season (Kassie et al., 2018). This reduces dependence on a single harvest and stabilizes household food supply and income flows. In environments characterized by price volatility, unpredictable rainfall, and limited access to insurance or credit, such risk-buffering strategies are essential to sustaining livelihoods (Nwokoro et al., 2021).

Intercropping also contributes to broader ecological resilience. Increased plant diversity suppresses weed growth, disrupts pest life cycles, and lowers the need for chemical inputs, thereby enhancing

environmental sustainability (Midega et al., 2015). Accordingly, crop combinations play a dual role; they support immediate household needs while contributing to the long-term sustainability of smallholder production systems (Biru et al., 2020).

For many rural households, diversification is not simply a cultural tradition but a rational and necessary response to the constraints and uncertainties of rain-fed small-scale agriculture (Ruben, 2024). It enables farmers to meet food security objectives while simultaneously participating in local and regional markets. As argued by Pretty et al. (2018) and Raseduzzaman (2016), diversification remains an important livelihood strategy where production risks are high and resources are limited.

2.3 Role of credit on agricultural productivity

Financial inclusion is a key driver of agricultural performance. Farmers who have access to financing can invest in improved technologies, like quality seeds, fertilizer, and farm equipment that boost productivity (Rahman et al., 2022). Evidence demonstrates the strong link between access to credit and agricultural output across different contexts.

In Nigeria, Osabohien et al. (2020) employed Propensity Score Matching (PSM) on data from 4,210 households and established that farmers with access to credit achieved significantly higher production levels than those without. Similar trends are reported in Ghana, where Akudugu (2016) examined the nexus between financial access, farm size, and productivity, revealing that credit access raised agricultural output by nearly 45% at a 1% significance level. These findings reinforce the concept that capital access is a key catalyst for intensification and modernization in smallholder farming.

Evidence from Asia further strengthens this argument. Jimi et al. (2019), in a study of Bangladeshi rice farmers, distinguished between gains in technical efficiency and technological change associated with credit. Their results showed that farmers who had access to credit attained an average increase of 14% in output, highlighting the role of credit not only in improving efficiency but also in facilitating the adoption of advanced production technologies.

Beyond its direct effects on yield, credit also acts as an important mechanism for risk management. Farmers who lack financial resources often cope with shocks by reducing consumption or selling productive assets, strategies that undermine both present and future livelihoods (Osabohien et al.,

2020). Therefore, credit access not only enhances productivity but also cushions households against income volatility and climate or market-related risks.

Studies across Africa consistently confirm both the immediate and long-term benefits of rural credit. For instance, in Benin, Assouto and Houngbeme (2023), found that access to agricultural credit increased yield per hectare by over 40%. Likewise, Taremwa et al. (2021) reported that smallholder maize and rice farmers in Rwanda experienced a 44% increase in productivity when they accessed credit. Awotide1 et al. (2015) also observed that access to loans significantly enhanced cassava productivity among Nigerian farmers. These results collectively suggest that agricultural credit is important not only to improving output but also to enabling smallholders to transition from subsistence to more commercially oriented farming systems.

The benefits of agricultural credit extend to broader household welfare outcomes. Quach (2016) using Vietnam Living Standards Survey data, found that credit access had a positive and lasting effect on household welfare, particularly through increased per capita expenditure. While both formal and informal loans contributed to welfare improvements, formal credit exerted a comparatively stronger and more sustainable influence due to its structured repayment terms and lower interest rates.

However, despite the consistency of these positive effects, the extent to which credit influences agricultural performance varies by crop type, production system, and socioeconomic conditions. The nature of input requirements, market integration, and risk exposure differ across crops (Alvarez & Berg, 2019). This shows that the productivity gains associated with credit are context-specific. Given the importance of maize as a primary food crop and an important means of livelihood for smallholder farmers (Saptia & Rusnani, 2024), understanding how credit access affects maize productivity is important. The subsequent section 2.3.1 and 2.3.2, therefore, focus specifically on the linkage between credit and maize productivity among smallholder farmers as well the factors influencing credit access.

2.3.1 Credit and maize productivity

Maize is a vital component of Uganda's economic sector. It serves as both a staple diet and an income-generating crop. However, its productivity continues to lag behind potential levels, with national yields averaging only between 1.5 and 1.8 tons per hectare (Asea et al., 2023) compared

to the achievable 2.1 tons under optimal supervision conditions (FAO, 2021). This persistent yield gap is largely attributed to the limited uptake of enhanced maize varieties, continued use of traditional agricultural practices, and limited access to modern inputs and extension services (Semalulu et al., 2022).

Apart from its economic importance, maize plays an essential role in household food security. Filipponi et al. (2024) observe that maize contributes to over 50% of the caloric intake in rural households in Eastern Uganda. Similarly, Nakato et al. (2024) found that increases in maize productivity significantly improve household food security outcomes. This aligns with the broader consensus that improvements in maize productivity are instrumental in raising household incomes (Midamba, 2022) and ensuring sustainable food and nutritional security among vulnerable rural populations (Grote et al., 2021).

Although several studies (Ahmadu and Edeoghon 2018; Erenstein et al. 2022) recognized the contribution of maize to household food security, its potential as an income-generating commodity remains constrained by several market-related challenges. Osewe et al. (2023) cautions that poor market connectivity and low farm-gate prices undermine the income benefits of maize production for smallholder farmers.

The commercialization of maize in Uganda remains uneven and is shaped by the availability of credit and market information. Kisaame and Kavuma (2023) observed that farmers with reliable financing and market knowledge were more likely to commercialize production. However, low maize yields continue to be experienced across Sub-Saharan Africa. For instance, in Mali, yields remain below 2 tons per hectare, primarily due to inadequate input availability and limited financial resources (Diamoutene and Jatoe 2020 ; Adebayo et al. 2021). These findings emphasize credit as a key enabler of productivity improvement through increased access to agricultural inputs

Credit empowers smallholder farmers to acquire inputs that boost productivity, such as improved seeds, fertilizers, and pesticides. Evidence demonstrates this linkage. Lukwago et al. (2025) found that credit access in Northern Uganda led to higher adoption of hybrid seeds and fertilizers, which led to a 19.9% increase in maize earnings. Similarly, Kipkogei et al. (2025) showed that Kenyan farmers who accessed microcredit and adopted improved technologies achieved higher yields and farm returns. However, the extent of credit's effect on productivity remains context-specific. Auci

& Coromaldi, (2022) reported increased technical efficiency from improved seed use in Uganda, though adoption was constrained by cost. Semalulu et al. (2022) also found that improved maize varieties raised yields by 20-25%, but uptake depended heavily on farmers' ability to finance input purchases.

The effectiveness of credit is further shaped by broader institutional and infrastructural conditions. Jayme and Lee (2024) demonstrated that limited uptake of drought-tolerant maize varieties among Ugandan farmers resulted from weak distribution networks and insufficient farmer awareness. Government-led credit schemes, such as the Agricultural Credit Facility (ACF), have attempted to address financing gaps (Mabaya et al. (2021), and public-private partnerships have improved input access to some extent (Aseete et al., 2023).

Credit also promotes mechanization and land expansion, though benefits vary. Mwaura (2014), noted increases in cultivated land and productivity due to production loans, whereas Osewe et al. (2023) argued that loan sizes in Uganda often remain insufficient for substantial mechanization. Thus, while credit can improve production capacity, its impact depends on loan adequacy, input availability, and market conditions.

Group-based lending has been promoted as a strategy to improve credit access. Akioya and Ikoyo-Eweto (2019) found that collective lending increased the likelihood of obtaining credit, and Kabila, (2022) reported improved access to hybrid seeds and fertilizers through cooperative bargaining. However, Dawes and Mushongachiware (2024) caution that the small loan sizes associated with group lending limit transformative investments such as mechanization and land expansion.

Finally, the impact of credit on productivity depends on how credit is utilized. Muwereza (2024) concluded that loans directed toward production activities yielded greater productivity gains than those diverted to consumption. Likewise, Lelisho and Mesfin (2024) noted that credit used for input purchases significantly raised farm income, whereas credit allocated to household needs had minimal effects. Nordjo and Adjasi (2020), argue that even production-focused credit may not translate into higher productivity when input prices are high, emphasizing that credit alone is not sufficient to guarantee yield improvement.

Despite extensive research on credit and agricultural productivity, important gaps remain. Ahimbisibwe et al. (2023) stated that existing literature rarely distinguishes the effects of credit across different cropping arrangements or disaggregates credit by type and use. Notably, little is known about how credit influences productivity across the diverse maize-based cropping combinations practiced by smallholder farmers in Uganda.

2.3.2 Determinants of credit access

Access to credit among smallholder maize farmers is shaped by a range of demographic, economic, institutional, and structural factors. Sociodemographic characteristics play an important role in determining who obtains agricultural financing. Mutungi et al. (2025) found that younger and more educated farmers are more likely to secure loans because they are perceived by lenders as lower risk. Education enhances financial literacy and improves farmers' ability to interact with financial institutions, leading to greater uptake of credit services (Wabwire, 2020). However, differences persist across gender lines. Ogunleye et al. (2024) observed that female-headed households face structural disadvantages during loan evaluations, despite often possessing agricultural experience comparable to their male counterparts.

Economic endowments, such as land size, income, and asset ownership, significantly influence credit access. Abenaitwe et al. (2024) reported that farmers with larger landholdings and diverse asset portfolios had higher probabilities of obtaining formal credit, as collateral enhances lender confidence. Similarly, Midamba et al. (2023) emphasised that livestock ownership and savings increased farmers' bargaining power with lenders. On the other hand, Marus et al. (2021) noted that asset-poor smallholders are frequently excluded from formal credit markets, despite their high input needs, demonstrating how wealth disparities reinforce inequalities in financial access.

Institutional support also shapes pathways to credit access. Collective organizations such as farmer groups, cooperatives, and producer associations enhance credit uptake by leveraging social networks and collective bargaining power. Cherotich et al. (2022) have shown that membership in such groups are more than double the likelihood of securing formal credit. Also, Mukoki et al. (2023) found that access to extension services that connect farmers to financial institutions significantly increased credit uptake. However, in contexts where formal institutional support is

weak, farmers often rely on informal networks to meet their financing needs, even though such arrangements sometimes involve exploitative repayment terms (Achieng et al., 2025).

Geographic location further influences credit accessibility. Farmers in remote rural areas face high transaction costs due to the lack of nearby banking facilities (Ninsiima et al., 2023). Kipkogei et al. (2025) similarly observed that proximity to financial institutions increases the likelihood of credit uptake. However, advances in mobile banking and digital finance have reduced geographic barriers, indicating that infrastructure development can mitigate spatial inequalities (Martiniello et al., 2022).

Smallholder farmers frequently draw on both formal and informal credit sources. Jayme and Lee (2024) found that while 76.7% of Ugandan farmers accessed some form of credit, only 32.6% did so from formal institutions. Informal sources, such as SACCOs, moneylenders, and relatives, often serve as bridging mechanisms but may involve high interest rates and unfavourable repayment terms (Mwalupaso et al., 2025). Nwafor (2021) argues that reliance on informal credit may meet short-term liquidity needs but limits long-term investments necessary for productivity growth.

Social capital and gender dynamics also affect credit access. Kehinde et al. (2021) found that men with strong social connections tend to secure formal credit, whereas women and youth are often excluded. Badstue et al. (2020) similarly show that gendered constraints limit women's participation in financial systems despite their active role in maize production. Land ownership patterns further reinforce gendered inequities. Wangui (2019) reported that male-headed households in western Uganda benefited disproportionately from credit-supported productivity gains. However, Rao and Mahalingam (2025) demonstrated that microcredit programs specifically targeting women, particularly when paired with training, improved both access and agricultural performance.

Finally, financial literacy and access to information strongly influence credit uptake. Kankwatsa et al. (2024) identified limited understanding of borrowing procedures and weak record-keeping practices as major barriers to accessing formal credit. Sensitization and financial training enhance credit utilization and support more efficient farm management, as illustrated by Siaw et al. (2021) and Ullah et al. (2020) in Pakistan.

CHAPTER THREE: METHODOLOGY

3.0 Introduction

This chapter presents the methodological approach used in the study. It outlines the study design, describes the data sources, explains the procedures followed to clean and harmonise the datasets, details the construction of key variables, and discusses the analytical strategy employed. The purpose was to provide a clear and transparent account of how the final analytical dataset was developed and how the empirical analysis was conducted.

3.1 The maize-based cropping combinations

To describe the prevailing maize-based cropping combinations practiced by Ugandan smallholder farmers, crop-level records were aggregated at the plot level. Dummy indicators were created for the presence of beans and cassava on maize plots. Based on the cropping combination of each plot, the plots were classified into four categories: maize-only, maize-beans, maize-cassava, and maize-beans-cassava. Frequencies and percentages were then used to determine the prevalence of the different maize-based cropping combinations.

3.2 Effect of credit access on maize productivity

The analysis is grounded in the neoclassical theory of profit maximization. Under the neoclassical framework, farmers are assumed to choose input levels that maximize profit, subject to a production technology available to them (Debertin, 2012). While the profit-maximization framework explains farmers' input-use decisions, the production function provides the empirical basis for modelling maize productivity.

Assuming a maize farmer cultivates a plot i, the profit function for maize production can be specified as:

$$\pi_i = P_y Y_i - \sum_{j=1}^{m} P_j X_{ji} \quad (1)$$

Where: π_i represents the profit obtained from plot i, P_y represents the price of maize output, Y_i represents the maize output produced on plot i, P_j is the price of the j^{th} production input, X_{ji} is the quantity of the j^{th} input used on plot i, and $\sum_{j=1}^{m} P_j X_{ji}$ represents the total expenditure on all production inputs.

Solving the profit maximization problem, we find that the $X=f(P_y, P_{ji})$. Substituting this result in production function we have $Y=f(P_y, P_{ji})$, implying that the production depends on price of output and inputs.

To estimate the determinants of maize productivity, the study assumes that maize production follows a Cobb-Douglas production technology because of its flexibility, ease of estimation and direct interpretation of coefficients as output elasticities. The Cobb-Douglas production function is specified as:

$$Y_i = AX_{1_i}^{\beta_1} X_{2_i}^{\beta_2} \dots\dots X_{k_i}^{\beta_k} \quad (2)$$

Where A represents total factor productivity, $X_{1i}, X_{2i}, \dots, X_{ki}$ denote production inputs and other explanatory variables, $\beta_1, \beta_2, \dots, \beta_k$are parameters measuring the responsiveness of output to changes in each explanatory variable. Taking natural logarithms of both sides of equation (2) yields a production function that is linear in the parameters and therefore suitable for estimation using ordinary least squares (OLS). The general estimating equation is specified as:

$$InY_i = \beta_0 + \sum_{j=i}^{r} \beta_j \, InX_{ji} + \sum_{k=1}^{s} yk \, D_{ki} + \varepsilon_i \quad (3)$$

Where: Y_i= maize productivity on plot i; X_{ji}= the j^{th}continuous explanatory variable measured in positive units and entered in natural logarithms, D_{ki}= the k^{th}binary or categorical (dummy) explanatory variable, β_j= coefficients associated with the continuous variables, γ_k= coefficients associated with the dummy variables and ε_i= error term. Accordingly, this study estimated the following empirical model:

$$\ln(Y_i) = \beta_0 + \beta_1 C_i + \beta_2 Z_i + \beta_3 (C_i \times Z_i) + \beta_4 X_i + \varepsilon_i \quad (4)$$

Where: $\ln(Y_i)$ = natural logarithm of maize productivity (yield per hectare) on plot i; β_0 = intercept term, β_1–β_4 = parameters to be estimated, C_i = access to credit, Z_i = maize-based cropping combination category, ($C_i \times Z_i$) = interaction terms between credit access and cropping combinations, X_i = vector of control variables, including extension services, farmer group membership, education, hired labour, farming experience, fertilizer and pesticide use, asset ownership, household size, Region, and ε_i = error term

A joint F-test was conducted after estimating the ordinary least squares (OLS) regression model to determine whether credit access and its interaction terms with the three maize-based cropping combinations were jointly statistically significant in explaining maize productivity. The test examined the null hypothesis that the coefficient of credit access and the three interaction coefficients were simultaneously equal to zero, against the alternative hypothesis that at least one of these coefficients differed from zero. The null hypothesis was rejected if the p-value was less than the 5% significance level; otherwise, it was not rejected.

3.2.1 Estimation of marginal effects

Following estimation of the interaction model in equation (10), Average Marginal Effects (AMEs) were computed to quantify the effect of credit access on maize productivity across the different maize-based cropping combinations. Although the interaction coefficients from the OLS model indicate whether the effect of credit access differs across cropping systems, they do not directly provide the effect of credit access within each cropping combination. The computation of AMEs, therefore, facilitates interpretation by estimating the average effect of changing credit access from 0 (no access) to 1 (access), while holding the remaining explanatory variables at their observed values. For each maize-based cropping combination j, the average marginal effect of credit access was computed as

$$AME_j = \frac{1}{N}\sum_{i=1}^{N}\left[\widehat{In(Y_i)}(C_i = 1, Z_j, X_i) - \widehat{In(Y_i)}(C_i = 0, Z_j, X_i)\right] \quad (5)$$

Where: AME_j is the average marginal effect of credit access for the cropping combination j, $N$is the total number of observations, $\widehat{In(Y_i)}(C_i = 1, Z_j, X_i)$ is the predicted natural logarithm of maize productivity when a farmer i has access to credit, $\widehat{In(Y_i)}(C_i = 0, Z_j, X_i)$ is the predicted natural logarithm of maize productivity when a farmer i does not have access to credit, Z_j denotes the maize-based cropping combination, and X_i represents the other explanatory variables.

The estimated AMEs were obtained after OLS estimation using the margins command in Stata. The command computes predicted values for each observation under the two levels of credit access while keeping all other explanatory variables at their observed values, and then averages the resulting differences across all observations belonging to each cropping combination. Since the dependent variable was specified in natural logarithms, the estimated marginal effects represent

differences in logarithmic units. To express these effects in percentage terms, each estimated AME was transformed using

$$\%\Delta Y = 100 \times (e^{\sigma} - 1) \quad (6)$$

Where: $\%\Delta Y$ is the percentage change in maize productivity attributable to credit access, σ is the estimated average marginal effect (dy/dx) and e is the base of the natural logarithm.

3.2.2 Description of the variables and their expected signs

The selection of explanatory variables was based on the previously reviewed literature. Variables representing household characteristics, access to productive resources, institutional support, and input use were included because they influence farmers' production decisions and their ability to transform inputs into output. The expected relationships between these variables and maize productivity are presented in Table 1.

Table 1 Description of variables and expected signs

Variable	Measure	Definition	Expected sign	Citation
Access to credit	Binary	1-accessed credit, 0 = no access	(+)	Ankrah Twumasi et al., (2020), Linh et al. (2019)
Education	Categorical	1-primary, 2 = secondary and 3 = higher	(+)	Kaviku et al. (2024); Jimi et al., (2019); Afutu-Kotey et al. (2017)
Household size	Continuous	Number of people	(+)	Asiamah et al. (2021), Silong and Gadanakis (2019)
Fertilizer & pesticides used	Binary	1-Yes, 0-No	(+)	Jimi et al. (2019)
Extension services	Binary	1-Yes, 0-No	(+)	Moahid et al. (2021) and Kaviku et al. (2024)
Hired labour	Binary	1-Yes, 0-No	(+)	Owusu (2017b)
Asset count	Continuous	In numbers	(+)	Isaga (2018)
Member of a farmer group	Binary	1-Yes, 0-No	(+)	Olugbenga et al. (2016)
Farming experience	Continuous	Number in years	(+)	Adewuyi et al. (2024) and Owusu (2017)
Region	Categorical	1-Central, 2-Eastern, 3-Northern, 4-Western	(+/-)	Salima et al. (2023)
Cropping Combinations	categorical	1 = Maize-only; 2 = Maize-beans; 3 = Maize-cassava; 4 = Maize-beans-cassava	(+/−)	
Credit × maize-beans	Interaction	1 = Maize-only; 2 = Maize-beans; 3 = Maize-cassava; 4 = Maize-beans-cassava	(+/−)	
Credit × maize-cassava	Interaction	Credit access multiplied by the maize-cassava indicator	(+/−)	
Credit × maize-beans-cassava	Interaction	Credit access multiplied by the maize-beans-cassava indicator	(+/−)	

From Table 1 above, access to credit was measured as a binary indicator, taking the value 1 if the household accessed credit and 0 otherwise. A positive relationship was expected between access to credit and maize productivity, consistent with previous studies by (Ankrah et al., 2021; Linh et al., 2019). Access to credit enables farmers to adopt improved production technologies such as improved seed, fertilizers, pesticides, hired labour, and mechanization (Chandio & Jiang, 2018). On the other hand, education was categorized as primary, secondary, or higher. It was expected to have a positive relationship with maize productivity, similar to the previous studies of (Kaviku et al., 2024; Jimi et al., 2019; Afutu-Kotey et al., 2017). Education enhances farmers' ability to access and understand agricultural information. Educated farmers are more likely to easily adopt improved farming technologies, understand extension advice, and make informed decisions as far as crop management and resource allocations are concerned (Rahman et al., 2022).

Hired labour was measured as a dichotomous variable coded as 1 for households that employed hired labour on their plots and 0 otherwise. It was expected to have a positive effect on maize productivity, consistent with (Areebahoona et al., 2024). Hired labour supplements family labour, especially during critical periods of farming operations such as land preparation, planting, weeding, and harvesting. Timely and effective attainment of these activities helps farmers to achieve the finest crop growth, which results in high yields (Owusu, 2017b).

Farming experience was measured as the number of years the household head had engaged in farming activities and served as a proxy for accumulated agricultural knowledge and skills. A positive relationship was expected between farming experience and maize productivity, consistent with findings by (Adewuyi et al., 2024; Owusu, 2017). Farmers with greater farming experience are likely to possess better knowledge of crop management practices, resource allocation, and production decision-making, which can contribute to higher levels of productivity (Tingting et al., 2018).

Household size was measured by the total number of individuals residing in the household. It was expected to have a positive association with maize productivity, consistent with the discoveries of (Asiamah et al. 2021; Owusu 2017b). Larger households generally have a larger supply of family labour that can be allocated to farm operations, thereby improving the timeliness of agricultural activities and potentially increasing maize productivity. Access to extension services was included

as a binary variable, taking the value of 1 if the household received agricultural extension services and 0 otherwise. The variable was expected to have a positive influence on maize productivity, consistent with the observations of (Moahid et al., 2021; Kaviku et al., 2024). Extension services provide farmers with technical knowledge, training, and information on improved agricultural practices. As a result, households that received extension services were expected to achieve higher maize productivity than those without access to such services.

Membership in a farmer group was coded as a binary variable, taking the value of 1 if the farmer belonged to a farmer group and 0 otherwise. The variable was expected to have a positive relationship with maize productivity, consistent with findings of (Olugbenga et al., 2016). Farmers who participated in farmer groups were expected to achieve higher productivity than non-members. Farmer groups facilitate access to agricultural information, extension services, training opportunities, production inputs, and market linkages. Asset count was measured as the total number of assets owned by the household. It was expected to have a positive effect on maize productivity, consistent with (Isaga, 2018). Asset ownership serves as an indicator of household wealth and resource endowment. Households with more assets are better able to finance agricultural activities, purchase improved inputs, hire labour, and invest in productivity-enhancing technologies, thereby increasing productivity.

Fertilizer and pesticide use were included as a binary production input variable. These inputs are important for improving crop productivity by enhancing soil fertility and reducing losses caused by pests, diseases, and weeds. Consequently, their use was expected to have a positive effect on maize productivity, consistent with (Jimi et al., 2019). The region was included to capture differences in agroecological and socioeconomic conditions across Uganda. Variations in rainfall, soil fertility, market access, infrastructure, extension services, and access to agricultural technologies may influence maize productivity. Consequently, the effect of the region was expected to be either positive or negative relative to the Central region, consistent with (Salima et al., 2023).

3.2.3 Diagnostic tests

Heteroscedasticity test

To assess whether the variance of the regression error terms was constant, the White test for heteroscedasticity was employed. The White test is a general diagnostic test that detects heteroscedasticity without requiring a specific functional form of the error variance. It does this by estimating an auxiliary regression in which the squared residuals from the original regression are regressed on the explanatory variables, their squared terms, and cross-product terms. The test statistic is based on the coefficient of determination (R^2) from the auxiliary regression and follows a chi-square distribution under the null hypothesis. The null hypothesis (H_0) states that the error terms are homoscedastic (have constant variance), while the alternative hypothesis (H_1) states that the error terms are heteroscedastic (have non-constant variance). A statistically significant p-value ($p < 0.05$) leads to rejection of the null hypothesis

Model specification

The Ramsey Regression Equation Specification Error Test (RESET) was conducted to assess whether the estimated regression model suffered from omitted variable bias or an incorrect functional form. The RESET test examines model specification by adding powers (such as squared and cubed terms) of the fitted values from the original regression to the estimated model and testing whether these additional terms are jointly statistically significant. If the added terms do not significantly improve the model, it suggests that the original model is correctly specified. The test evaluates the null hypothesis (H_0) that the model is correctly specified against the alternative hypothesis (H_1) that the model is mis-specified due to omitted variables, incorrect functional form, or both. Failure to reject the null hypothesis indicates that the model is adequately specified and that there is no evidence of specification errors.

Multicollinearity

This was assessed using the Variance Inflation Factor (VIF) to determine whether the independent variables were highly correlated. The VIF measures the extent to which the variance of an estimated regression coefficient is inflated due to linear relationships among explanatory variables. According to Gujarati (2003), VIF values less than 10 indicate no correlation between a given predictor and other explanatory variables

3.3 Data sources and type

This research was based solely on secondary data accessed from the Uganda National Panel Survey (UNPS) wave VIII conducted by the Uganda Bureau of Statistics (UBOS) 2019/2020. The UNPS is a nationally representative survey designed to monitor the welfare and living standards of Ugandan households. It employed a stratified two-stage sampling design and covered approximately 3,000 households across the country, providing comprehensive and high-quality data suitable for policy and academic research.

The UNPS dataset contains several modules relevant to this study, including information on crop production, land ownership, input use, household demographics, education, assets, livestock, credit access, and extension services. Each module was stored separately, and households were linked across modules using a unique household identifier. The agricultural modules provide detailed information on crops grown, quantities harvested, units of measurement, sales, and plot characteristics, while the household modules capture demographic characteristics, education levels, household size, asset ownership, and access to credit.

For this research, the focus was narrowed to households engaged in maize cultivation. From the national sample of about 3,000 households, the final sample comprised 789 maize-producing households cultivating 1,046 maize plots. A smallholder farmer refers to one cultivating not more than two hectares of land, consistent with the national definition used by (UBOS, 2015). Productivity was defined as the farmer's yield in kilograms per hectare, derived from the crop-level information in the agricultural module.

3.4 Study design

The study adopts a quantitative cross-sectional design. This design is appropriate because the UNPS collects detailed information on agricultural production, household characteristics, and economic activities at a single point in time. The analysis focuses on plots where maize was grown. Maize is one of the most widely cultivated crops in Uganda and provides a strong basis for examining productivity outcomes.

3.5 Data management and cleaning

The data management process began with harmonising household identifiers across all survey modules. Although the UNPS uses a consistent household ID, the format varies across datasets,

which can create challenges when linking household-level, plot-level, and crop-level information. To ensure accurate merging, all identifiers were standardised into a uniform string format. After establishing consistent identifiers, the next step involved selecting the relevant observations for the study.

The analysis focused on three major crops commonly grown in Uganda: maize, beans, and cassava. Observations related to other crops were excluded to maintain comparability and reduce noise in the dataset. Since maize productivity is the main outcome of interest, only households that cultivated maize were retained for the final analytical sample. Once the relevant households and crops were identified, additional steps were taken to organise the agricultural information in a structure suitable for analysis.

Households often cultivate multiple crops on multiple plots; a unique identifier was created to link each crop to the specific plot on which it was grown. This ensured that variables such as crop area, seed type, and stand density could be accurately matched to the corresponding harvest information. The crop production data were originally recorded in long format, with each row representing a crop grown on a particular plot. The final analytical dataset was maintained at the plot level because maize productivity and cropping combinations are plot-specific characteristics.

The UNPS dataset also provides sampling weights associated with its survey design. These weights are intended to account for differences in household selection probabilities and support population-level inference. Because the final analytical dataset was organised at the plot level, with some households contributing multiple maize plots, appropriate consideration of the relationship between household-level weights and plot-level observations is necessary. The analytical procedures described in this study used ordinary least squares (OLS) regression with robust standard errors, as specified in Section 3.2

3.6 Limitations to the study

There was lack of information about potentially relevant predictors of credit access, such as interest rate, perception of financial institutions, loan amount, and loan terms, due to data limitations from the Uganda National Panel Survey data 2019/2020

3.7 Ethical considerations

The study uses publicly available secondary data that have been anonymised by the Uganda Bureau of Statistics. No personal identifiers are included, and the analysis does not involve direct interaction with respondents. Ethical approval was therefore not required. The study adheres to principles of responsible data use, confidentiality, and academic integrity.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Maize-based cropping combinations

The results show that smallholder farmers practiced different maize-based cropping combinations on their maize plots. Four major maize-based cropping combinations were identified: maize only, maize-beans, maize-cassava, and maize-beans-cassava, as presented in Table 2. Out of the 1,046 maize plots included for analysis, 456 plots were cultivated with maize as a sole crop, 372 plots were intercropped with beans, 96 plots were intercropped with cassava, and 122 plots were intercropped with both cassava and beans.

The findings indicate that maize monocropping was the most prevalent cropping combination, accounting for 43.59 percent of all maize plots. This was followed by the maize-beans cropping combination, represented with 35.56 percent of the plots. The maize-beans-cassava and maize-cassava cropping combinations accounted for 11.66 percent and 9.18 percent of the plots, respectively.

Table 2 Maize-based cropping combinations

Cropping combinations	Frequency	Percentage	Cumulative
Maize only	456	43.59	43.59
Maize-beans	372	35.56	79.16
Maize-cassava	96	9.18	88.34
Maize-beans-cassava	122	11.66	100.00

The predominance of maize monocropping shows that many smallholder farmers consider maize as both a security food crop and an important source of income. Maize is one of the most widely grown crops in Uganda (Midamba, 2022). Its widespread cultivation was partially attributed to its comparatively short maturity period, which enables farmers to harvest within a few months after planting (Chemura et al., 2025). Maize is also highly adaptable to a wide range of agroecological conditions throughout the country (Epule et al., 2021).

In addition, the crop enjoys strong market demand from several consumers and institutions. The demand for maize comes from households for food consumption, traders for commercial dispersal, agro-processors for value addition, and public institutions such as schools and prisons (Babirye et

al., 2024). As a result, many farmers may allocate all their plots to maize production to maximize output and generate marketable surplus. Therefore, the high allocation of maize-only plots shows the crucial role that maize contributes to the livelihoods of rural households and Uganda's agricultural economy.

Furthermore, the dominance of maize monocropping also suggests a gradual shift towards agricultural commercialization among some smallholder farmers. Ogutu & Qaim (2019), ascertained that farmers tend to focus more on crops that offer reliable market opportunities and income-generating potential. As farmers become more market-oriented, they often allocate larger portions of their land to crops with established value chains and predictable market demand. In this case, maize fits this profile because it is widely consumed in Uganda and extensively traded across East African regional markets (Mutayoba, 2025). Accordingly, some farmers perceive maize monocropping as a means of maximizing returns from limited land resources.

This observation is consistent with the findings of (Fita et al., 2025) who noted a shift from multiple cropping systems towards monocropping as farmers became increasingly market-oriented. Similar trends have been observed in Zambia and South Africa, where monocropping is more prevalent in commercialized farming systems characterized by improved market access, extensive use of improved inputs, and stronger integration into agricultural value chains (Jayne et al., 2018).

The prevalence of intercropping systems, particularly the maize-bean cropping combination, implies that maximizing productivity is not the only objective guiding smallholder farmers' production decisions. More than one-third (35.56 percent) of all maize plots were cultivated with the maize-beans cropping combination. This shows that crop diversification is a crucial strategy among rural households. Different from large farms that always focus on specialization, smallholder farmers often operate under conditions of uncertainty arising from unpredictable weather patterns, fluctuating output prices, limited access to credit, and land constraints (Madembo et al., 2020). In such cases, diversification through intercropping serves as an important risk-management mechanism.

Intercropping maize and beans enables smallholder farmers to achieve both agronomic and livelihood objectives. The combination improves resource-use efficiency through better utilization

of land, sunlight, and soil nutrients. As a legume, beans fix nitrogen, which increases soil fertility and benefits the maize component (Madembo et al., 2020; Race et al., 2022). Also, beans mature faster than maize, which provides households with a quicker source of food and income. This enhances food security and income diversification.

Additionally, the preference for the maize-bean cropping combination also has a strong cultural background. They are culturally interlinked in Ugandan diets, commonly referred to as "posho and beans". It is a staple meal in many households, schools, and public institutions (Babirye et al., 2024). Intercropping, therefore, is not only an agronomic practice but also a cultural tradition, passed down through generations as part of indigenous knowledge systems. Women, who are instrumental in maintaining household food security, often favour these diversified cropping combinations to ensure adequate nutrition and minimize food shortages (Njuki et al., 2022).

The substantial percentage of maize-beans plots observed in this study was consistent with previous studies conducted in other East African countries, for example, Kenya and Tanzania, where smallholder farmers prefer intercropping maize with legumes to maintain soil fertility and diversify production (Vanlauwe et al., 2019). Similar socio-cultural motivations were also observed in Nigeria and Ghana, where maize-legume cropping combinations are practiced due to cultural and nutritional reasons (Nwokoro et al., 2022).

The maize-cassava and maize-beans-cassava cropping combinations were relatively less prevalent, accounting for 9.18 percent and 11.66 percent of maize plots, respectively. This lower prevalence may be attributed to the long maturity period of cassava, which occupies land for extended periods and can limit farmers' flexibility in managing their plots (Jensen, 2017). Subsequently, smallholder farmers, particularly those facing land constraints, may prefer cropping systems that allow more frequent harvests and fast production cycles.

Despite their lower prevalence, the continued adoption of cassava-based combinations suggests that some farmers prioritize household food security and resilience to climatic shocks. Cassava is widely recognized for its drought tolerance and ability to provide yields under adverse environmental conditions. This makes it an important risk-management crop for smallholder households (Borku, 2025). As a result, integrating cassava with maize may serve as a strategy for stabilizing food supplies and reducing vulnerability to weather-related production shocks.

These results align with the previous research of (Filipponi et al. 2024; Yildirim & Ekinci, 2017), which observed that intercropping is a rational strategy for smallholder farmers operating under limited land and capital resources. Combining different crops on the same plot enables farmers to maximize the productivity of available land, diversify production, and enhance household food security while mitigating production risks.

4.2 Effect of credit access on Maize-based productivity

Before estimating the model on the effect of credit on productivity across different maize-based cropping combinations, a series of diagnostic and specification tests were conducted to assess the validity and reliability of the estimated model, and the results are presented in Table 3.

Table 3 Diagnostic and specification tests

Diagnostic test	Null hypothesis	Test statistic	p-value	Decision
VIF	Multicollinearity	Mean Vif = 1.54		Mean Vif <10
White test	Homoskedasticity	$\chi^2(182) = 188.20$	0.361	Fail to reject H_0
Ramsey RESET test	No omitted variables	$F(3, 1023) = 0.29$	0.836	Fail to reject H_0

Multicollinearity was assessed using the Variance Inflation Factor (VIF). The results showed a mean VIF of 1.54, while individual VIF values ranged from 1.04 to 2.76. Since all VIF values were well below the commonly accepted threshold of 10, multicollinearity was not considered a serious problem in the model. Therefore, the estimated coefficients are unlikely to be affected by excessive correlation among the explanatory variables

The presence of heteroskedasticity was examined using White's test. The results failed to reject the null hypothesis of homoskedasticity ($\chi^2(182) = 188.20$, $p = 0.361$). Therefore, there was no evidence of heteroskedasticity in the estimated model. Although White's test indicated no evidence of heteroskedasticity, robust standard errors were employed as a precautionary measure to ensure consistent and reliable inference in the event of any minor departures from the homoskedasticity assumption.

Model specification was assessed using the Ramsey RESET test. The test failed to reject the null hypothesis of correct model specification ($F(3,1023) = 0.29$, $p = 0.836$). This indicates that there

is no evidence of omitted variable bias or functional form misspecification in the estimated model. Therefore, the model was considered appropriately specified for analysing the relationship between credit access, cropping combinations, and maize productivity.

Ordinary Least Square regression was used to assess the effect of credit access on maize productivity. It included the main effects of credit access and cropping combinations, as well as interaction terms between credit access and the various cropping combinations, and other control variables. The interaction model was estimated to determine whether the productivity effect of credit access varied across maize-based cropping combinations. The OLS regression analysis incorporated the UNPS sampling weights to account for differences in household selection probabilities and improve the representativeness of the estimates. Robust standard errors were used for statistical inference.

The results in Table 4 showed that credit access had a positive and statistically significant association with maize productivity. However, the presence of an interaction term implied that the effect of credit was not uniform across all cropping combinations. Therefore, average marginal effects were estimated and discussed in the subsequent section to provide a clearer understanding of how credit access influenced maize productivity across the different cropping combinations.

Table 4 OLS regression results for maize productivity with interaction effects between credit access and cropping combinations

Variables	Coefficient	Robust standard errors	Significance level
Credit access	0.4244929	0.1545308	0.006
crop combinations			
Maize-beans	-0.3277954	0.0981212	0.001
Maize-cassava	-0.2297872	0.1152029	0.046
Maize, beans-cassava	-0.5847104	0.1274479	0.000
Interaction (credit*crop comb)			
Maize-beans	-0.2406342	0.2227236	0.280
Maize-cassava	-0.5155225	0.4157149	0.215
Maize-beans-cassava	-0.7008216	0.3898776	0.073
Control Variables			
Fertilizer used	0.530614	0.1955884	0.007
Hired labour	0.0421607	0.100417	0.675
Farming experience	0.1862728	0.0704166	0.008
Education			
Primary	0.0548289	0.1067454	0.608
Secondary	-0.01829	0.1217206	0.881
Higher	0.0981568	0.1615527	0.544
Household size	0.0098053	0.0124333	0.431
Asset count	-0.0010298	0.0048383	0.831
Extension services	0.0103099	0.1182777	0.931
Member of farmer group	-0.2920947	0.2118511	0.168
Region			
Eastern	0.2448329	0.0963742	0.011
Northern	0.297508	0.1287172	0.021
Western	-0.1664356	0.0990304	0.093
Constant	5.62197	0.2918501	0.000
Overall model F-statistic	7.03		0.000
R-squared	0.1107		
Joint F-test: credit access and interactions	2.38		0.0503

The results indicate that maize-beans, maize-cassava, and maize-beans-cassava cropping combinations had significantly lower maize productivity than maize-only plots, holding other factors constant and when credit access was zero. The coefficients for maize-beans (-0.328), maize-cassava (-0.230), and maize-beans-cassava (-0.585) were statistically significant at the 1%, 5%, and 1% levels, respectively. Since the dependent variable was expressed in logarithmic form, these coefficients correspond approximately to 28.0%, 20.5%, and 44.3% lower maize productivity, respectively, relative to maize-only plots.

These results may partly be explained by competition among crops for essential production resources, including soil nutrients, moisture, sunlight, and growing space. In maize-bean systems, although beans can improve soil fertility through biological nitrogen fixation (Race et al., 2022), this benefit may not fully offset competition for resources under all growing conditions. In maize-cassava systems, competition for nutrients, moisture, and space may affect maize growth, particularly where planting arrangements and crop management are not optimal. The maize-beans-cassava combination may involve more complex competition for these resources and require more careful management to meet the growth requirements of all three crops (Brooker et al., 2015)

The interaction terms between credit access and cropping combinations indicated whether the relationship between credit access and maize productivity differed across the mixed-cropping systems relative to maize-only plots. The interaction coefficient between credit access and maize-beans was negative (-0.241) but statistically insignificant ($p = 0.280$). Similarly, the interaction between credit access and maize-cassava was negative (-0.516) and statistically insignificant ($p = 0.215$). These results suggested that there was insufficient statistical evidence that the association between credit access and maize productivity differs between maize-beans or maize-cassava plots and maize-only plots.

The interaction between credit access and the maize-beans-cassava combination was also negative (-0.701), with a p-value of 0.073. Although this coefficient was not statistically significant at the 5% level, it was statistically significant at the 10% level. This implied that the positive association between credit access and maize productivity was smaller for maize-beans-cassava plots than for maize-only plots.

The results further showed that some control variables were significantly associated with maize productivity. The use of fertilizer and/or pesticides had a positive and statistically significant association with maize productivity ($\beta = 0.531$, $p = 0.007$). This finding suggested that plots where these inputs were used had higher maize productivity than plots where they were not used, holding other variables constant. Fertilizers improve soil nutrient availability, while pesticides help reduce crop losses caused by pests and related threats. The finding is consistent with (Jimi et al., 2019), who identified the importance of production inputs in improving agricultural productivity. The result also supports the expectation that access to and use of productivity-enhancing inputs can help farmers improve maize output per unit of land.

Farming experience was also positively and significantly associated with maize productivity ($\beta = 0.186$, $p = 0.008$). This finding suggests that farmers with more years of farming experience may be better able to make production decisions, manage farm operations, and apply their accumulated practical knowledge to crop production. The result is consistent with the expected positive relationship discussed by (Adewuyi et al., 2024; Owusu, 2017a). Nevertheless, farming experience does not necessarily guarantee higher productivity, since outcomes may also depend on farmers' access to inputs, technologies and other production resources.

Maize productivity was significantly higher in the Eastern and Northern regions than in the Central region, with coefficients of 0.245 ($p = 0.011$) and 0.298 ($p = 0.021$), respectively. These findings indicated regional differences in maize productivity after controlling for the other variables included in the model. Such differences reflect variation in agroecological conditions, including rainfall patterns and soil characteristics, as well as differences in farming practices, input use and production environments.

Regional differences in access to agricultural technologies and markets also contribute to productivity variation. This result is consistent with the rationale for including regional characteristics in the model and with the regional perspective discussed by (Salima et al., 2023). In contrast, hired labour, education level, household size, asset ownership, access to extension services and membership in farmer groups were not statistically significantly associated with maize productivity at the 5% significance level.

Finally, a joint F-test was conducted to assess whether credit access and its interaction terms with the three maize-based cropping combinations were jointly statistically significant. The test yielded an F-statistic of 2.38 (F(4, 1025) = 2.38, p = 0.0503). Since the p-value was marginally above the 5% significance threshold, the null hypothesis that all four credit-associated coefficients were jointly equal to zero could not be rejected at the 5% level. However, the result was statistically significant at the 10% level.

4.2.1 Marginal effects of access to credit by cropping combination

Following estimation of the interaction model between credit access and maize-based cropping, average marginal effects were computed to assess the effect of credit access on maize productivity within each cropping combination. The marginal effects represent the average expected change in the natural logarithm of maize productivity associated with access to credit while holding the other explanatory variables constant. The results are presented in Table 5.

For maize-only plots, credit access was associated with approximately 52.9 percent higher maize productivity, holding other variables in the model constant, compared to maize-only plots without credit access (dy/dx = 0.4245, p = 0.006). For maize-bean plots, credit access was associated with an increase of approximately 20.2 percent in maize productivity relative to plots without credit access. However, the effect was not statistically significant (p = 0.254). Similarly, for maize-cassava and maize-beans-cassava plots, access to credit was associated with decreases of approximately 8.7 percent and 24.1 percent in maize productivity, respectively. However, these effects were not statistically significant (P>0.05)

Table 5 Average marginal effects of access to credit on maize productivity

Cropping combination	Marginal effects (dy/dx)	standard error	Significance level	Percentages
Maize only	0.4245	0.1545	0.006	52.9
Maize-beans	0.1839	0.161	0.254	20.2
Maize-cassava	-0.091	0.39	0.816	-8.7
Maize-beans-cassava	-0.2763	0.3576	0.44	-24.1

The positive and significant effect of credit access on maize monocropping implies that access to credit was associated with the ability to overcome financial constraints that limit investment in productivity-enhancing inputs. According to the small farm production model proposed by (Carter, 1989), credit facilitates the acquisition of productive resources such as improved seed, inorganic fertilizer, pesticides, mechanized services, and hired labour. When these inputs are applied effectively, crop yields and productivity are expected to increase.

The findings suggest that credit access is more strongly associated with maize productivity among farmers cultivating maize as a sole crop than among those practicing the other maize-based cropping combinations examined. Cultivating maize-only allows farmers to allocate credit-financed inputs, such as fertilizers, improved seeds and pesticides, directly to maize production. In intercropping systems, maize may compete with associated crops for nutrients, water, sunlight and growing space. Such competition may influence maize growth and the extent to which additional inputs translate into higher maize yields.

As a result, investments financed through credit may generate more immediate and measurable productivity gains. For example, fertilizer application rates, seed selection, and agronomic practices can be optimized for maize without concerns about compatibility with companion crops.

These findings match with the previous findings of (Ankrah et al., 2021; Linh et al., 2019; Chandio & Jiang, 2018) who reported that access to financial capital promotes the adoption of yield-enhancing technologies. Farmers with access to credit were more capable of purchasing improved production inputs and overcoming liquidity constraints that often limit agricultural investment.

In contrast, the marginal effects indicated that credit access did not significantly improve productivity among maize-bean, maize-cassava, or maize-beans-cassava combinations. Intercropping systems are frequently motivated by objectives beyond yield maximization. Smallholder farmers often combine crops to diversify production, improve food security, improve soil fertility, and reduce exposure to climatic and market risks.

The complexity of managing intercropped plots may reduce the effectiveness of purchased inputs. For example, fertilizer recommendations developed for monocropped maize may not produce equivalent outcomes when applied in intercropping systems. Similarly, competition among crops

for nutrients, water, and sunlight may limit the productivity response of maize even when farmers invest in improved inputs using credit.

Furthermore, credit obtained by rural households is not always used exclusively for agricultural production. Smallholder households often face competing financial demands, such as school fees, healthcare expenditures, consumption needs, and non-farm enterprises. As a result, the amount of credit ultimately invested in intercropped maize production may not be sufficient to generate statistically detectable productivity gains.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study sought to (i) describe the different maize-based cropping combinations commonly practiced by smallholder farmers, (ii) analyse the effect of credit access on productivity of maize-based cropping combinations. Using secondary data from the Uganda National Panel Survey (UNPS) 2019/2020, the analysis was conducted at the plot level because both maize productivity and cropping combinations are plot-specific characteristics.

Descriptive statistics identified the prevailing maize-based cropping combinations. At the same time, Ordinary Least Squares regression with interaction terms and average marginal effects assessed the relationship between credit access and maize productivity across cropping combinations.

The findings revealed that smallholder farmers in Uganda practice a diverse range of maize-based cropping combinations, reflecting the heterogeneous production strategies employed to meet both subsistence and commercial objectives. Among the identified cropping systems, maize monocropping was the most prevalent, accounting for 43.59 percent of all maize plots, followed by the maize-beans combination, which represented 35.56 percent of the plots. However, maize-cassava and maize-beans-cassava combinations were relatively less common, accounting for 9.18 percent and 11.66 percent of maize plots, respectively.

The predominance of maize monocropping suggests that many farmers continue to view maize as a strategic crop for both household food security and income generation. At the same time, the substantial presence of intercropping systems, particularly maize-beans, indicates that diversification remains an important production strategy for managing risk, improving resource utilization, and enhancing household livelihood security.

The relationship between credit access and maize productivity varied across cropping combinations. The significant positive response was observed for maize-only plots, while estimates for the other cropping combinations were not statistically significant. The effectiveness of credit depends on the cropping combination practiced.

5.2 Recommendations and Policy Implications

Findings from this study imply that the government of Uganda, financial institutions, and development partners need to strengthen access to affordable agricultural credit among smallholder farmers. Affordable credit facilities will attract many smallholder farmers to get these credit facilities with less fear of failure to pay back. Cheap access to credit will enhance farmers' capacity to acquire productivity-enhancing inputs such as improved seed, fertilizers, pesticides, and mechanized services, which results in increased productivity.

Financial institutions should be sensitized to the importance of linking credit provision with productive and sustainable cropping systems. The credit facilities extended to especially smallholder farmers should be targeted to farmers cultivating maize-only on their plots. Promoting such targeted credit support will amplify the effectiveness of agricultural financing, which will enable farmers to achieve better yields and also enhance their loan repayment capacity.

Credit programmes targeting productivity enhancement may achieve greater yield responses among farmers practicing maize monocropping. However, support for diversified systems should continue because of their food security and risk-management benefits.

Agricultural credit initiatives should be closely integrated with extension services to ensure that borrowed funds are effectively invested in productivity-enhancing cropping systems and specifically those cultivating maize-only. This will help expand financial inclusion, improve the productive use of credit, and contribute to sustainable growth in the smallholder maize sector.

REFERENCES

Abenaitwe, J., Bateyo, A., Burani, A., & Michael, M. N. (2024). Loan portfolio planning and financial performance of Savings and Credits Cooperatives in Uganda: Evidences from SACCOs in Rubirizi District, Western Uganda. *Research Journal of Finance and Accounting*, *15*(2), 78–88. https://doi.org/10.7176/rjfa/15-2-08

Achieng, S. F., Adewale, C. I., Okello, D. M., & Mugonola, B. (2025). Village saving loan association membership and commercialization among smallholder maize farmers in northern Uganda. *Discover Agriculture*, *3*(1). https://doi.org/10.1007/s44279-025-00235-2

Adebayo, I. O., Samuel, O. O., Kabir, K. S., Aremu, A. O. O., Kehinde, O. O., & Adeyemi, O. (2021). *Socio-economic Drivers of Food Security among Rural Households in Nigeria: Evidence from Smallholder Maize Farmers* (pp. 155,583–599). Social Indicators Research. https://doi.org/https://doi.org/10.1007/s11205-020-02590-7

Adewuyi, S. A., Tolorunju, E. T., Olusanya, I. O., & Akinbode, S. O. (2024). Determinants and Constraints of Access to Credit by Poultry Egg Farmers in Ogun State Nigeria. *Asian Journal of Agricultural Extension, Economics & Sociology*, *42*(11), 357–365. https://doi.org/https://doi.org/10.9734/ajaees/2024/v42i112622 Open

Afutu-Kotey, R. L., Gough, K. V., & Owusu, G. (2017). Young Entrepreneurs in the Mobile Telephony Sector in Ghana: From Necessities to Aspirations. *Journal of African Business*, *18*(4), 476–491. https://doi.org/10.1080/15228916.2017.1339252

Ahimbisibwe, B. P., Morton, J. F., Feleke, S., Alene, A. D., Abdoulaye, T., Wellard, K., & Manyong, V. (2023). Assessing the crop productivity and household welfare effects of adopting certified seeds of improved cassava varieties in Uganda. *Agrekon*, *62(2)*, *164*, 62(2), 164-177.

Ahmadu, J., & Edeoghon, C. O. (2018). Effect of maize production on poverty alleviation of farmers in Edo state, Nigeria. *Agrosearch*, *18*(1), 53. https://doi.org/10.4314/agrosh.v18i1.5

Akioya, A. O., & Ikoyo-Eweto, G. . (2019). Analysis of Mass Media Use and Preferences in Information Sourcing among Farming Households in Edo State. *Journal of Agriculture and Veterinary Science*, *11*(2), 9–15. https://doi.org/10.9790/2380-1107020915

Akudugu, M. A. (2016). Agricultural productivity, credit and farm size nexus in Africa: a case study of Ghana. *Research Paper*, *34*(1), 1–5. https://doi.org/https://doi.org/10.1108/AFR-12-2015-0058

Alvarez, J. A., & Berg, C. N. (2019). Crop Selection and International Differences in Aggregate Agricultural Productivity. *IMF Working Papers*.

Ankrah, D. A., Kwapong, N. A., Eghan, D., Adarkwah, F., & Gyambiby, D. B. (2021). Agricultural insurance access and acceptability : examining the case of smallholder farmers in Ghana. *Agriculture & Food Security*, 1–14. https://doi.org/10.1186/s40066-021-00292-y

Ankrah Twumasi, M., Jiang, Y., Osei Danquah, F., Chandio, A. A., & Agbenyo, W. (2020). The role of savings mobilization on access to credit: a case study of smallholder farmers in Ghana. *Agricultural Finance Review*, *80*(2), 275–290. https://doi.org/10.1108/AFR-05-2019-0055

Areebahoona, A., Tindimwebwa, K., & Okurut, F. (2024). Determinants of Access to Bank Credit by Smallholder Agricultural Households in Uganda : Evidence from UNHS 2019 / 2020. *East African Journal of Business and Economics*, *7*(2), 190–208. https://doi.org/10.37284/eajbe.7.2.2377.IEEE

Asea, G., Kwemoi, D. B., Sneller, C., Kasozi, C. L., Das, B., Musundire, L., Makumbi, D., Beyene, Y., & Prasanna, B. M. (2023). Genetic trends for yield and key agronomic traits in pre-commercial and commercial maize varieties between 2008 and 2020 in Uganda. *Frontiers in Plant Science*, *14*(March), 1–13. https://doi.org/10.3389/fpls.2023.1020667

Aseete, P., Barkley, A., Katungi, E., Ugen, M. A., & Birachi, E. (2023). Public–private partnership generates economic benefits to smallholder bean growers in Uganda. *Food Security*, *15*(1), 201–218. https://doi.org/10.1007/s12571-022-01309-5

Asiamah, T. A., Steel, W. F., & Ackah, C. (2021). Determinants of credit demand and credit constraints among households in Ghana. *Heliyon*, *7*(10), e08162. https://doi.org/10.1016/j.heliyon.2021.e08162

Assouto, A. B., & Houngbeme, D. J. L. (2023). Access to credit and agricultural productivity: Evidence from maize producers in Benin. *Cogent Economics and Finance*, *11*(1). https://doi.org/10.1080/23322039.2023.2196856

Auci, S., & Coromaldi, M. (2022). Adoption Determinants of Improved Seeds and Technical Efficiency of Ugandan Small Farmers. In Innovation in Small-Farm Agriculture. In I. M. C. & S. A. (Eds.) (Ed.), *Innovation in small-farm agriculture* (p. (pp. 207-216).). CRC Press.

Awotide1, B. ., Abdoulaye, T., A, A., & V.M, M. (2015). Impact of Access to Credit on Agricultural Productivity: Evidence from Smallholder Cassava Farmers in Nigeria. *AgEcon Search*, 18. file:///F:/Spec 2/Traffic Delay Model.pdf

Babirye, I., Otim, M. H., & Paparu, P. (2024). Quality and Price of Beans at the Market Node in Five Districts of. *Uganda Journal of Agricultural Sciences*, *22*(1), 15–34. https://doi.org/http://dx.doi.org/10.4314/ujas.v22i1.2

Badstue, L., Eerdewijk, A. van, Danielsen, K., Hailemariam, M., & Mukewa, E. (2020). How local gender norms and intra-household dynamics shape women's demand for laborsaving technologies: insights from maize-based livelihoods in Ethiopia and Kenya. *Gender, Technology and Development*, *24*(3), 341–361. https://doi.org/10.1080/09718524.2020.1830339

Beillouin, D., Ben-Ari, T., & Makowski, D. (2019). Evidence map of crop diversification strategies at the global scale. *Environmental Research Letters*, *14*(12). https://doi.org/10.1088/1748-9326/ab4449

Bhola, N. D. (2024). Assessment of Agriculture Productivity Performance in the Tarai Region of Nepal Bhola Nath Dhakal 1 1. *Economic Review of Nepal*, *7*(1), 24–32.

Biru, W. D., Zeller, M., & Loos, T. K. (2020). The Impact of Agricultural Technologies on Poverty and Vulnerability of Smallholders in Ethiopia: A Panel Data Analysis. *Social Indicators Research*, *147*(2), 517–544. https://doi.org/10.1007/s11205-019-02166-0

Bocher, T. F., Alemu, B. A., & Kelbore, Z. G. (2017). Does access to credit improve household welfare? Evidence from Ethiopia using endogenous regime switching regression. *African Journal of Economic and Management Studies*, *8*(1), 51–65. https://doi.org/10.1108/AJEMS-03-2017-145

Borku, A. W. (2025). Cassava (Manihot esculenta Crantz): its nutritional composition insights for future research and development in Ethiopia. *Discover Sustainability*, *6*(1). https://doi.org/10.1007/s43621-025-00996-2

Brooker, R. W., Bennett, A. E., Cong, W. F., Daniell, T. J., George, T. S., Hallett, P. D., Hawes, C., Iannetta, P. P. M., Jones, H. G., Karley, A. J., Li, L., Mckenzie, B. M., Pakeman, R. J., Paterson, E., Schöb, C., Shen, J., Squire, G., Watson, C. A., Zhang, C., … White, P. J. (2015). Improving intercropping: A synthesis of research in agronomy, plant physiology and ecology. *New Phytologist*, *206*(1), 107–117. https://doi.org/10.1111/nph.13132

Carter, M. R. (1989). THE IMPACT OF CREDIT ON PEASANT PRODUCTIVITY DIFFERENTIATION IN NICARAGUA. *Journal of Development Economics*, *31*, 13–36.

Chaiya, C., Sikandar, S., Pinthong, P., & Saqib, S. E. (2023). The Impact of Formal Agricultural

Credit on Farm Productivity and Its Utilization in Khyber Pakhtunkhwa , Pakistan. *Sustainability*.

Chandio, A. A., & Jiang, Y. (2018). Determinants of Credit Constraints: Evidence from Sindh, Pakistan. *Emerging Markets Finance and Trade*, *54*(15), 3401–3410. https://doi.org/10.1080/1540496X.2018.1481743

Chemura, A., Arumugum, P., Murken, L., Romanovska, P., Kutesa, E. A., von Loeben, S., & Gornott, C. (2025). Contribution of improved varieties to maize productivity under climate change in Uganda. *Food Security*. https://doi.org/10.1007/s12571-025-01564-2

Cherotich, J., Sibiko, K. W., & Ayuya, O. I. (2022). Analysis of extent of credit access among women farm-entrepreneurs based on membership in table banking (TB). *Agricultural Finance Review*, *82*(1), 89–112. https://doi.org/10.1108/AFR-08-2020-0125

Dawes, M., & Mushongachiware, R. (2024). *Financial services and financing mechanisms for ensuring the development of identified Sasso poultry and sorghum business models in Murewha and Mbire districts in Zimbabwe*. *1*(October).

Debertin, D. L. (2012). *Agricultural Production Economics* (Second Edi).

Diamoutene, A. K., & Jatoe, J. B. D. (2020). Access to credit and maize productivity in Mali. *Agricultural Finance Review*, *81*(3), 458–477. https://doi.org/10.1108/AFR-05-2020-0066

Economic Policy Research Centre. (2024). *Agricultural Finance Year Book*. 1–144. https://www.abi.co.ug/en/wp-content/uploads/filr/642/2020-AFYB-Final_Edited.pdf

Emong, H. R. (2023). An econometric analysis of modernized cereal production in reducing multidimensional poverty in Uganda, 1975-2014. *Review of Economics and Political Science*. https://doi.org/10.1108/REPS-04-2020-0051

Epule, T. E., Dhiba, D., Etongo, D., Peng, C., & Lepage, L. (2021). Identifying maize yield and precipitation gaps in Uganda. *SN Applied Sciences*, *3*(5), 1–12. https://doi.org/10.1007/s42452-021-04532-5

Erenstein, O., Jaleta, M., Sonder, K., Mottaleb, K., & Prasanna, B. M. (2022). Global maize production, consumption and trade: trends and R&D implications. *Food Security*, *14*(5), 1295–1319. https://doi.org/10.1007/s12571-022-01288-7

FAO. (2018). Enhancing national capacity for the management of Fall Armyworm (FAW): Focus in Uganda. *Training and Mobilizing Communities and Extension Personnel to Monitor and Respond to FAW*, 2. https://www.fao.org/3/CA1324EN/ca1324en.pdf

FAO. (2021). *Crop sector development strategy for Eastern Africa 2021–2026. FAO Subregional Office for Eastern Africa*. https://openknowledge.fao.org/handle/20.500.11766/12345

FAO. (2024). *Uganda Investment Plans and Opportunities; Hand IN Hand Investment Forum*.

Feder, G., Lau, L. J., Lin, J. Y., & Xiaopeng, L. (1989). Agricultural Credit and Farm Performance in China '. *JOURNAL OF COMPARATIVE ECONOMICS*, *526*, 508–526. https://doi.org/https://doi.org/10.1016/0147-5967(89)90024-3

Ferris, S., Robbins, P., Best, R., Seville, D., Buxton, A., Shriver, J., & Wei, E. (2014). Linking Smallholder Farmers to Markets and the Implications for Extension and Advisory Services - MEAS Discussion Paper Series on Good Practices and Best Fit Approaches in Extension and Advisory Service Provision. *MEAS Brief*, *4*(10), 1–46. www.meas-extension.org

Filipponi, T., Oommen, H., Harris, A., & Evans, P. (2024). Food consumption patterns, seasonal dietary diversity, and factors affecting food intake in rural Eastern Uganda: A mixed-methods cross-sectional study. *Appetite*, *201*(February), 107550. https://doi.org/10.1016/j.appet.2024.107550

FinScope. (2018). *FinScope Topline Findings Report Acknowledgements*. *June*.

Fita, M., Toma, S., Wei, W., Yirsaw, E., Ketema, H., & Bekele, B. (2025). A shift from multiple to monocropping farming system in response to change in agroforestry-dominated land use type in East Africa Rift Valley. *Environmental and Sustainability Indicators*, *27*(June), 100748. https://doi.org/10.1016/j.indic.2025.100748

Fuglie, K. O., Morgan, S., & Jelliffe, J. (2024). World Agricultural Production , Resource Use , and Productivity ,. *Economic Research Service*.

Grote, U., Fasse, A., Nguyen, T. T., & Erenstein, O. (2021). Food Security and the Dynamics of Wheat and Maize Value Chains in Africa and Asia. *Frontiers in Sustainable Food Systems*, *4*(February), 1–17. https://doi.org/10.3389/fsufs.2020.617009

Gujarati, N. D. (2003). Basic Econometrics. In *The Economic Journal* (Vol. 82, Issue 326). https://doi.org/10.2307/2230043

Isaga, N. (2018). Access to bank credit by smallholder farmers in Tanzania: a case study. *Afrika Focus*, *31*(1), 241–256. https://doi.org/10.21825/af.v31i1.9048

Jayme, A. E. S. J. M., & Lee, Y. (2024). Determinants of Credit Source Choice by Small-Scale Corn Farmers in the Philippines. *Journal of International Development Cooperation*, *19*(1), 73–94. https://doi.org/10.34225/jidc.2024.19.1.73

Jayne, T. S., Chamberlin, J., Traub, L., Sitko, N., Muyanga, M., Yeboah, F. K., Anseeuw, W., Chapoto, A., Wineman, A., Nkonde, C., & Kachule, R. (2016). Africa's changing farm size distribution patterns: the rise of medium-scale farms. *Agricultural Economics (United Kingdom)*, *47*, 197–214. https://doi.org/10.1111/agec.12308

Jayne, T. S., Mason, N. M., Burke, W. J., & Ariga, J. (2018). Review: Taking stock of Africa's second-generation agricultural input subsidy programs. *Food Policy*, *75*(October 2017), 1–14. https://doi.org/10.1016/j.foodpol.2018.01.003

Jensen, E. S. (2017). Does intercropping enhance yield stability in arable crop production ? A. *European Journal of Agronomy*, *91*(September), 25–33. https://doi.org/10.1016/j.eja.2017.09.009

Jimi, N. A., Nikolov, P. V., Malek, M. A., & Kumbhakar, S. (2019). The effects of access to credit on productivity: separating technological changes from changes in technical efficiency. *Journal of Productivity Analysis*, *52*(1–3), 37–55. https://doi.org/10.1007/s11123-019-00555-8

Kabila, J. O. (2022). ASSESSING THE EFFECT OF COVID-19 ON AGRICULTURAL PRODUCTION IN GULU. *(Doctoral Dissertation, GULU UNIVERSITY)*, *5*(8.5.2017), 2003–2005.

Kankwatsa, P., Kyomugisha, M., Muzira, R., Mutenyo, H., Ntakyo, P. R., & Muhumuza, J. B. (2024). Impact of Banana Xanthomonas Wilt Epidemics on Farmers' Livelihoods in the South Western Agro-Ecological Zone of Uganda. *OALib*, *11*(06), 1–33. https://doi.org/10.4236/oalib.1111692

Kassie, M., Marenya, P., Tessema, Y., Jaleta, M., Zeng, D., Erenstein, O., & Rahut, D. (2018). Measuring Farm and Market Level Economic Impacts of Improved Maize Production Technologies in Ethiopia: Evidence from Panel Data. *Journal of Agricultural Economics*, *69*(1), 76–95. https://doi.org/10.1111/1477-9552.12221

Kaur, A., & Sharma, S. (2025). *Intercropping a sustainable holistic approach for improving growth and productivity of crops*. *8*(4), 133–139.

Kaviku, A. M., Muraya, M. M., Muchiri, J. M., & Mwangi, I. D. (2024). Determinants of microfinance credit uptake and the amount of credit by smallholder dairy cattle farmers in Maara sub-county, Tharaka Nithi County, Kenya. *World Journal of Advanced Research and Reviews*, *21*(3), 1953–1960. https://doi.org/10.30574/wjarr.2024.21.3.0887

Kehinde, A. D., Adeyemo, R., & Ogundeji, A. A. (2021). Does social capital improve farm productivity and food security? Evidence from cocoa-based farming households in Southwestern Nigeria. *Heliyon*, *7*(3), e06592. https://doi.org/10.1016/j.heliyon.2021.e06592

Kipkogei, S., Han, J., Mwalupaso, G., Tanui, J., & Brenya, R. (2025). The synergistic effects of microcredit access and agricultural technology adoption on maize farmer's income in Kenya. *PLoS ONE*, *20*(1 January), 1–26. https://doi.org/10.1371/journal.pone.0316014

Kisaame, E. K., & Kavuma, N. S. (2023). *Factors Influencing Maize and Cassava Commercialization Among Smallholder Farmers in Uganda*. 1–16.

Lelisho, A. E., & Mesfin, E. L. (2024). Impact of credit use on crop productivity and gross income of smallholder farmers: a propensity score matching approach. *Discover Agriculture*, *2*(1). https://doi.org/10.1007/s44279-024-00058-7

Linh, T. N., Long, H. T., Chi, L. Van, Tam, L. T., & Lebailly, P. (2019). Access to rural credit markets in developing countries, the case of Vietnam: A literature review. *Sustainability (Switzerland)*, *11*(5), 1–18. https://doi.org/10.3390/su11051468

Liqiong, L., Wang, W., Gan, C., Cohen, D. A., & Nguyen, Q. T. . (2019). Rural Credit Constraint and Informal Rural Credit Accessibility in China. *Sustainability*, *11*(7), 1935. https://doi.org/10.3390/su11071935

Lukwago, M. M., Micheal, O. D., & Mugonola, B. (2025). Institutional and technical drivers of intra-household marketing decisions for smallholder farmers in Uganda: evidence from Northern Uganda. *Cogent Food and Agriculture*, *11*(1). https://doi.org/10.1080/23311932.2025.2498775

Mabaya, E., Waithaka, M., Tihanyi, K., Mugoya, M., Kanyenji, G., Ssebuliba, R., & Kyotalimye, M. (2021). Uganda Country Report 2024. *Btitransformationindex*.

Madembo, C., Mhlanga, B., & Thierfelder, C. (2020). Productivity or stability ? Exploring maize-legume intercropping strategies for smallholder Conservation Agriculture farmers in Zimbabwe. *Agricultural Systems*, *185*(August), 102921. https://doi.org/10.1016/j.agsy.2020.102921

Makate, C., Angelsen, A., Hunduma, T., & Tveitereid, O. (2025). The dynamics of crop diversity and seed use in the context of recurrent climate shocks and poverty : Seasonal panel data evidence from rural Uganda. *World Development Perspectives*, *39*(December 2024). https://doi.org/https://doi.org/10.1016/j.wdp.2025.100698

Makuluni, E. F., & Dunga, H. M. (2022). *THE IMPACT OF ACCESS TO CREDIT ON WELFARE INEQUALITY IN MALAWI Fatso E. MAKULUNI Hannah Mayamiko DUNGA * University of South Africa, Pretoria South Africa*. *67*(2), 50–66. https://doi.org/10.2478/SUBBOEC-2022-0009

Manoharan, N., & Varkey, R. S. (2021). *Agricultural credit and agricultural productivity across Indian states : An analysis*. *December 2020*, 1–12. https://doi.org/10.1002/pa.2597

Martiniello, G., Owor, A., Bahati, I., & Branch, A. (2022). The fragmented politics of sugarcane contract farming in Uganda. *Journal of Agrarian Change*, *22*(1), 77–96. https://doi.org/10.1111/joac.12455

Marus, E., Fabian, M., Mary, E., & Sammy, G. P. (2021). Financial inclusion: Is it a precursor to agricultural commercialization amongst smallholder farmers in Uganda? A comparative analysis between Lango and Buganda sub-regions. *Journal of Economics and International Finance*, *13*(1), 1–12. https://doi.org/10.5897/jeif2020.1093

Mcauley, W. P., Bourgault, M., & Congreves, K. A. (2025). Agriculture , Ecosystems and Environment Productivity , soil fertility and soil health benefits associated with intercropping small grains and oilseeds with legumes in the semi-arid environment of the Canadian Prairies. *Agriculture, Ecosystems and Environment*, *389*(December 2024), 109694. https://doi.org/10.1016/j.agee.2025.109694

Midamba, D. C. (2022). Determinants of Maize Production Income in Western Uganda. *East African Journal of Agriculture and Biotechnology*, *5*(1), 1–13. https://doi.org/10.37284/eajab.5.1.532.1

Midamba, D. C., Kwesiga, M., & Ouko, K. O. (2023). Determinants of adoption of sustainable agricultural practices among maize producers in Northern Uganda. *Cogent Social Sciences, 10(1).* https://doi.org/https://doi.org/10.1080/23311886.2023.2286034

Midega, C. A. O., Bruce, T. J. A., Pickett, J. A., & Khan, Z. R. (2015). Ecological management of cereal stemborers in African smallholder agriculture through behavioural manipulation. *Ecological Entomology*, *40*(S1), 70–81. https://doi.org/10.1111/een.12216

Moahid, M., Khan, G. D., Yoshida, Y., Joshi, N. P., & Maharjan, K. L. (2021). *Agricultural Credit and Extension Services : Does Their Synergy Augment Farmers ' Economic Outcomes ?* https://doi.org/10.3390/su13073758

Mothobi, O., & Kebotsamang, K. (2024). The impact of network coverage on adoption of Fintech

and financial inclusion in sub-Saharan Africa. *Journal of Economic Structures*, *13*(1). https://doi.org/10.1186/s40008-023-00326-7

Mujeri, M. K. (2015). Improving Access of the Poor to Financial Services. *A Report Prepared for the General Economics Division of the Planning Commission to Serve as a Background Study for Preparing the 7th Five Year Plan (2016-2020) of Bangladesh*, *January 2015*.

Mukoki, J., Mukisa, I., Ssebulime, K., & Musoke, E. (2023). Household Income Diversification Strategies, Welfare and Child Nutrition in Uganda: A Dynamic Panel Analysis 2005-2020. *International Journal of Empirical Economics*, *2*(4), 1–38. https://doi.org/10.1142/S2810943023500129

Mutayoba, V. R. (2025). *East African Journal of Business and Economics Maize Prices : The Great Shilling Showdown-Who ' s Got the Corn for the*. *8*(3), 298–308. https://doi.org/10.37284/eajbe.8.3.4106

Mutungi, E., Bua, B., & Kwesiga, P. (2025). Navigating Educational Disruptions. *Jumuga Journal of Education, Oral Studies, and Human Sciences*, *8*(1), 1–8. https://doi.org/10.35544/jjeoshs.v8i104

Muwereza, N. (2024). *Journal of Development and Agricultural Economics Analysis of the predictors of the post-harvest losses among smallholder maize farmers: A case study of eight districts from Uganda Muwereza Nelson*. *17*(March), 1–11. https://doi.org/10.5897/JDAE2024.1429

Mwalupaso, G. E., Wang, S., Geng, X., & Kipkogei, S. (2025). Bridging credit gaps for sustainable agriculture: The role of rural savings and credit cooperatives among smallholder farmers. *Agricultural Economics (Czech Republic)*, *71*(5), 254–272. https://doi.org/10.17221/436/2024-AGRICECON

Mwaura, F. (2014). Effect of Farmer Group Membership on Agricultural Technology Adoption and Crop Productivity in Uganda. *African Crop Science Journal*, *22*(s4), 917–927.

Nabuuma, D., Ekesa, B., Faber, M., & Mbhenyane, X. (2021). Community perspectives on food security and dietary diversity among rural smallholder farmers: A qualitative study in central Uganda. *Journal of Agriculture and Food Research*, *5*, 100183. https://doi.org/10.1016/j.jafr.2021.100183

Nahalomo, A., Ole, P., Id, I., Andreassen, A., Kaaya, A., Rukooko, A. B., & Rukundo, P. M. (2023). Food insecurity , dietary diversity and the right to adequate food among households

in landslide-prone communities in Eastern Uganda : A cohort study. *PLoS ONE*, *18*(4), 1–22. https://doi.org/10.1371/journal.pone.0283078

Nakato, A. L., Kabanda, U., Nakitende, P., & Muyanga, M. (2024). *Effect of Pesticide Use on Crop Production and Food Security in*. *March*.

Ninsiima, R., Bulyaba, R., & Makosa, D. (2023). *DETERMINANTS OF PARTICIPATION IN AGRICULTURAL GROUP GUARANTEE LOANS: A CASE OF SMALLHOLDER FARMERS IN EASTERN UGANDA*. *23*(4), 23039–23060.

Njuki, J., Eissler, S., Malapit, H., Meinzen-dick, R., Bryan, E., & Quisumbing, A. (2022). A review of evidence on gender equality , women ' s empowerment , and food systems. *Global Food Security*, *33*(June), 100622. https://doi.org/10.1016/j.gfs.2022.100622

Nordjo, R. E., & Adjasi, C. K. D. (2020). The impact of credit on productivity of smallholder farmers in Ghana. *Agricultural Finance Review*, *80*(1), 91–109. https://doi.org/10.1108/AFR-10-2018-0096

Nwafor, C. U. (2021). Marketing channel preference among smallholder cocoyam farmers in South Africa. *Journal of Agribusiness and Rural Development*, *59*(1), 415–428. https://doi.org/10.17306/j.jard.2021.01507

Nwokoro, C. C., Kreye, C., Necpalova, M., Adeyemi, O., Barthel, M., Pypers, P., Hauser, S., & Six, J. (2022). Cassava-maize intercropping systems in southern Nigeria: Radiation use efficiency, soil moisture dynamics, and yields of component crops. *Field Crops Research*, *283*(April), 108550. https://doi.org/10.1016/j.fcr.2022.108550

Nwokoro, C. C., Kreye, C., Necpalova, M., Adeyemi, O., Busari, M., Tariku, M., Tokula, M., Olowokere, F., Pypers, P., Hauser, S., & Six, J. (2021). Developing recommendations for increased productivity in cassava-maize intercropping systems in Southern Nigeria. *Field Crops Research*, *272*, 108283. https://doi.org/10.1016/j.fcr.2021.108283

Ogunleye, A., Akinloye, M. O., Kehinde, A., Ajayi, O. M., & Wongnaa, C. A. (2024). Impacts of credit constraints on adoption of risk management strategies and income of maize farmers in Northern Nigeria. *Agricultural Finance Review*, *84(2/3)*, 114-142.

Ogutu, S. O., & Qaim, M. (2019). Commercialization of the small farm sector and multidimensional poverty. *World Development*, *114*, 281–293. https://doi.org/10.1016/j.worlddev.2018.10.012

Olugbenga, O. A., Alimi, F. L., & Onyebuchi, C. H. (2016). *ACCESS TO FORMAL CREDIT*

FACILITIES AMONG SMALLSCALE CROP FARMERS' IN GWAGWALADA AREA COUNCIL, ABUJA, NIGERIA. *1*(January), 57–66.

Ortiz-Bobea, A., Ault, T. R., Carrillo, C. M., Chambers, R. G., & Lobell, D. B. (2021). Anthropogenic climate change has slowed global agricultural productivity growth. *Nature Climate Change*, *11*(4), 306–312. https://doi.org/10.1038/s41558-021-01000-1

Osabohien, R., Osuagwu, E., Osabuohien, E., Ekhator-Mobayode, U. E., Matthew, O., & Gershon, O. (2020). Household access to agricultural credit and agricultural production in Nigeria: A propensity score matching model. *South African Journal of Economic and Management Sciences*, *23*(1), 1–11. https://doi.org/10.4102/sajems.v23i1.2688

Osewe, M., Aijun, L., & Jiqin, H. (2023). Sustainable intensification and food security: A panel data assessment of the smallholder maize farmers in Uganda. *Global Food Security*, *39*(October), 100724. https://doi.org/10.1016/j.gfs.2023.100724

Owusu, S. (2017a). Effect of Access to Credit on Agricultural Productivity: Evidence from Cassava Farmers in the Afigya-Kwabre District of Ghana. *International Journal of Innovative Research in Social Sciences & Strategic Management Techniques*, *4*(2), 55–67. http://internationalpolicybrief.org/journals/international-scientific-research-consortium-journals/intl-jrnl-of-innovative-research-in-soc-sci-strategic-mgt-techniques-vol4-no2-september-2017

Owusu, S. (2017b). *Factors Affecting Farm Households' Access to Credit in the Afigya-Kwabre District of Ghana http://internationalpolicybrief.org/journals/ijasr-online-journals/intl-jrnl-of-sci-research-in-social-sciences-mgt-studies-vol2-no1-sept-2017*. *2*(1), 98–113. http://internationalpolicybrief.org/journals/ijasr-online-journals/intl-jrnl-of-sci-research-in-social-sciences-mgt-studies-vol2-no1-sept-2017

Pretty, J., Benton, T. G., Bharucha, Z. P., Dicks, L. V., Flora, C. B., Godfray, H. C. J., Goulson, D., Hartley, S., Lampkin, N., Morris, C., Pierzynski, G., Prasad, P. V. V., Reganold, J., Rockström, J., Smith, P., Thorne, P., & Wratten, S. (2018). Global assessment of agricultural system redesign for sustainable intensification. *Nature Sustainability*, *1*(8), 441–446. https://doi.org/10.1038/s41893-018-0114-0

Quach, H. M. (2016). Does access to finance improve household welfare? *Investment Management and Financial Innovations*, *13*(2), 76–86. https://doi.org/10.21511/imfi.13(2).2016.08

Race, D., Suka, A. P., Oktalina, S. N., Bisjoe, A. R., Muin, N., & Arianti, N. (2022). Modern

Smallholders: Creating Diversified Livelihoods and Landscapes in Indonesia. *Small-Scale Forestry*, *21*(2), 203–227. https://doi.org/10.1007/s11842-021-09495-4

Rahman, Z., Islam, M. J., Mahmuda, S., & Hossain, D. M. E. (2022). Factors Influencing Farmers' Access to Formal Credit Market in Naogaon District of Bangladesh: An Empirical Analysis. *European Journal of Business and Management Research*, *7*(5), 30–38. https://doi.org/10.24018/ejbmr.2022.7.5.1593

Rao, D. N., & Mahalingam, M. (2025). AI and ML Modeling and Autonomous Finance in Microfinance: An Overview. Computational Intelligence for Autonomous Finance. *Wiley Online Library*, 167–197.

Raseduzzaman, M. (2016). Intercropping for enhanced yield stability and food security. *Swedish University of Agricultural Sciences Library*, 1–59. http://stud.epsilon.slu.se/9396/1/raseduzzaman_m_160817.pdf

Ruben, R. (2024). What Smallholders Want : Effective Strategies for Rural Poverty Reduction. *Sustainability*.

Rukhsana, R., Xia, L. C., Ishap, M. N., Mukhtar, M., & Waseem, M. (2016). Determinants Influencing the Demand of Microfinance in. *International Journal of Agricultural Extension and Rural Development Studies*, *3*(4), 45–58. http://www.eajournals.org/wp-content/uploads/Determinants-Influencing-the-Demand-of-Microfinance-in-Agriculture-Production-and-Estimation-of-Constraint-Factors.pdf

Salima, W., Manja, L. P., Chiwaula, L. S., & Chirwa, G. C. (2023). The impact of credit access on household food security in Malawi. *Journal of Agriculture and Food Research*, *11*(December 2022), 100490. https://doi.org/10.1016/j.jafr.2022.100490

Saptia, Y., & Rusnani. (2024). The simultaneous effect of credit on sustainable food crop production and agricultural economic growth in Indonesia. *IOP Conference Series: Earth and Environmental Science*, *1302*(1). https://doi.org/10.1088/1755-1315/1302/1/012134

Semalulu, O., Kibaya, P., Kyebogola, S., Mworozi, E., Sewankambo, N., & Gebru, B. (2022). Profitability and Farmer Acceptability of Selected Climate Smart Technologies and Practices for Maize-Beans Production in Drought-Prone Areas, Uganda. *Agricultural Sciences*, *13*(11), 1259–1284. https://doi.org/10.4236/as.2022.1311077

Siaw, A., Jiang, Y., Ankrah Twumasi, M., Agbenyo, W., Ntim-Amo, G., Osei Danquah, F., & Ankrah, E. K. (2021). The ripple effect of credit accessibility on the technical efficiency of

maize farmers in Ghana. *Agricultural Finance Review*, *81*(2), 189–203. https://doi.org/10.1108/AFR-05-2020-0068

Silong, A. K. F., & Gadanakis, Y. (2019). Credit sources, access and factors influencing credit demand among rural livestock farmers in Nigeria. *Agricultural Finance Review*, *80*(1), 68–90. https://doi.org/10.1108/AFR-10-2018-0090

Taremwa, N. K., Macharia, I., Bett, E., & Majiwa, E. (2021). *Journal of Agribusiness and Rural Development IMPACT OF AGRICULTURAL CREDIT ACCESS ON AGRICULTURAL PRODUCTIVITY AMONG MAIZE AND RICE SMALLHOLDER FARMERS IN RWANDA*.

Tingting, L., Randall, J. F. B., & Matthew, T. H. (2018). Factors Influencing Farmers ' Factors Influencing Farmers' Adoption of Best Management Practices: A Review and Synthesis. *Sustainability*, 1–26. https://doi.org/10.3390/su10020432

UBOS. (2015). Statistical Abstract Information on: Environmental, Demographic, Socio-economic, Production and Macroeconomic sectors. *Statistical Abstract*, *October*, 353.

UBOS. (2024). *NATIONAL POPULATION AND HOUSING CENSUS 2024*. *1*(December).

Ullah, A., Mahmood, N., Zeb, A., & Kächele, H. (2020). Factors determining farmers' access to and sources of credit: Evidence from the rain-fed zone of pakistan. *Agriculture (Switzerland)*, *10*(12), 1–13. https://doi.org/10.3390/agriculture10120586

Vanlauwe, B., Hungria, M., Kanampiu, F., & Giller, K. E. (2019). The role of legumes in the sustainable intensification of African smallholder agriculture: Lessons learnt and challenges for the future. *Agriculture, Ecosystems and Environment*, *284*(March), 106583. https://doi.org/10.1016/j.agee.2019.106583

Wabwire, J. M. (2020). FINANCIAL INCLUSION DETERMINANTS AND THEIR EFFECT ON UTILISATION OF FORMAL FINANCIAL SERVICES BY SMALLHOLDER FARMER. *A Thesis Report Presented to the Institute of Postgraduate Studies of Kabarak University in Partial Fulfilment of the Requirements for the Award of Doctor of Philosophy Degree in Business Administration (Financ*, *2*, 1–9.

Wadeya, L. O. (2022). *Determinants of Credit Access and Its Effect on Smallholder Dairy Farm Income in Kinangop Sub-County, Nyandarua County, Kenya.*

Wangui, L. M. (2019). The impact of access to credit on process innovation. *Heritage and Sustainable Development*, *1*(2), 48–63. https://doi.org/10.37868/hsd.v1i2.1

Wollburg, P., Thomas, B., Yuchen, L., Christopher, U., & Douglas, G. (2024). Crop yields fail to

rise in smallholder farming systems in sub - - Saharan Africa. *ECONOMIC SCIENCES SUSTAINABILITY SCIENCE*, 1–6. https://doi.org/10.1073/pnas.

Yildirim, E., & Ekinci, M. (2017). *Intercropping Systems in Sustainable Agriculture*. *2*(1), 100–110.

Zabatantou, L. H., Bouity, C. A., & Owonda, F. (2023). Impact of Agricultural Credit on Productivity. *Theoretical Economics Letters*, *13*(06), 1434–1462. https://doi.org/10.4236/tel.2023.136081

APPENDIX

Variables	VIF	1/VIF
Credit access	2.28	0.438211
Cropping combination		
maize-beans	1.61	0.621898
maize-cassava	1.25	0.800153
maize-beans-cassava	1.44	0.696311
Credit access * cropping combination		
maize beans	2.13	0.46942
maize cassava	1.25	0.797025
maize-beans-cassava	1.31	0.760951
Fertilizer/pesticide use	1.11	0.904885
Hired labour	1.09	0.917311
Farming experience	1.04	0.961396
Education		
primary	2.76	0.36195
secondary	2.42	0.412853
higher	1.77	0.566433
Household size	1.08	0.929717
Asset count	1.09	0.916732
Extension services	1.26	0.794986
Farmer experience	1.21	0.827248
Region		
Eastern	1.66	0.601539
Northern	1.52	0.656254
Western	1.47	0.679229
Mean VIF	**1.54**	