DETERMINANTS AND IMPLICATIONS OF LAND MANAGEMENT PRACTICES FOR MAIZE YIELD IN EASTERN UGANDA

BY

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A DISSERTATION SUBMITTED TO THE DIRECTORATE OF RESEARCH AND GRADUATE TRAINING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A DEGREE OF MASTER OF ARTS IN GEOGRAPHY OF KYAMBOGO UNIVERSITY

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DECLARATION

I **NEKESA IRENE EGESSA.** declare that this dissertation report titled ***"DETERMINANTS AND IMPLICATIONS OF LAND MANAGEMENT PRACTICES FOR MAIZE YIELD IN EASTERN UGANDA"*** is my original work and has never been submitted or presented to any university or institution of higher learning for any award.

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APPROVAL

We the undersigned certify that this research entitled Assessment of the ***"DETERMINANTS AND IMPLICATIONS OF LAND MANAGEMENT PRACTICES FOR MAIZE YIELD IN EASTERN UGANDA"*** *has* been conducted and compiled under our guidance and supervision, and is now ready for submission to the Directorate of Research and Graduate Training with our approval.

Signature…………………………………………………..Date……………………………

DR. GABIRI GEOFREY

Signature……………………………………………….Date…………………………………

ASSOCIATE PROFESSOR. BARASA BERNARD

DEDICATION

To my three beloved daughters, Wilma, Bithum, and Myra. May this thesis inspire and guide you on your academic journeys, reminding you that hard work and determination can conquer any obstacle. I dedicate this work to you with all my love and pride. May you find joy, growth, and success in all your pursuits. "Trust in the Lord with all your heart and lean not on your own understanding; in all your ways submit to Him, and he will make your paths straight." (Proverbs 3:5-6).

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I stand at the culmination of a journey, a journey marked by milestones, challenges and triumphs, and as I reflect upon its completion, I find myself humbled and profoundly grateful to those who have been instrumental in shaping this path.

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ABSTRACT

Soil degradation threatens maize farming sustainability in eastern Uganda, necessitating effective land management practices. Despite prior research, the socio-economic factors influencing land management remain underexplored. This study investigated sustainable land management practices to boost soil productivity, mitigate land degradation, and improve maize yields in the Kyoga basin. Data were gathered from 379 households through interviews and focus groups, focusing on the adoption of practices like fertilizer application, pesticide use, and tillage conservation. The study analyzed adoption factors such as education, land ownership, access to inputs, and crop yields, alongside the impact of organic and inorganic fertilizer use on maize production. Descriptive statistics summarized the prevalence of different practices, while Chi-square tests and ANOVA compared practices and yields between the Kyoga plains and highland agro-ecological zones (AEZs). Logistic regression identified significant adoption factors. Results showed regional differences ($P<0.05$), with the Kyoga plain AEZ benefiting more from inorganic fertilizer and pesticide use. Key adoption determinants included soil fertility loss (69%), soil erosion (60%), and access to land (78.6%). The study concludes that addressing soil degradation requires tailored educational programs and localized interventions to enhance farmers' knowledge and improve agricultural sustainability, contributing to food security and poverty reduction in the region. The study recommended the need to promote LMPs that enhance soil fertility, such as agroforestry and mulching, to improve soil health & maize in both AEZs. Improved access to inputs and credit facilities to smallholder farmers, especially in both AEZs, promote the Use of Inorganic Fertilizers and pesticides in Highland AEZ since the application of inorganic fertilizers and pesticides significantly improved maize yields in the Kyoga plain AEZ; these practices should be promoted in the Highland AEZ as well. **Key words:** Soil degradation, sustainable land management, maize yield, adoption factor, agro-ecological zones (AEZs).

CHAPTER ONE:

INTRODUCTION

1.1 Background

Land management practices have gained increasing importance on the global scale as nations grapple with the challenges of climate change, biodiversity loss and food security (Rattan et al., 2015). Land management practices refer to the systematic planning, implementation, and monitoring of actions aimed at optimizing the use of land resources while promoting sustainability, productivity and environmental conservation (Rockstrom et al., 2016; Pretty et al., 2018). The imperative to adopt land management practices is driven by rapid population growth and exacerbated climatic crisis (Pham et al., 2023). This conviction stems from the understanding that LMP is a dependable strategy to mitigate adverse environmental impacts and enhance efficiency in food supply system (Berti et al., 2020). It comprises an adverse set of strategies and techniques designed to optimize the use of land resources, balancing Agricultural productivity with environmental sustainability. (Giller et al., 2015). A wide range of (LMPs) includes the application of fertilizers, contour ploughing, mulching crop rotation, and agroforestry (Thapa et al., 2010).

Globally, land management practices play a crucial role in agricultural sustainability, particularly in maize farming, a staple crop worldwide (Nair et al., 2017). Simultaneously, a significant majority, exceeding 80% of the rural populations globally, remain dependent on agriculture for their livelihoods (Roshan et al., 2023). Nevertheless, sustainable agriculture development faces challenges such as land degradation and the growing reliance on chemical fertilizer application and pesticides. The global population is projected to reach 9.7 billion by 2050, necessitating increased food production (FAO 2017). Efficient land management practices are essential to meet the growing demand for food while ensuring environmental conservation. According to the Food Agricultural Organization (FAO 2015), agricultural land management practices have the potential to increase global food production by 58% and lift 480 million people out of poverty, contributing significantly to sustainable development goals. The role of sustainable land management practices in achieving the Sustainable Development Goals by 2030 indicates the potential impact on poverty reduction and food security. This has contributed significantly to SDG 1 and SDG 2 zero hunger. However, despite this potential, the adoption of such practices varies widely across regions, and is influenced by socioeconomic, cultural and environmental factors.

The causes of inadequate land management practices globally are multifaceted, including resource constraints, lack of awareness, and socio-economic factors. This is exacerbated by the use of unstainable land management practices such as overreliance on chemical inputs, improper irrigation, and deforestation (IPCC, 2019): The impacts are profound, with soil erosion and declining fertility compromising agricultural productivity (Bai et al., 2018; Lal et al., 2015) asserting that land degradation costs about 2-5% of agricultural GDP annually. The degradation of land exacerbates poverty, especially in developing regions, as agricultural livelihoods are directly impacted. In maize farming, land management practices directly influence production outcomes. Agricultural practices such as agroforestry and conservation agriculture can enhance soil fertility, positively affecting maize yields (Muriuk et al., 2018). Conversely, poor land management contributes to soil degradation, reducing the resilience of maize crops to climate variability and limiting overall productivity in sub-Saharan Africa. Agriculture, being the main source of livelihood for a significant portion of the population, contributes substantially to the gross domestic product of numerous countries in Sub-Saharan Africa (FAO 2019). The export of agricultural products, including crops like maize constitutes a major source of foreign exchange earnings for the African countries (Fafchamps et al., 2019). The adoption of land management practices is a critical component of ensuring food security. Land in Africa serves as both a home and workplace, shared harmoniously with the entire biotic complex. The Africa Agriculture Status Report (ASR, 2019) emphasizes the need for sustainable intensification of agriculture to address declining soil fertility and increased land degradation.

In Uganda, where maize accounts for a significant portion of agricultural production, smallholder farmers in the Kyoga plains and highland agroecological zones are particularly affected by the challenges of land degradation and declining yields (Sserwanga et al., 2019). The Uganda Bureau of Statistics (UBOS, 2022) reports that maize is grown on over 1.5 million hectares, yet many smallholder farmers face yield declines of up to 40% due to soil erosion, nutrient depletion, and inadequate land management practices (Mulinde et al., 2019; UBOS, 2022). The vulnerability of farmers in these regions is heightened by limited access to essential inputs such as fertilizers and quality seeds, as well as their reliance on rain-fed agriculture, which is increasingly disrupted by climate variability (Owuor et al., 2018; Salami et al., 2021).

Several studies have examined land degradation and the adoption of land management practices in Uganda and other regions. For instance, Sserwanga et al. (2019) highlighted the impact of soil erosion on declining crop productivity in the Kyoga plains, while Mugerwa et al. (2020) examined the role of climate-smart agricultural practices in enhancing resilience to climate variability. Additionally, Mulinde et al. (2019) focused on the challenges of soil fertility management in eastern Uganda. However, despite the growing body of literature, there is limited understanding of the socio-economic factors that influence the adoption of sustainable LMPs in the specific context of maize farming in the Kyoga plains and highland AEZs. While much attention has been given to the environmental effects of LMPs, fewer studies have explored how smallholder farmers' perceptions, economic status, and access to resources shape their willingness and ability to implement these practices (Saguye et al., 2021; Nakalembe et al., 2022).

The magnitude of this problem is substantial, with declining maize yields directly affecting the food security and livelihoods of over 7 million smallholder farmers in eastern Uganda (UBOS, 2019). In regions such as the Kyoga plains and highlands AEZs, poor land management and erratic rainfall exacerbate soil degradation, threatening household income and national food production (Mulinde et al., 2019). The vulnerability of smallholder farmers is further amplified by inadequate support structures, including limited agricultural extension services and insufficient government policies to promote sustainable practices (Ajayi et al., 2016; Akinsola et al., 2020). This study aims to bridge the gap by examining the key factors influencing the adoption of sustainable LMPs and their effects on maize productivity. Understanding the socio-economic, environmental, and institutional barriers to adoption will provide insights into how policy interventions and targeted support can enhance the sustainability of maize farming. The findings will inform government policies, agricultural extension programs, and community-level initiatives, ultimately contributing to improved soil health and increased maize yields in eastern Uganda.

1.2 Statement of the problem.

Soil fertility decline because of soil degradation significantly threatens maize productivity in eastern Uganda, particularly in the Kyoga plains and highland agro-ecological zones (AEZ). Improper land management practices, population pressure, and erratic climate patterns drive this degradation. The magnitude of the problem is substantial, as increasing soil erosion rates have led to the loss of topsoil and thus a decline in soil fertility, adversely affecting maize yield. While interventions like sustainable land management practices such as afforestation and soil conservation programs have been introduced, their effectiveness is limited by low farmer awareness and adoption, exacerbated by resource shortages.

Previous studies have examined the socio-economic significance of maize farming and the impact of land management practices on soil productivity in eastern Uganda. For instance, Omony et al. (2018) highlighted the socio-economic importance of maize farming, while Namubiru et al. (2017) and Nimusiima et al. (2018) explored the implications of land management practices on soil productivity. Additionally, Kalyebara et al. (2021) identified the influence of socioeconomic factors on adopting sustainable agricultural practices, and Adebayo et al. (2022) examined the effects of climate variability on agricultural productivity in the region. Despite these contributions, there is still limited information and scientific data on the socio-economic factors that influence farmers' decisions to adopt effective land management practices (LMPs) and how these practices affect maize yields. Yet this is crucial for developing targeted interventions that can promote soil conservation, improve maize yields, and support long-term agricultural sustainability. Therefore, the study seeks to bridge this knowledge gap by investigating the socio-economic determinants of LMP adoption and evaluating their impact on maize yields in eastern Uganda.

1.3 General objective of the study

The general objective of the study was to improve understanding of the major land management practices that determine soil productivity of maize farming systems within the Lake Kyoga basin, with the aim of improving maize production in the Kyoga plain and highland agro-ecological zones.

1.4 Specific objective

The specific objectives were:

i. To characterize the land management practices adopted by maize farmers in Kyoga plain and Highland agro-ecological zones.
ii. To examine the factors that determine the adoption of land management practices among maize farmers in Kyoga plain and Highland agro-ecological zones.

iii. To evaluate the effect of adopted land management practices on maize yield, within Kyoga plain and Highland agro-ecological zones.

1.5 Research Questions

From the specific objectives of the study, the following research questions were developed to guide the study:

1. What are the primary land management practices adopted by farmers for maize production in the Kyoga plain and highland agro-ecological zones?
2. What are the key factors that determine the adoption of land management practices in maize production within Kyoga plain and highland agroecological zones?
3. How do adopted land management practices affect maize yield within Lake Kyoga plains and Highland agro-ecological zones?

1.6 Significance of the study

If barriers to adoption are understood, identifying the factors that influence the adoption of sustainable practices is vital for designing targeted interventions. Resources and extension services can be tailored to address these specific challenges. This knowledge also helps create awareness campaigns focusing on critical drivers of behavior change among farmers. As a result, the study can contribute to accelerating the adoption of sustainable agricultural systems.

Evaluating the impact of land management practices on soil quality is essential for ensuring the long-term sustainability of Agricultural production. Healthy soils are the foundation of productive agriculture, and understanding how various practices affect soil structure, nutrient content and water retention can guide farmers in making informed decisions. Additionally, this information is critical for policy formation as it highlights the environmental benefits of sustainable practices and their potential contribution to mitigating issues such as erosion and nutrient depletion.

Understanding the range of household land management practices is crucial because it provides insights into the level of awareness and adoption of sustainable practices in these zones. This knowledge can inform policymakers, Agricultural extension services and NGOs about the effectiveness of existing initiatives and where, additionally, characterizing these practices helps create a foundation for sharing successful strategies among farmers, ultimately contributing to more resilient and productive agricultural systems.

The study holds significance at multiple levels, addressing key policy frameworks on national, regional, and global scales. On the National Level, this study aligns with Uganda's National Agricultural Policy (NAP), which emphasizes promoting sustainable land management practices to enhance agricultural productivity and ensure food security. By identifying the factors influencing the adoption of sustainable land management practices (LMPs) in maize farming and evaluating their impact on soil quality, this research directly contributes to national efforts aimed at mitigating land degradation and improving smallholder farmers' resilience to climate change. The findings could inform the National Agriculture Extension Policy (NAEP), by guiding resource allocation and improving the effectiveness of extension services tailored to specific farming challenges in the Kyoga plains and highland AEZ.

At the regional level, this study supports the goals of the Comprehensive Africa Agriculture Development Programme (CAADP), under the African Union's Agenda 2063, which seeks to achieve agricultural transformation, food security, and sustainable development across the continent. By offering insights into adopting sustainable land management practices and their impact on productivity, this research contributes to regional efforts to increase agricultural output while maintaining environmental sustainability. It also aligns with the East African Community (EAC) Agriculture and Rural Development Policy, which aims to promote climate-smart agriculture and address regional land degradation.

Globally, the study contributes to the achievement of several Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on Land). By fostering a better understanding of sustainable land management practices that enhance soil productivity, the research supports efforts to combat desertification, restore degraded land, and ensure sustainable agricultural practices. The study also aligns with the United Nations Framework Convention on Climate Change (UNFCCC) objectives and the Paris Agreement, which focus on improving agricultural resilience to climate variability through sustainable land use practices.

1.6 Scope of the study

The study was conducted in two agro-ecological zones within eastern Uganda. The Kyoga plains and Highland agro-ecological zones of the Kyoga basin. These regions offer a wide range of agro-ecological conditions, from the fertile plains to the highlands. This diversity allows for examining land management practices across varying altitudes, soil types and microclimates. It provides a unique opportunity to explore how these practices adapt to different conditions and impact soil productivity. Besides, the Kyoga plains and highland agro-ecological zones are representative of many other similar agro-ecological regions within Uganda, partially those facing challenges related to soil fertility, rainfall variability and land management practices. Thus, findings from this study can be applied to a broader context-additionally, these areas are known for agricultural significance within Uganda, where agriculture is a primary livelihood. The challenges faced by farmers in these zones are indicative of larger issues that affect the region's food security and rural livelihoods. These factors collectively make these regions an ideal location for research addressing the critical issues of soil productivity, land management and environmental sustainability.

In terms of research content, the study focused on assessing and comparing maize production status and adoption of land management practices in the Kyoga plains and highland agro-ecological zones of eastern Uganda relative to other districts within these regions. This comparative approach aims to provide a comprehensive understanding of the factors influencing agricultural productivity and utilization of land management practices. By comparing these regions to other districts in terms of maize production and land management practices, the study can uncover insights that are crucial for regional agricultural development. Understanding the disparities in maize production and adoption rates among districts will help identify best practices, challenges and opportunities. It can inform targeted interventions and policy recommendations to improve agricultural productivity and environmental sustainability in both Kyoga plains and highland agro-ecological zones and their nieghbouring areas.

The research employed a mixed methods approach, combining quantitative surveys to gather data on maize production, land management practices and the factors for adoption with qualitative interviews and focus group discussions to gain deeper insights into the underlying dynamics. A comparative analysis was conducted to assess the differences between the Kyoga plains and highland agro- ecological zones

1.7 Conceptual framework

This detailed representation visually illustrates the relationship between various variables. The independent variables are the land management practices adopted by maize farmers in Kyoga basin agro-ecological zones. The dependent variable is maize yield and environmental factors within the Kyoga basin agro-ecological zone. The intervening variables are the factors for adoption and their ultimate impact on crop yield. Thus, by analyzing this mediation process, the study aims to uncover the pathways through which these variables influence each other, offering insights for better agricultural practices.

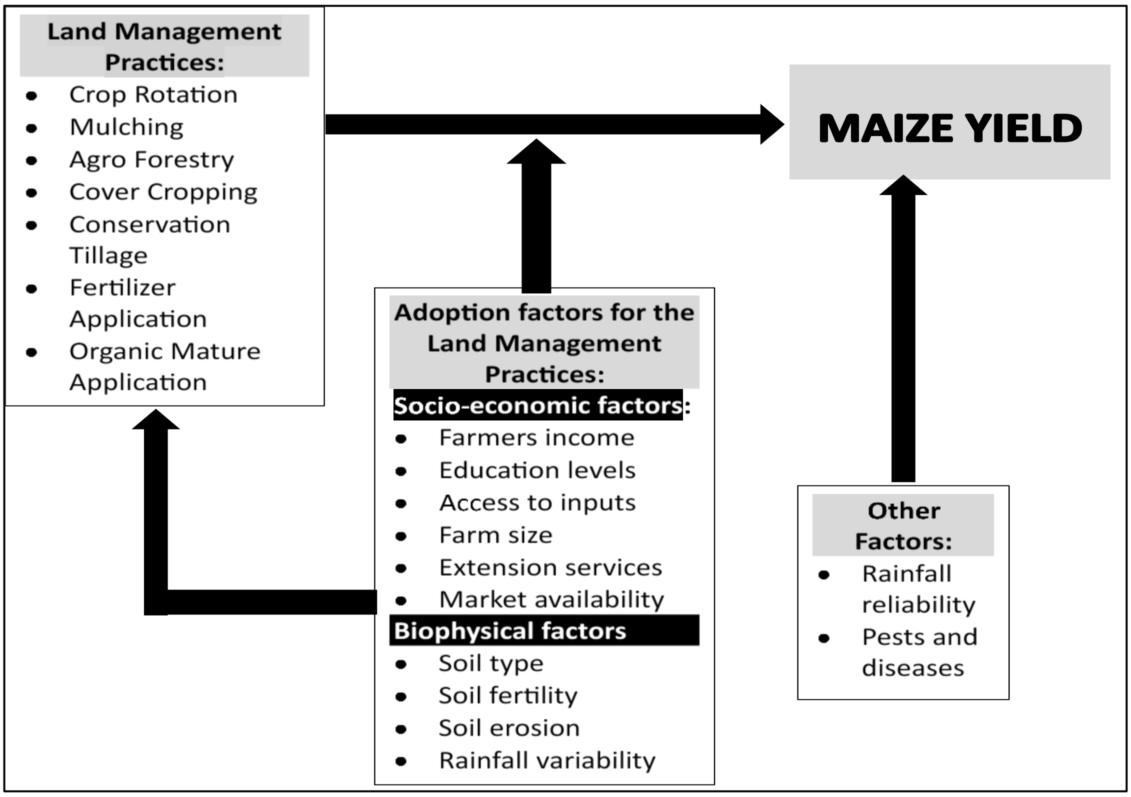

Figure 1.1: Conceptual framework of the study

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter contains a review of related literature in line with determinants of the adoption of land management practices to enhance soil productivity in a maize farming system.

2.2 Agro-ecological zones and Rainfall variability

Agroecological zones (AEZs) and rainfall patterns play a crucial role in shaping the agricultural potential of various regions. AEZs are defined by climatic, soil, and topographical conditions, which determine the suitability for different agricultural activities (FAO, 2016). Globally, studies have shown that the classification of AEZs is essential in understanding agricultural productivity and challenges such as climate variability and land degradation (Glover et al., 2019). In Africa, AEZ-based studies have revealed the importance of agro-ecological suitability for crop production, particularly under changing climatic conditions (Gachene & Kimaru, 2018; Tumushabe et al., 2019)

Globally, AEZs are recognized as essential tools for understanding agricultural potential and limitations. They aid in sustainable land management and planning by highlighting the interaction of climatic, soil, and topographical factors that shape agricultural systems. According to Thiemig et al. (2015), "agro-ecological zones are regions with distinct agricultural potentials and constraints, shaped by the interaction of climatic, soil, and topographical factors.

In Africa, AEZs are crucial for understanding the diverse agricultural potential across the continent. The continent's varied climatic, soil, and topographical conditions lead to the establishment of multiple AEZs, each with unique agricultural characteristics and challenges. For example, studies have shown that integrating crop and livestock farming in semi-arid regions can enhance resilience to climatic variability (Ekaya et al., 2019). This is particularly relevant in areas such as Uganda’s Eastern and north Eastern Savannah, which face high temperatures and variable rainfall patterns (Mukiibi et al., 2016).

East Africa encompasses a wide range of agro-ecological zones (AEZs) due to its diverse climate and topography, which play a key role in determining agricultural productivity (Bamutaze et al., 2017; Ngetich et al., 2019). In Uganda, the main AEZs include the Lake Victoria Crescent, Eastern and North Eastern Savannahs, Northern Moist Farmlands, Western Highlands, South Western Grasslands, and Western Savannah Grasslands. Each of these zones is defined by distinct climatic, soil, and vegetation conditions, which in turn influence the types of crops that can be cultivated and the agricultural practices that are most suitable for each zone (Tumushabe et al., 2018; Nabikolo et al., 2020). Each zone is characterized by distinct climatic, soil, and vegetation conditions, influencing the types of crops cultivated and suitable agricultural practices. In Eastern Uganda, particularly the Kyoga plains and highland agro-ecological zones, understanding AEZs and rainfall variability is crucial for agricultural planning and productivity. This AEZ surrounds Lake Victoria, including urban areas like Kampala, Entebbe, and Jinja. It experiences a tropical rainforest climate with bimodal rainfall (Nsubuga et al., 2017), supporting diverse crops such as bananas, coffee, and maize (Kiwanuka et al., 2018). Eastern and North Eastern Savannah, including areas like Soroti and the Karamoja region, this zone has a semi-arid climate with high temperatures affecting agricultural practices. Emphasizing integrated crop and livestock farming has been shown to enhance resilience in these regions (Ekaya et al., 2019). Northern Moist Farmlands, covering areas such as Gulu and Arua, this AEZ features a tropical savannah climate that supports various crops and livestock (Nampala et al., 2020; Tumwine et al., 2018).

Western highlands, including regions like Kabale and the Rwenzori mountains, this zone has a cool, temperate climate ideal for high-value crops like tea and coffee. Agroforestry practices in these highlands have been beneficial (Mugisha et al., 2022). South Western Grassland, covering areas such as Mbarara and Ntungamo, this AEZ supports a variety of crops and livestock farming. Integrated crop-livestock systems enhance resilience in these regions (Bamutaze et al., 2018; Kanyesigye et al., 2020). Western Savannah Grasslands, including regions like Hoima and Masindi, this zone has a tropical savannah climate that supports a mix of crop and livestock farming. Sustainable soil management is crucial for maintaining productivity here (Mbabazi et al., 2017; Katongole et al., 2023).

In conclusion, understanding agro-ecological zones and rainfall variability is essential for sustainable agricultural development. These zones help optimize land use, enhance productivity, and promote environmental sustainability. In Uganda, the diverse AEZs—from the Lake Victoria Crescent to the Western Savannah Grasslands—each present unique opportunities and challenges. Effective agricultural policies and practices tailored to these zones can significantly address food security and climate change challenges, particularly in regions like Eastern Uganda.

2.3 Land management and soil productivity in agricultural systems

Land management involves the strategic use of practices to optimize the quality of agricultural land (Derpsch et al., 2016). On the contrary, soil productivity refers to the ability of the soil to support healthy crop growth and high yields (Lal et al., 2014). The relationship between land management practices and soil productivity is a critical aspect of sustainable agriculture. Understanding how practices like conservation tillage, crop rotation, and organic matter incorporation, impact soil properties and crop yields is vital, shedding light on the outcomes of different land management practices on soil health and agricultural productivity. Globally, agriculture is a cornerstone of food production, economic stability and livelihoods. Sustainable land management practices have gained prominence as essential tools to ensure the long-term viability of agricultural systems (FAO 2019, emphasizing the urgent need for sustainable practices to address challenges related to soil degradation. The adoption of these practices varies across regions with different agroecological zones requiring context-specific strategies. (UN 2015) stressed the interconnectedness of these goals and the role of sustainable agriculture in achieving them.

Across the African continent, agriculture is pivotal sector that provide employment and sustenance to millions. Gebrekidan et al. (2017) highlighted the role of indigenous knowledge and traditional farming systems in preserving soil fertility. This diversity underscores the importance of understanding region-specific land management practices and their adoption in relation to local conditions. Land management is a growing focus, with efforts to combat soil degradation and enhance agricultural productivity. Mekonnen et al. (2019) have highlighted the diversity of land management practices in African agriculture, from conservation tillage to agroforestry. Africa's agro ecological diversity demands tailored approaches to land management. Sub-Saharan Africa faces challenges, including soil erosion, nutrient depletion and climate variability. Zingore et al. (2015) discussed these challenges, emphasising the importance of sustainable practices to mitigate soil degradation and ensure food security. The promotion of conservation agriculture, crop rotation and organic matter incorporation has gained traction, particularly in regions with erratic patterns.

One influential study by Derpsch et al. (2016) focused on conservation agriculture practices and their effects on soil properties and crop yields. This research emphasized the potential of no-till and minimum-tillage practices to improve soil organic matter, water retention, and nutrient content. It highlighted that these practices can increase maize yields while preserving soil quality. Furthermore, a study by Zingore et al. (2015) investigated the benefits of crop rotation and organic matter incorporation in maize-based cropping systems in sub-Saharan Africa. The findings emphasized the role of these practices in enhancing soil fertility and nutrient cycling, which in turn, resulted in improved crop yields. The research also underlined the importance of tailoring practices to the specific agroecological conditions of the region.

The incorporation of organic matter, such as crop residues or green manure, into the soil is a well-documented land management practices (Fosu-Mensah et al., 2016; Martnez et al., 2017) investigated the effects of organic matter incorporation in maintain soil fertility in sub-Saharan Africa. Organic matter incorporation enhances soil structure, adds nutrients and fosters microbial activity. It is particularly relevant for regions, where soil quality has been compromised. This practice helps to maintain soil productivity, foster sustainable agriculture and reduce the reliance on synthetic fertilizers. (Benemann et al., 2018) emphasized that sustainable practices like organic matter addition and reduced tillage promote microbial diversity in soil, leading to improved nutrient mineralization and overall soil health.

In the context of East Africa, research by Place et al. (2017) explored the impact of agro-forestry systems on soil fertility and maize yields. This study demonstrated the potential of integrating trees into agricultural systems to improve soil health and increase crop productivity. It also highlighted the relevance of these findings for regions with varying agroecological diversity, where agroforestry practices can be adapted to local conditions. (Thierfelder et al., 2017) focused on conservation agriculture practices in maize production systems in sub-Saharan Africa. The research emphasized the positive effects of these practices on soil properties, particularly in terms of organic matter and water infiltration. It highlighted that these practices can contribute to resilient and sustainable agricultural systems. Furthermore, conservation tillage practices have gained prominence in sustainable agriculture. Scholars such as Smith et al., (2018) have highlighted the benefits of conservation tillage, which involves reduced or no-till farming, in mitigating soil erosion, improving soil structure and enhancing water retention.

Crop rotation is another fundamental practice with notable impacts on soil quality.it is a strategy in which different crops are cultivated sequentially on the same field. (Brown et al., 2016) emphasized the significance of crop rotation in breaking disease and pest cycles, reducing nutrient depletion and improving soil fertility. The characterization of crop rotation practices involves determining suitable crop sequences and their effects on soil crop health

In eastern Uganda, the Kyoga plains and highland agro-ecological zones are of significant agricultural importance. Maize farming is a key component of the local economy, providing both food and income. Scholars such as Omony et al. (2018) have examined the dynamics of maize farming in this region, highlighting its socio-economic importance (Namubiru-Mwaura et al. (2017) and have explored land management practices and their implications for soil productivity and crop yield. However, there is a need for further investigation to comprehensively identify and evaluate the impact of these practices within specific agroecological zones of Kyoga plains and highland agroecological zones. The importance of agricultural research in Uganda cannot be overstated. Local institutions such as National Agricultural Research Organization (NARO) are actively involved in agricultural research (Kasenge et al., 2019) and highlighted the collaborative efforts of NARO in addressing agricultural challenges in Uganda. However, there is room for further research focusing on specific agroecological zones like the Kyoga basin.

Despite these strengths, several weaknesses limit the broader applicability of the findings. One significant limitation is the overgeneralization of recommendations across large regions. For instance, research by Derpsch et al. (2016) and Zingore et al. (2015) provides broad conclusions applicable to sub-Saharan Africa but fails to account for the unique agro-ecological conditions of smaller, localized regions like the Kyoga plains and highland AEZs. This approach can undermine the effectiveness of recommended practices, as they may not be well suited to specific local environmental conditions and socio-economic contexts. Moreover, many studies offer limited exploration of the socio-economic dimensions that influence the adoption of sustainable land management practices. While Smith et al. (2018) and Mekonnen et al. (2019) provide valuable insights into environmental benefits; they neglect to sufficiently address the economic viability, labour constraints, and access to resources faced by smallholder farmers in developing regions like eastern Uganda. These socio-economic factors are crucial for understanding why certain land management practices may or may not be adopted by farmers, particularly in resource-limited settings.

Additionally, the literature tends to emphasize short-term environmental outcomes without adequately considering the long-term impacts of these practices. Studies by Fosu-Mensah et al. (2016) and Martinez et al. (2017) focus primarily on immediate improvements in soil structure and nutrient cycling but fail to explore the sustainability of these benefits over extended periods, especially in the context of climate variability and persistent soil degradation issues.

A key research gap is the lack of localized studies that examine land management practices within specific agroecological contexts, such as the Kyoga plains and highland AEZs. Most of the existing literature focuses on broader regions within sub-Saharan Africa, and while the findings are valuable, they do not address the particular challenges faced by farmers in these smaller, distinct zones. As Namubiru-Mwaura et al. (2017) and Omony et al. (2018) suggest, there is a pressing need for more region-specific research that takes into account local climatic conditions, soil types, and farming systems. Another gap is the limited focus on the socio-economic factors that drive or hinder the adoption of sustainable land management practices. While environmental and agronomic outcomes are well-studied, the literature has not sufficiently explored how factors such as access to credit, availability of labor, and the influence of local policies affect farmers' decisions to adopt or reject specific land management techniques. For instance, Place et al. (2017) and Kasenge et al. (2019) highlight the role of institutions in promoting sustainable practices, but more research that is detailed is needed to understand how these dynamics play out in localized agro-ecological zones like the Kyoga plains. Finally, there is a gap in long-term studies on the sustainability of land management practices. While short-term improvements in soil productivity and crop yields have been documented, little is known about how these benefits hold up over time, particularly in the face of challenges like climate variability, market fluctuations, and population growth.

These studies conducted in the past decades have significantly contributed to the understanding of the relationship between land management practices and soil productivity in agricultural systems. They underscore the importance of practices that enhance soil health, improve nutrient availability, and ultimately increase crop yields. The insights from these studies are particularly relevant to the study in the Kyoga plains and highland agroecological zones, where the evaluation of land management practices and their effects on soil properties is central to enhancing agricultural sustainability.

2.4 Maize production in Uganda's agro-ecological zones

Maize is a critical staple crop in Uganda, vital for food security and rural income generation. However, production varies significantly across Uganda's diverse agro-ecological zones (AEZs), shaped by climatic conditions, soil fertility, and land management practices (LMPs) available in each region. As Mutegi et al. (2020) explain, "Variations in agro-climatic conditions significantly affect the viability of maize production across Uganda, with implications for yield outcomes and sustainable agricultural practices." This essay explores maize productivity across Uganda's key AEZs, focusing on the unique potentials and challenges in the Eastern region, especially the Kyoga Plains and highland areas.

The Western Region, known for its fertile volcanic soils, benefits from high rainfall and favorable temperatures. The Albertine Zone and Rwenzori Mountain areas report relatively high maize yields, averaging 3-4 tons per hectare (Mugisha & Diiro, 2017). Despite this, challenges arise due to soil erosion and nutrient depletion, especially on mountainous slopes. As one study highlights, continuous cultivation without restorative practices leads to "significant soil degradation, reducing maize productivity over time" (Mugisha & Diiro, 2017).

Moving to the Northern Region, which includes the Acholi and West Nile sub-regions, yields are more modest, around 1-1.5 tons per hectare. This disparity is largely due to the drier conditions and relatively poor soil quality in the region (Kansiime & Mastenbroek, 2016). Nonetheless, natural seasonal flooding offers some replenishment of soil nutrients, supporting limited maize cultivation.

In the Central Region, including the Lake Victoria Crescent, productivity is moderate, with yields around 2.5-3 tons per hectare. The area benefits from consistent rainfall, which stabilizes productivity. However, urbanization and population pressures are increasingly consuming arable land, posing a long-term challenge to maize farming. As Nkonya et al. (2016) discuss, "Rising urban sprawl limits available farmland, straining the region's agricultural capacity."

The Eastern Region — particularly the Kyoga Plains and highland AEZs — represents a vital maize-growing area with both considerable potential and significant challenges. Yields here average around 2-3 tons per hectare under traditional farming methods, yet the region's bi-modal rainfall pattern offers an opportunity for higher productivity with proper LMPs (Bagamba et al., 2019). According to Asio et al. (2021), "Eastern Uganda's agro-ecological diversity provides fertile soils and favorable weather patterns, making it one of the more promising maize-growing regions." Despite these advantages, Eastern Uganda faces severe challenges from soil degradation and limited access to modern agricultural inputs. Musinguzi et al. (2019) observe, "The depletion of soil nutrients due to unsustainable farming practices remains a primary obstacle to achieving maximum maize productivity." This situation is compounded by inconsistent access to fertilizers and limited farmer training on effective LMPs, such as cover cropping and mulching. In response, various stakeholders advocate for policies promoting the adoption of practices like agroforestry and minimal tillage, which not only improve soil health but also enhance crop resilience.

Land Management Practices (LMPs) have been increasingly adopted in Eastern Uganda to address these issues. Cover cropping, for instance, plays a crucial role in soil conservation, reducing erosion, and enriching soil organic matter. Additionally, agroforestry practices integrate trees within maize farms, offering windbreaks and enhancing biodiversity. As Nakazi et al. (2017) assert, "Adopting sustainable LMPs is crucial for Eastern Uganda, where both ecological and economic benefits can enhance maize yields." However, the adoption rate remains limited due to high input costs and a lack of support infrastructure. Thus, maize production in Uganda's AEZs illustrates the potential of the country's agricultural landscape, but also the limitations imposed by environmental and economic challenges. The Eastern region, with its fertile Kyoga Plains and highland zones, stands out as a promising area that could benefit significantly from improved LMPs. By addressing the barriers to adoption, Uganda can optimize maize productivity across these zones, reinforcing food security and enhancing rural livelihood

This research underscored the crucial contribution of maize to household food security and income generation, emphasizing its significance in the context of rural subsistence agriculture. Additionally, the study highlighted the adoption of maize farming practices to varying agroecological conditions, which is particularly relevant to the diverse landscapes of the Kyoga plains and highland agro-ecological zones. Furthermore, a research by Nakavuma et al., (2016) emphasized the importance of maize in Uganda's crop production. The study identified the varying agro-ecological zones within the country, each with unique characteristics and challenges. It pointed to the adaptability of maize cultivation to different zones, acknowledging the need for tailored approaches to maximize maize yields.

According to Nimusiima et al. (2018) investigated the impacts of climate change scenarios on maize yield in Uganda. This research highlighted maize production in eastern and northern Uganda, is anticipated to face instability, becoming susceptible to climatic variations and exhibiting sensitivity to changes in land productivity. Equally, a study on crop suitability in Northern and Eastern Uganda by Mulinde et al. (2019). Despite concerted efforts to encourage the adoption of innovative agricultural practices, these regions have witnessed a significant decrease in land productivity, so there is need to a understand the adaptation measures they are implementing in land management and determine which land management practices would be better.

A study conducted by Mwai et al. (2015) assessed the maize value chain in Uganda. This research highlighted the economic significance of maize, particularly in regions like Kyoga plains, where maize farming is the dominant agricultural activity. The study revealed the potential for value addition and market opportunities within the maize sector, which is critical for rural economies in these zones. These studies conducted in the past decades shed light on the paramount role of maize production and farming in Uganda, emphasizing its link to specific agro-ecological zones. These findings underscore the importance of understanding the dynamics of maize farming within the Kyoga plains, and highland agro-ecological zones, considering their unique characteristics and challenges in promoting food security and economic growth.

2.5 Adoption of land management practices for maize production

Adoption of land management practices, according to Tittonell et al. (2017), refers to the deliberate use of sustainable techniques to enhance soil health, water management, and overall agricultural sustainability in cropping systems, especially in maize production. This area has been extensively researched across sub-Saharan Africa, including Uganda. Understanding the factors that influence farmers' decisions to adopt these sustainable land management practices is crucial for promoting environmentally friendly and economically viable agriculture. Several studies have made significant contributions to this field. Tittonell et al. (2017) explored the adoption of conservation agriculture practices in sub-Saharan Africa, highlighting the socio-economic and environmental determinants. Their research emphasized the importance of contextual factors such as conservation tillage, crop rotation, and organic matter incorporation, showing that successful adoption depends on tailoring practices to meet the specific needs and conditions of farmers. For example, Pittelkow et al. (2015) found that conservation tillage reduces soil erosion, improves water infiltration, and contributes to soil carbon sequestration in maize farming. Furthermore, integrated pest management, as discussed by Nyasani et al. (2019), combines biological control and the use of resistant crop varieties with reduced pesticide application to manage pests sustainably.

Another important study by Mutenje et al. (2016) assessed the adoption of sustainable agricultural practices in maize production and stressed the role of socio-economic factors, such as access to credit and land tenure security, in influencing farmers' decisions. Their work also highlighted the significance of extension services and farmer-to-farmer learning. In Uganda, Mutenje et al. (2017) specifically investigated the adoption of sustainable agricultural practices among smallholder farmers, emphasizing that access to information, social capital, and community networks are key determinants of adoption. Similarly, Bashir et al. (2018) emphasized that higher education levels and access to extension services significantly enhance the adoption of sustainable practices.

However, despite the contributions of these studies, there are notable gaps in the literature. One weakness is that many studies, such as those by Derpsch et al. (2016) and Zingore et al. (2015), provide generalized recommendations for large regions like sub-Saharan Africa without addressing the specific agro-ecological nuances of smaller areas, such as the Kyoga plains and highland AEZ in Uganda. This lack of localized focus may result in recommendations that are not always applicable to farmers in these specific zones. Mulinde et al. (2019), for example, identified a significant research gap regarding the socio-economic factors influencing the adoption of sustainable land management practices within the Lake Kyoga Basin. They noted that despite farmers actively adopting good land management practices, the region is experiencing a decline in land productivity and considerable climate variability. While Nkonya et al. (2016) emphasized the potential of sustainable practices to enhance soil productivity and crop yields; they did not thoroughly investigate the socio-economic dynamics that affect farmers' decisions to adopt these practices. Additionally, studies by Fosu-Mensah et al. (2016) and Martinez et al. (2017), while insightful on the benefits of organic matter incorporation, do not explore the long-term impacts of these practices on different soil types or in the context of climate variability. Moreover, research on conservation tillage and agroforestry, though promising, often lacks a thorough investigation into their economic viability for smallholder farmers. For instance, Smith et al. (2018) focused on environmental outcomes but did not address the practical challenges or economic constraints that might hinder the adoption of conservation tillage.

A major gap in the literature is the limited research on specific agroecological zones like the Kyoga plains and highland AEZ in Uganda. While Omony et al. (2018) and Namubiru-Mwaura et al. (2017) have addressed land management in these regions, more comprehensive evaluations are needed on how these practices affect soil productivity and maize yields in these specific areas. Furthermore, most studies do not fully integrate socioeconomic factors such as access to resources, education, or market dynamics, nor do they examine the role of policies and institutions in supporting the adoption of these practices. The present study seeks to address this gap by providing a detailed analysis of the socio-economic factors influencing the adoption of sustainable land management practices among maize farmers in the Kyoga plains and highland AEZ. By focusing on these dimensions, the study will contribute valuable insights that can inform targeted policy interventions aimed at enhancing maize productivity and promoting sustainable agriculture. The findings will also provide localized insights that are better suited to the unique challenges of these zones, such as soil degradation and declining maize yields.

In conclusion, this study builds on previous research by offering a comprehensive analysis of land management practices in the Kyoga plains and highland AEZ, filling important gaps in the literature. Its findings will contribute to more sustainable agricultural practices, improve maize yields, and offer practical recommendations for smallholder farmers, ultimately making it a valuable addition to the field of sustainable agriculture in Uganda

2.6 Assessment of the effect of land management practices on maize yield.

Land management practices play a crucial role in determining agricultural productivity and sustainability. Effective land management can enhance soil fertility, water retention, and maize yield, while poor practices can lead to soil degradation, erosion, and reduced agricultural output. This Study explores the impact of various land management practices on maize yield, drawing on scholarly research and the significant findings in areas such as soil fertility, water management, and sustainable agriculture practices.

Globally, Soil fertility management, including the application of organic and inorganic fertilizers, crop rotation, and cover cropping, has been widely researched. Zhang et al., (2016) found that integrated nutrient management, which combines organic and inorganic fertilizers, significantly improves soil fertility and crop yields in maize production systems in China. This practice enhances soil organic matter content and microbial activity, which are crucial for nutrient availability and plant growth. Similarly, Lal et al. (2018) emphasized the importance of conservation tillage and organic amendments in enhancing soil structure and fertility. Their research demonstrated that conservation tillage, combined with compost and manure, increased wheat and corn yields by 20-30% compared to conventional tillage practices. Effective water management is another critical factor influencing maize yield (Nouri et al., 2019). Techniques such as drip irrigation, mulching, and rainwater harvesting have been shown to significantly affect agricultural productivity. According to (Fan et al. 2016), drip irrigation systems in arid and semi-arid regions of India led to a 50% increase in tomato yields compared to traditional flood irrigation methods. Furthermore, Lal et al. (2018) highlighted the benefits of mulching in maize cultivation in sub-Saharan Africa, showing that mulch application reduced soil moisture evaporation, maintained soil temperature, and suppressed weed growth, resulting in a 15-25% increase in maize yields.

Despite extensive research on soil fertility management and water management techniques globally, including the application of organic and inorganic fertilizers, conservation tillage, an irrigation system, there remains a significant gap in understanding the socio-economic and context-specific factors that influence the adoption of these practices in smallholder farming systems, particularly in sub-Saharan Africa. While studies by Zhang et al. (2016) and Lal et al. (2016) and Lal et al. (2018) demonstrate the potential of integrated nutrient management and conservation tillage to improve crop yield they focus primarily on large-scale or more controlled environments, leaving a gap in addressing smallholder farmers' unique challenges. Furthermore, research has focused largely on the technical efficacy of these practices, with a limited investigation into how local conditions, farmer awareness, resource access, and policy support affect their adoption. This gap is particularly evident in regions like Uganda’s Lake Kyoga Basin, where despite the demonstrated benefits of such practices, their adoption remains inconsistent. Therefore, further research is needed to explore these socio-economic barriers and regional-specific dynamics that hinder the widespread adoption of effective soil fertility and water management techniques.

Sustainable agriculture practices, including agroforestry, intercropping, and crop diversification, have also been linked to improved crop yields. (Pretty et al., 2020) examined the impact of agroforestry on crop productivity in East Africa and found that integrating trees with crops provided shade, improved soil fertility through leaf litter decomposition, and enhanced biodiversity, leading to a 30-40% increase in maize and bean yields. Similarly, Smith et al. (2017) investigated the effects of intercropping legumes with cereals in South Asia, reporting a 20-35% yield increase in intercropped systems compared to sole cropping. The adoption of precision agriculture technologies, such as GPS-guided machinery, remote sensing, and data analytics, has revolutionized land management practices. Mulla, 2019) assessed the impact of precision farming on crop yields in the United States and found that precision agriculture practices led to yield increases of up to 25% in corn and soybean production. (Basso et al., 2020) highlighted that precision agriculture not only improves yields but also enhances resource use efficiency, reducing the environmental footprint of farming.

In Sub-Saharan Africa, sustainable land management practices are crucial for enhancing agricultural productivity and ensuring food security. Conservation tillage, crop rotation, integrated nutrient management, and organic amendments have shown significant promise. (Lal et al. (2018) demonstrated that conservation tillage and the use of organic amendments, such as compost and manure, substantially improved soil fertility and crop yields in various African countries. This is particularly important in regions with degraded soils and low organic matter content. The benefits of effective water management in Africa are also well-documented. (Lal et al. (2018) noted the advantages of mulching in sub-Saharan Africa, where erratic rainfall patterns pose a significant challenge to crop production. Mulching helps retain soil moisture, reduce evaporation, and suppress weeds, leading to higher yields. Additionally, practices such as rainwater harvesting and efficient irrigation systems are vital for optimizing water use in water-scarce regions.

In East Africa, particularly Eastern Uganda, agroforestry, intercropping, and crop diversification are key strategies for improving crop yields and enhancing sustainability. (Pretty et al. (2020) found that agroforestry practices in East Africa increased maize and bean yields by 30-40%, thanks to improved soil fertility and biodiversity. This region also benefits from intercropping, as shown by

(Smith et al. (2017), who reported a 20-35% yield increase in intercropped systems involving legumes and cereals. In Eastern Uganda, specific land management practices have been adapted to local conditions to improve agricultural productivity. For instance, conservation tillage and the use of organic amendments, such as compost and manure, have been promoted to enhance soil fertility and structure. Studies in the region have demonstrated that these practices can lead to significant yield increases, supporting the overall sustainability of farming systems.

In conclusion, recent scholarly research has documented the impact of land management practices on crop yield. Conservation tillage, crop rotation, integrated nutrient management, agroforestry, efficient water management, and organic amendments have all been shown to enhance agricultural productivity. These practices contribute to sustainable farming by improving soil health, increasing nutrient use efficiency, and enhancing resilience to climatic variations. Future research should continue to focus on optimizing these practices for different agroecological zones, including specific regions like Eastern Uganda, to maximize their benefits.

CHAPTER THREE:

METHODOLOGY

3.1 Introduction

This chapter describes the methodology employed in the study, including the research design and detailed data collection and analysis methods for the respective study objectives.

3.2 Description of the study area

3.2.1 Location

The study was conducted in the Lake Kyoga basin Agro-ecological zones (Figure 3.1). Two zones were selected, including the Kyoga plains and the highland ranges of Mountain Elgon. Mbale District is located in the Eastern region of Uganda, lying along the western slopes of Mount Elgon, which forms part of the highland agro-ecological zone (Zziwa et al., 2012). The district is at Latitude 1.0708°N, and Longitude 34.1788°E. It is bordered by Sironko District to the north, Bududa District to the east, Manafwa District to the southeast, and Butaleja District to the southwest. Mbale town, the district's administrative center, is a significant urban hub in eastern Uganda. Pallisa District, also in the Eastern region, is situated in the Kyoga plains agro-ecological zone at Latitude 1.1731°N, and Longitude 33.8666°E. It is bordered by the districts of Budaka to the southeast, Kibuku to the south, and Kumi to the west. Pallisa is known for its flat terrain and fertile soils, with agriculture being a key economic activity. The proximity to Lake Kyoga and the associated wetlands, such as the Mpologoma Swamp, influences the local hydrological system, making small-scale farming common in this region (Nsubuga et al., 2014). Both districts, located within Uganda's eastern region, play vital roles in agricultural productivity and were chosen for this study due to their contrasting agro-ecological conditions, as well as the observed decline in maize yields in recent years (Mulinde et al., 2019).

The Kyoga plains are low-lying, relatively flat areas with fertile soil. Numerous wetlands and lakes, including Lake Kyoga, which plays a crucial role in the region’s hydrology and agriculture (DDEG 2023), characterize the plains. The highland agro-ecological zones are hilly or mountainous areas with varying altitudes (Atukunda et al., 2015). They often have diverse soil types due to their topography (Agro-climatic zone and agro-ecological zone 2021). The study area was chosen due to its agricultural importance, representing different agro-ecological conditions. Kyoga plains offer insights into lowland agricultural practices, while the highland agroecological zone provides perspectives on hilly or mountainous regions. This diversity allows for a comprehensive assessment of land management practices and their effects on maize farming in different contexts. Representative districts were considered in each agroecological zones, with the Pallisa district chosen for the Kyoga plains and the Mbale district for the highland range.

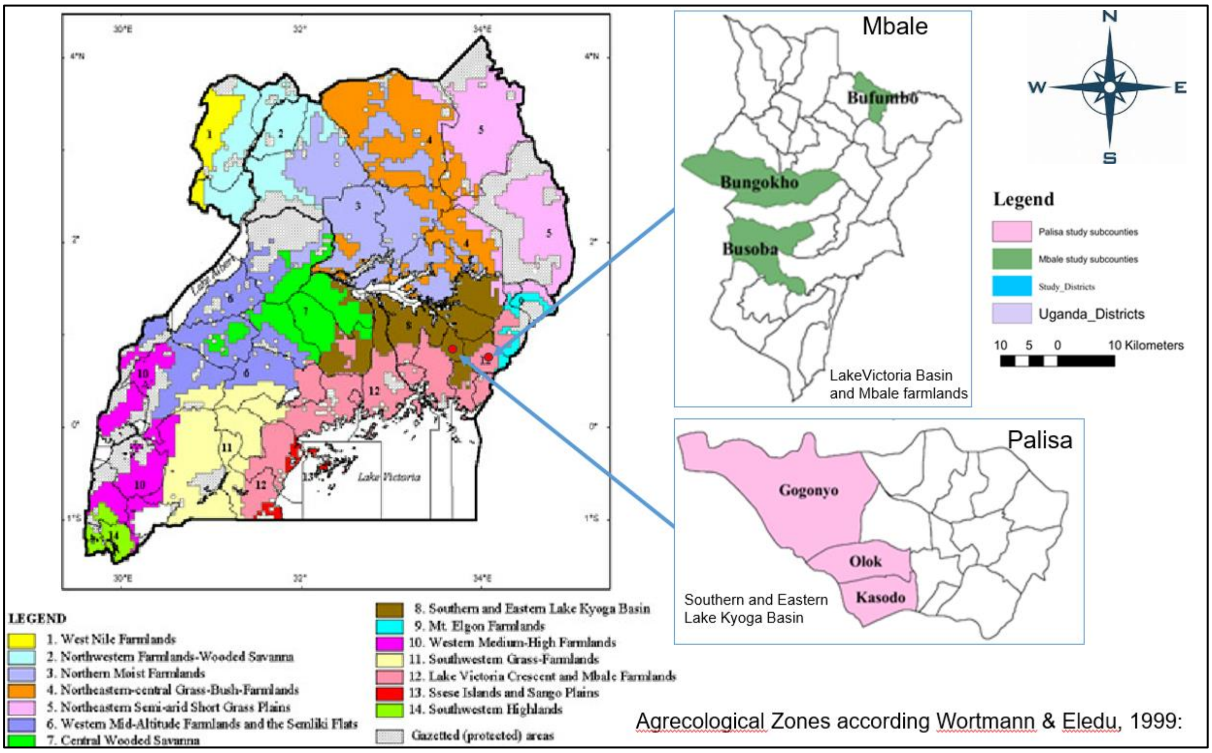

Figure 3.1: Location of Mbale district of the highland agro ecological zones and Pallisa district of the Kyoga plains.

3.2.2 Climate

Pallisa District, located in the Kyoga plains, is characterized by a tropical rainforest climate, marked by distinct wet and dry seasons. The region experiences significant rainfall, particularly during the wet season, which typically spans from March to November. According to Nakileza et al. (2019), the average annual rainfall in Pallisa ranges from 900 mm to 1,200 mm, with peak rainfall occurring in April and May. In contrast, Mbale, situated in the highland agroecological zones, has a subtropical highland climate. The rainfall pattern in Mbale is bimodal, with two rainy seasons and two dry seasons. The long rainy season extends from March to May, while the short rainy season occurs from September to November. Mugisa et al. (2017) indicate that the average annual rainfall in Mbale ranges from 1,200 mm to 1,600 mm, with the majority of rainfall occurring during the long rainy season. In terms of temperature, Pallisa District experiences warm and consistent conditions throughout the year, with average temperatures typically ranging from 20°C to 30°C (Apio et al., 2018). In comparison, Mbale, due to its higher elevation, has cooler temperatures, with averages ranging from 15°C to 25°C.

These seasonal climate variations significantly influence the choice of land management practices adopted by farmers in each zone, as different crops and practices are suited to the varying conditions. Understanding these climatic factors is essential for developing effective agricultural strategies tailored to each region's unique environmental characteristics.

3.2.3 Geology and Soils

Palisa district is located in the Kyoga plains, which is part of the larger East African rift valley systems. The geological and soil characteristics in this region play a significant role in agriculture. The geology of the Kyoga plains is characterized by a variety of geological formations (Mugagga et al., 2018). The plains consist of alluvial deposits from the numerous rivers and streams that crisscross the area, contributing to the fertile soils. The soils in Palisa district are generally fertile, due to the alluvial deposits. They are often classified as Ferralsols or Acrisols. Ferralsols are rich in iron and aluminum oxide and are well-situated for crop cultivation (Isabirye et al., 2013). Mbale located in a highland agro ecological zone, has a distinct geology and soil characteristics influenced by its elevation. The geology of the area is characterized by volcanic formations and faulting (Tindimugaya et al., 2014).

The soils in Mbale are often classified as Andosols or Acrisols, depending on their specific characteristics. Andosols are volcanic soils with good fertility. Acrisols are more weathered soils found in lower elevations (Nakileza et al., 2018), in both regions, the geological and soil characteristics influence land management practices. Farmers in Pallisa may have access to fertile alluvial soils that require specific management practices, while those in Mbale may need to consider volcanic soils and variations in elevation. These geological and soil attributes contribute to the unique agricultural conditions and challenges in these areas, affecting crop choice, land management practices and overall agricultural sustainability.

3.2.4 Socio-economic activities

Agriculture is the main economic activity in the study area with a significant portion of the population engaged in farming. Maize is among the main food crops, providing sustenance and income for the local communities. Local markets play a significant role in both Palisa and Mbale; these markets serve as hubs for the exchange of agricultural products, households and artisanal products.

3.3 Research design

The study employed a mixed-methods approach to examine the various land management practices utilized by farmers in Lake Kyoga agroecological zone and their effects on crop productivity. Both quantitative and qualitative data collection methods were utilized to achieve the study objectives. The qualitative approaches involved conducting interviews, surveys, and focused group discussions, with farmers to understand their motivations, barriers and experiences concerning land management practices. These qualitative approaches aimed to gain insights into farmers' perspectives on the outcomes and challenges associated with specific land management practices. Additionally, the quantitative approach involved collecting data on the prevalence and frequency of these practices within the study area providing a comprehensive overview. Furthermore, data were gathered on maize yield where different land management practices were implemented.

3.4 Sampling design

A purposive sampling technique (Marshall et al., 2015), was used in this investigation to select participants for both qualitative and quantitative components of the study. First, the sub counties were chosen carefully for their ecological significance as well as their proximity to the research site. Three sub-counties were chosen from the two-agro ecological zones purposively. In Mbale, the sub-counties selected were Busoba, Bufumbo, and Bungokho. In Palisa, the sub-counties selected were Kasodo, Olok, and Gogonyo. This was based on the criteria, where the highest number of households in maize growing was considered and maize yield statistics (UBOS, 2019) for household population census. This was done collaboratively with the sub-county agricultural officer, who provided a sample frame and a simple random sampling technique was used to choose the target farmers from each group.

The selection criteria included farmers located in the Pallisa and Mbale district, especially in areas where maize cultivation is prevalent. Farmers with significant levels of experience in maize farming were selected to ensure a deep understanding of their land management practices. Include participants with varying land management sizes to capture arrange of farming practices. This also included smallholder farmers as well as those with larger plots. Identify farmers who actively adopt specific land management practices such as cover cropping, agroforestry, mulching, organic farming or conservation tillage among others. Consider farmers with different socio-economic backgrounds to account for potential variations in resource availability. Age, gender and educational background may influence LMP. Ensure diversity in this demographic factor, considering farmers with varying access to resources like technology, agricultural inputs and extension services, as this can affect the adoption of LMP.

The participants in this study included sub-county local agricultural extension staff, who helped identify maize farmers in the target region. The Community Development Officer provided recommendations for experienced maize farmers actively engaging in land management practices. Additionally, an environmentalist, a land officer, and the District Production and Marketing Officer, all of whom possess knowledge of farming practices and yield statistics in the study areas, were involved. An on-site visit to maize farms in the region was also conducted to observe land management practices directly and engage with farmers.

3.5 Sample population size

The sample population was mainly rural farming households who are engaged in maize crop production. A purposive sampling technique was used to select 379 farming households from 12 communities from three sub counties of each study district of both highland agroecological and lowland areas. Equation 1 given by (Kaur, 2017) was used to determine the sample size of the Mbale and Pallisa Districts, respectively.

Z-test for proportions is; a 95% confidence level corresponds to a Z-score of approximately 1.96. Compute in of Error (ME) using the formula ME = $(Z^* \sigma)/\sqrt{N}$. Where:

Z is the Z score
N is the Population sample size [population proportion]
Σ is the estimated population standard deviation

Therefore, n (Sample size) = (Z *σ/ME) 2 is the estimated sample for N (24,011) for Palisa and Mbale District at 50% population proportion, **n = 379 (approximately 380)**

3.6 Scope and Coverage

The Survey will cover two Agro-ecological zones under the Lake Kyoga Basin. Kyoga Plains and Highland Range zones have different climates, land use, and cropping patterns, which is relevant in designing and developing the sampling strategy.

Table 3. 1: Indicating the selected Districts, sub counties and parishes in the highland agro-ecological zone and Kyoga plain agro-ecological zone.

DISTRICT	SUB COUNTIES	Number of Households	District Parishes	SELECTED PARISHES /HH
Mbale District local Government	Busoba Bufumbo Bungokho	4,383 3,449 6,397	Bumasikye, Bunambutye, Bunanimi,Kama,Jewa,Mt.Elgon NP , Bumadanda,Bubyangu, Kirayi, Bumbobi, Bumageni, Bubirabi ,Bukhumwa	Jewa-16 Bumusiri-8 Bushikori-26 Bumageni-31 Busoba -23 Bumasikye-26
Pallisa District Local Government	Kasodo Olok Gogonyo	2,356 2,591 4,835	Kasodo, Nangodi Najenti, Kainja Nabitende, Apapa, Olok Odwarat, Ngalwe, Obutete Gogonyo, Ajepet, Kachango Angodi	Najenti -9 Kasodo-8 Olok -9 Apapa-15 Gongonyo-31 Angondi-12
Total number of Households		**24,011**		**204**

Household

To determine the number of households that were/would be selected from each parish, Equation 2 given by (Jarosz, n.d.) Was used where;

Number of households for each parish =
HH per parish / 24,011 * n (379)

X = Household population per parish

Figure 3.2. Selected districts of highland AEZ and Kyoga plain AEZ, Sub counties and Parishes

3.7 Data collection methods and data sources

3.7.1 Household Interviews

Semi-structured and open-ended household interviews were crafted (Twinomuhangi et al., 2021) and uploaded onto the Kobo Toolbox. The purpose was to explore various themes without constraining participants' responses. 379 households practicing diverse land management methods within a maize farming system were selected for these interviews. Conversations took place in English, Lugishu, and Lusoga across different households to ensure the inclusivity of both literate and illiterate populations. The household interview guide provided direction for the interviews, which were conducted by four recruited enumerators using iPad phones for data recording. Each household interview lasted approximately 20 minutes. Participants were actively engaged in locating relevant data and expressing their opinions freely (Khunoana et al., 2021).

3.7.2 Key Informants

Technical officials from the district and sub-county levels, possessing expertise in land management practices, were chosen for interviews as Key Informants. These individuals were purposefully selected due to their extensive knowledge of LMP within the study area. The study identified five key informants from each district, comprising an Environmental Officer, a Community Development Officer, an Agricultural Officer, a District Production and Marketing officer, and a Land Officer. Interviews with these officials lasted between 20 to 30 minutes, allowing sufficient time to address all study questions comprehensively.

The Environmental Officer was selected for their responsibility in overseeing environmental sustainability within the district. Given their role in monitoring and advising on practices impacting soil and land health, they offered valuable perspectives on the sustainability of various land management techniques. The Environmental Officer's knowledge helped ensure that insights into sustainable land practices were well represented in the study findings.

The Community Development Officer (CDO) was another essential informant due to their role as a liaison between the community and government. With their mandate to facilitate development programs, the CDO brought a unique community-focused perspective, particularly in understanding how land management practices are adopted at the grassroots level. Their inclusion allowed the study to capture information on community engagement and the socio-economic implications of LMP adoption.

The Agricultural Officer was selected for their direct involvement in guiding agricultural productivity and practices within the district. Their expertise in crop production and land-use practices made them a crucial informant for evaluating the effectiveness of different LMPs, especially concerning maize yield improvements. Their technical input was invaluable for examining the impact of these practices on productivity.

The District Production and Marketing Officer provided insights on the economic aspects of land management, including the benefits and challenges associated with these practices. Tasked with enhancing agricultural productivity and supporting market access, this officer helped the study gain a better understanding of the economic motivations and constraints around LMPs, especially for maize farmers seeking market opportunities.

Finally, the Land Officer was included for their expertise in land administration. Their role in managing land tenure and land-use issues allowed the study to address how these factors influence LMP adoption. This perspective was particularly important in understanding land access and ownership dynamics, which can significantly affect how farmers approach land management.

The purposive sampling method was justified because each of these officials, unlike household heads or local leaders, possesses technical knowledge directly relevant to land management practices. Their expertise ensured that the study captured in-depth and informed responses within the limited 20- to 30-minute interview sessions, addressing all the study’s key questions comprehensively.

3.7.3 Focus Group discussions (FGDs)

According to Nseka et al. (2012), focus groups are small groups of six to ten individuals who discuss a specific issue or topic. Focus groups have the potential to produce more data and knowledge than other methods because they provide participants with an environment that encourages free and open communication (Twinomuhangi et al., 2021). Four focused group discussions (FGDs) were conducted in each district, each comprising twenty participants, encompassing both males and females aged above 18. To ensure gender inclusivity, two FGDs were organized in each study area, with four parallel discussions held in every village – two for males and two for females. This approach aimed to mitigate the dominance of any particular gender. The sub-county Agricultural officer, who assisted in community mobilization, facilitated the sessions. Participants included community members, elders, and local leaders knowledgeable about land management practices in the area. The Agricultural officer guided the discussions, lasting between 30 to 40 minutes each.

3.8 Data analysis

Quantitative data analysis involves the utilization of statistical software, namely Excel, to examine descriptive statistics such as frequencies and percentages. This was instrumental in characterizing both land management practices and socio-economic variables. Additionally, inferential statistics, including logistic regression analysis, were employed to evaluate the determinants of practice adoption. Qualitative data analysis, comprising transcripts from FGDs, entailed thematic content analysis to identify recurring themes pertaining to land management practices and farmers' motivation. Furthermore, thematic analysis was applied to interview data to identify themes associated with land management practices and socio-economic factors.

To assess the impact of Land Management Practices (LMPs) on maize yields, Analysis of Variance (ANOVA) was utilized to compare the relationship between LMPs and maize yields across various LMPs Quantitative data was processed using Excel software, R-studio, while SPSS version 27 facilitated further analysis. Descriptive statistics such as means and frequencies were utilized to summarize socio-economic data and maize yields. Inferential statistics, including logistic regression analysis, were conducted to evaluate the relationships between land management practices, socio-economic variables, and crop yield.

3.8.1 Characterizing the LMPs adopted by maize farmers in Kyoga Plain and Highland agroecological zones.

The major land management practices adopted by maize farmers in Kyoga basin agroecological zones were characterized through qualitative data collected via in-depth interviews employing open-ended and closed-ended questions, key informant interviews, focus group discussions, and observations. Quantitative data was collected using structured surveys, which involved a purposively selected sample of farmers from the study area. The data collected included structured data on the prevalence of specific land management practices, along with demographic information of the farmers. To achieve this objective, interviews were conducted with farming households in the selected sub-counties in the regions of Kyoga plains and highland agroecological zones. A questionnaire was the main tool used for data collection. Data points collected included types of land management practices employed by farmers, frequency and intensity of these practices and farmers' perceptions of the sustainability of these practices. Thus, both qualitative and quantitative data were used.

3.8.2 Examining factors that determine the adoption of LMPs among maize farmers in Kyoga plains and Highland agroecological zones.

The factors that determined the adoption of land management practices among maize farmers in Lake Kyoga agro-ecological zones were investigated. Structured questionnaires and focused group discussions were conducted to achieve this objective. These were carried out with maize farming households in selected sub-counties in Kyoga plains and highland agro-ecological zones. These tools were used to gather qualitative and quantitative data on socio-economic factors, Face-to-face interviews were conducted with a purposively selected sample of farmers, allowing for the systematic collection of socio-economic data from participants, including income levels, access to resources, land size, and farming experience. Specific questions related to the adoption of land management practices were included in the surveys conducted in both Kyoga plains and highland agro-ecological zones. Participants were interviewed on their farms at community centers. Focus group discussions (FGDs) involved the use of FGD guidelines and organized group discussions with local farming communities. Key informants such as agricultural officials, senior community development officers, and District Production and Marketing officers at district levels were also consulted. These FGDs provided a platform for participants to share their perspectives, beliefs, and experiences regarding land management practices, helping uncover shared factors that influenced adoption. FGDs were conducted in community centres and at the district level within the study area.

3.8.3 Evaluate the effect of adopted LMPs on maize yields within Kyoga Plain and Highland agroecological zones.

To achieve this objective, it involved assessing the impact of land management practices on maize yield. A structured questionnaire was conducted with a purposively selected sample of farmers. This provided quantitative data on maize yield and land management practices employed by the participants and yield data, to assess their impact. Surveys were conducted on participants’ farms within the Kyoga plains and highland agroecological zones in eastern Uganda. Maize yield data collection, through measuring and recording crop yield from participants’ farms. Crop yield data was essential to evaluate the effectiveness of land management practices in terms of productivity.

CHAPTER FOUR

PRESENTATION OF RESULTS

4.1 Introduction

This chapter presents the findings regarding the assessment of the effect of land management practices on maize yield within the Kyoga basin. The results aligned with the specific objectives of the study which included: characterizing the LMPs implemented by maize farmers in the Kyoga plains and Highland agro-ecological zones, investigating the factors that determined the adoption of LMPs among maize farmers in the Kyoga plains and Highland AEZs and evaluating the effect of LMPs on maize yield, within the Kyoga plains and Highland agro-ecological zones.

4.2. Characterization of LMPs adopted by maize farmers in Kyoga plains and Highland agro-ecological zones.

4.2.1 Demographic characteristics of maize farmers

Table 4.1 shows the potential continuous demographic variables differentiating maize farmers in the highland AEZ from the Kyoga plain AEZ. The maize farmers in the highland AEZ and Kyoga plain AEZ are significantly different in two of the five continuous socio-economic demographic variables. Accordingly, the survey results indicated that the average household size for the maize farmers in highland and Kyoga plains AEZs were 7.32 and 9.30 with a standard deviation of 3.20 and 4.85, respectively. The results of household size showed a significant difference between the two groups of farmers in the two AEZ. The total land for crop production for the maize farmers across the two AEZ was significantly different. The maize farmers in the Kyoga plain AEZ had a higher land size for crop production of 3.08 ± 1.67 acres than the farmers in the highland AEZ with 2.32 ± 1.76 acres.

However, the total land utilized for maize cultivation was not significantly different across the two AEZs, although, the highland AEZ had a high allocation of land for maize cultivation of 2.09 acres than that of Kyoga plains with 1.85 acres of land allocated for maize farming. Other continuous socio-economic demographic variables, such as age and farming experience of the maize farmers across the two AEZ, were not significantly different. However, the maize farmers in the highland AEZ, on average, are in the age of 44.85 ±29.37 years than those in

Kyoga plain with an average of 42.67 ± 13.37 years. Farmers in Kyoga Plain have more farming experience of 22 years than those in the highland AEZ. Farming experience is assumed to influence the decision of farmers to adopt the different land management practices.

Table 4.1: Continuous demographic variables of the 370 maize farmers interviewed across the two AEZs

Variables	**Highland AEZ (Mbale district)**		**Kyoga plain AEZ (Pallisa district)**		***p-value***
	Mean	**Standard deviation**	**Mean**	**Standard deviation**	
Age (in years)	44.85	29.37	42.67	13.37	0.375
Household size (in numbers)	7.32	3.20	9.3	4.85	0.000**
Farming experience (in years)	20.56	13.95	22.04	14.03	0.310
Total land for crop production (in acres)	2.32	1.76	3.08	1.67	0.000**
Total land utilized for maize production (in acres)	2.09	1.64	1.85	1.15	0.114

*** indicates a significant difference at 5% probability level*

Table 4.2 presents the descriptive statistics of the categorical demographic variables of the maize farmers across the two AEZs. From the sample of 370 maize farmers interviewed, 246 (66.5%) were male and 124 (33.5%) were female across the two AEZs. The chi-square test results showed that there is a statistically significant difference between genders across the two AEZs. Furthermore, most of the farmers interviewed across the two AEZs significantly own land (268 respondents – 72.4%) for maize production compared to those who rent land (97 respondent-26.2%). Specifically, 153 farmers (76.1%) own land for maize production in the highland AEZ compared to 46 farmers (22.9%) who rented land for maize production. Likewise, in the Kyoga pains, the majority of the farmers (115 – 68.04%) own land for maize production and 51 farmers, i.e. 30.2% rent land for maize production. Land is one of the most vital production factors for agricultural production, and therefore, ownership of land is key to influencing the decision for the farmer to uptake the different land management practices.

Table 4.2: Dummy demographic variables of the 370 maize farmers interviewed across the two AEZs

Variable	Category	Highland AEZ (n=201)	Kyoga plain AEZ (n=169)	Total (370)	X^2
Gender	Female	86	38	124 (33.5%)	0.000**
	Male	115	131	246 (66.5%)	
Education level	No formal education	22	15	37	0.248
	Primary	85	80	165	
	Secondary	77	58	135	
	Vocational certificate	11	15	26	
	University	4	1	5	
Land ownership for maize production	Owned	153	115	268	0.003**
	Rented on agreed amount	46	51	97	
Access to credit	No	170	138	308	0.428
	Yes	30	22	52	
Access to inputs	No	158	135	293	0.122
	Yes	42	25	67	

*** indicates significant difference at 5% probability level*

4.3 Land management practices adopted by maize farmers in the two AEZs

Sustainable productivity of land resources requires sound land management measures in farming systems that enhance soil and land quality in general. This is vital as it influences agricultural productivity and local livelihoods. Low land productivity due to land degradation has stimulated a mosaic of responses and adaptation mechanisms by local farmers. This study made an inquiry on whether the maize farmers had undertaken any land management practices in their maize farmers to protect the land and improve production. Accordingly, the land management practices undertaken by maize farmers included integration of maize with cover crops, minimum tillage, pesticide application, construction of trenches, application of organic manure, application of inorganic fertilizers, agroforestry and mulching (Figure 4).

The majority of the respondent (96% in highland and 81% in Kyoga plain AEZs) indicated they have integrated maize with cover crops as a land management practice on their farms as a means of improving soil fertility and maize production (Figure 4). Further, 74.7% and 70.5% of the respondents undertook minimum tillage as a land management practice in the maize farms in the Kyoga plains and highland AEZs, respectively, followed by pesticide application and construction of trenches, among others, as indicated in Figure 4.

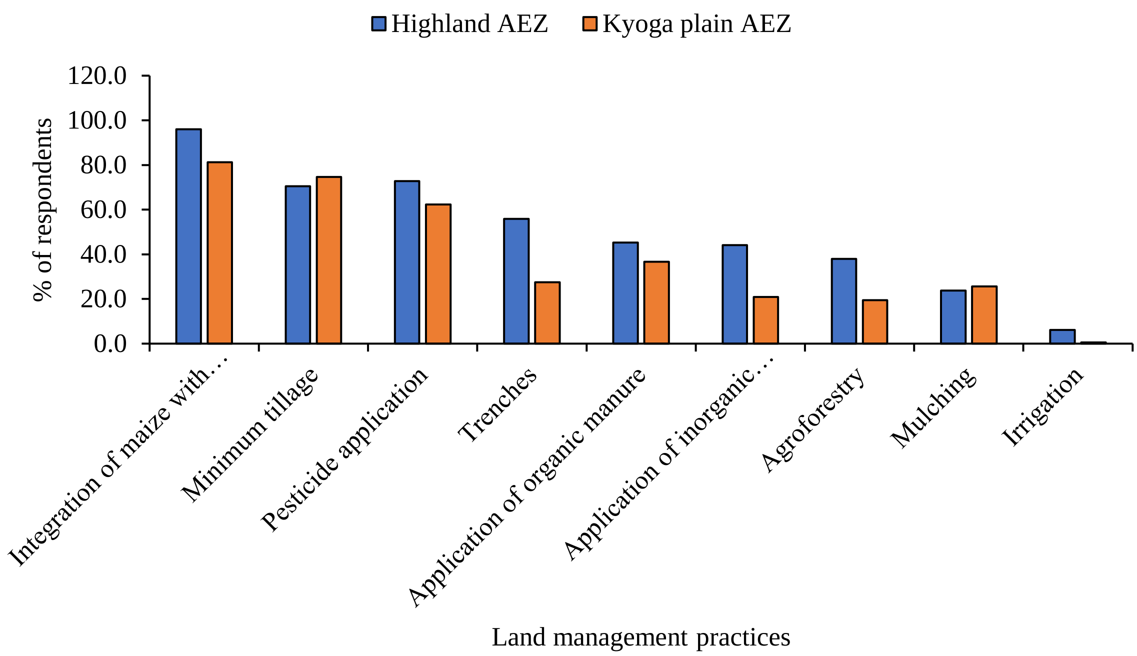

Figure 4.1: Prevalence of land management practices by agro-ecological zones

Plate 4.1: Agroforestry (integration of Eucalyptus urograndis trees and beans as cover crops) in Bufumbo sub county Mbale District.

Plate 4.2:Household interviews at Gogonyo Sub County Pallisa district

Plate 4.3: Household interviews at Bungokho Sub County Mbale district

Plate 4.4: Female FGD at Busoba Sub County Mbale district

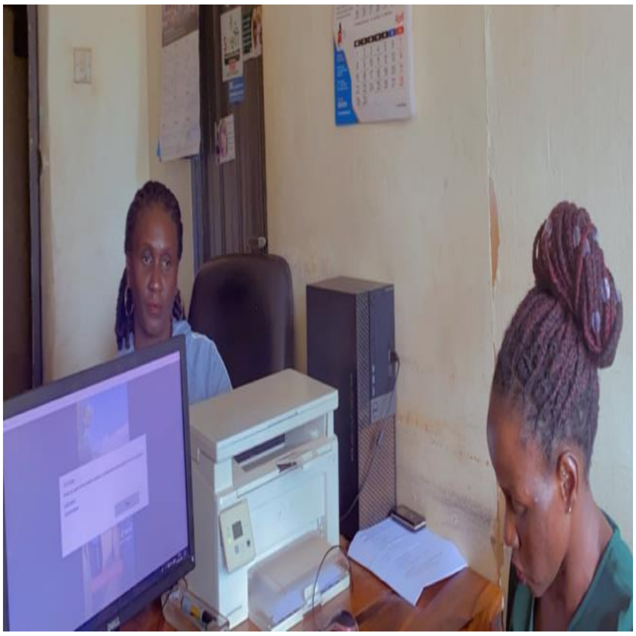

Plate 4.5: Key informant interview (agricultural officer) Pallisa district

Table 4.3 presents the summary results from the binary logistic regression analysis to explain the characteristics of demographic variables and the implemented land management practices across the two agro-ecological zones. Accordingly, a significant relationship occurs between the agro-ecological zones and agroforestry (P<.001), trenches (P<.001), irrigation (P =0.047), cover crops (P<.001), inorganic fertilizer application (P<.001), and pesticide application (P=0.006). Implementation of these land management practices is predominant in the highland AEZ except for pesticide application, which is mostly applied in the Kyoga plains in the Pallisa district. Gender significantly influences organic fertilizer and pesticide application across the two AEZ, and the male gender is most likely to apply these practices compared to the female counterparts in the two study areas. Further, the education level of the households significantly influences the choice and implemented of land management practices such as minimum tillage practice, mulching, cover crops integration with maize farming, inorganic fertilizer, and pesticide application across the two AEZ. Moreover, households with high education levels are more likely to implement mulching, cover crops, inorganic fertilizer and pesticide application compared to households with low education levels. Experience in farming significantly affects agroforestry and pesticide application; households with higher experience in farming are likely to choose to implement agroforestry and pesticides compared to those with low experience. The total land owned for maize production significantly influences only the construction of trenches whereby households who own land for cultivation are likely to construct trenches compared to those who rent land for farming.

Table 4.3*:* Analysis of land management practices based on the demographic characteristics using Binary Logistic regression Model

Demographics	**statistic**	**Agro forestry**	**Minimum Tillage**	**Trenches**	**Irrigation**	**Mulching**	**Cover crops**	**Inorganic fertilizer**	**Organic fertilizers**	**Pesticide Application**
AEZ	*P-value*	**<.001****	0.537	**<.001****	**0.047****	0.181	**<.001****	**<.001****	.073	**0.006****
	B	**-**1.198	177	-1.626	-2.166	.382	-1.716	-1.052	-432	.750
Gender	*P-value*	0.196	0.863	0.357	0.087	0.885	0.372	0.780	**0.032****	**<.001****
	B	-754	-047	-248	1.380	.041	-395	-070	.519	.898
Age	*P-value*	0.193	0.961	0.244	0.829	0.107	0.494	0.148	0.944	0.273
	B	0.000	0.000	0.017	0.004	0.025	0.004	-0.020	0.000	-0.61
Education	*P-value*	0.396	**0.002****	0.331	0.603	**0.005****	**0.034****	**0.000****	0.700	0.908
level	*B*	0.70	-0.308	0.081	0.095	0.290	0.241	0.00	-0.029	0.010
Experience in	*P-value*	**<.001****	0.069	0.659	0.861	0.257	0.323	0.529	0.562	**0.006****
farming	*B*	0.001	-0.017	-0.006	-0.005	-0.017	-0.014	0.008	0.045	0.038
Total land size	*P-value*	0.935	0.132	**<.001****	0.399	0.117	0.105	0.391	0.462	0.76
owned	*B*	0.072	-0.016	-292	0.204	0.135	-214	-0.138	0.005	-140

4.4 Factors determining the adoption of LMPs among maize farmers in Lake Kyoga Plain and Highland agro-ecological zones.

Table 4.4 presents the factors determining the adoption of the different land management practices among the maize farmers across the two agro-ecological zones in the Kyoga basin. Results indicate that most of the respondents (69.7%) reported the loss of soil fertility as the major factor influencing maize farmers in both AEZ to take up the land management practices protecting the soils. Pests and diseases (reported by 63.9%) follow this, soil erosion (60.5%), prolonged drought and floods (43.1%), low crop yields (40.6%), and rainfall variability (35.6%), among others. Chi-square test results for the individual determinants show that there is a statistically significant difference between the highland AEZ and Kyoga plain in terms of loss of soil fertility, soil erosion levels, rainfall variability and prolonged drought and flood occurrence. In fact, the loss of soil fertility is highly experienced in the highland AEZ (as reported by 128 respondents – 64%) than in the Kyoga plain. Soil erosion, pests and disease occurrences highly determine the land management practices more in the highland AEZ than in the Kyoga plains. Access to markets, access to agriculture inputs and services, access to credits, access to land for agriculture production, and investment costs are other factors which influence the choice of land management practices to be implemented by the maize farmers across the two AEZs.

Table 4.4: Determinants for adoption of land management practices among the maize farmers across the two AEZs

Determinants	Score (0-no;1-yes)	Highland AEZ (n=200)	Kyoga plain AEZ (n=160)	Total (n=360)	X^2
Loss of soil fertility	0	72	37	109 (30.3%)	**0.006****
	1	128	123	251 (69.7%)	
Soil erosion	0	52	90	142 (39.5%)	**0.00****
	1	148	70	218 (60.5%)	
Pests and diseases	0	79	52	131 (36.1%)	0.103
	1	121	108	229 (63.9%)	
Rainfall variability	0	120	112	232 (64.4%)	**0.031****
	1	80	48	128 (35.6%)	
Drought and floods	0	122	83	205 (56.9%)	**0.050****
	1	78	77	155 (43.1%)	
Low crop yields	0	118	96	214 (59.4%)	0.467
	1	82	64	146 (40.6%)	
Access to market	0	151	130	281 (78.1%)	0.118
	1	49	30	79 (21.9%)	
Access to inputs	0	170	138	308 (85.6%)	0.428
	1	30	22	52 (14.4%)	
Access to credit	0	158	135	293 (81.4%)	0.122
	1	42	25	67 (18.6%)	
Access to land	0	157	126	283 (78.6%)	0.53
	1	43	33	76 (21.4%)	
Investment costs	0	159	118	277 (76.9%)	0.123
	1	41	42	83 (23.1%)	

*** indicates significant difference at 5% probability level*

The Chi-square analysis between the determinants of land management practices and the individual land management practices disclosed that there is a significant association between soil erosion and the application of cover crops, mulching, and agroforestry at a 5% level of significance (Table 4.5). This could prove that farmers choose and apply mulching, integrate cover crops with maize plants, and do agroforestry to control soil erosion. In addition, the choice and application of organic and inorganic fertilizers, pesticides, and mulching have a significant association with crop pests and diseases and thus, maize farmers apply these practices mainly to control crop pests and diseases across the two AEZs. Mulching, irrigation, and agroforestry showed a significant association with rainfall variability, indicating that the maize farmers from the two AEZs apply these practices partly due to variability in rainfall and thus, these practices conserve the little available water for crop growth. The low crop yield, access to inputs, credit, market and small land holdings and investment costs have a significant association with mulching as a land management practice and thus, farmers with access to inputs, credit and market are likely to apply mulching in their maize farmers. Conversely, there is a significant association between investment costs and application of inorganic fertilizers, cover crops and mulching. This indicates that the higher the investment costs for buying fertilizers, cover crops and mulching materials, the lower the implementation of these practices by the farmers. Therefore, maize farmers in these two AEZs consider the investment costs of these practices prior to deciding if they can implement the or not.

Table 4.5: Chi-square tests of association between determinants and land management practices among maize farmers in the two AEZs

Determinants	Statistics	Organic fertilizer	Inorganic fertilizer	Pesticides	Cover crops	Mulching	Irrigation	Agroforestry
Low soil fertility	*X2*	1.779	1.436	0.005	0.070	3.131	1.442	1.493
	p	0.182	0.231	0.944	0.791	0.077	0.230	0.222
Soil erosion	*X2*	3.296	2.183	0.190	5.147	17.435	1.464	27.248
	p	0.069	0.140	0.663	**0.023***	**0.000***	0.226	**0.000***
Pests and diseases	*X2*	7.650	10.987	57.180	1.571	17.954	0.496	0.045
	p	**0.006***	**0.001***	**0.000***	0.210	**0.000***	0.481	0.833
Rainfall variability	*X2*	1.136	1.724	0.243	0.009	24.673	3.898	5.774
	p	0.286	0.189	0.622	0.923	**0.000***	**0.048*,**	**0.016***
Drought and floods	*X2*	3.461	1.625	0.882	0.133	40.279	1.811	3.818
	p	0.063	0.202	0.348	0.716	**0.000***	0.178	0.051
Low crop yield	*X2*	2.889	0.077	0.231	1.146	31.235	0.157	9.041
	p	0.089	0.782	0.631	0.284	**0.000***	0.692	**0.003***
Access to markets	*X2*	0.139	0.401	0.012	0.648	22.857	2.140	2.135
	p	0.709	0.527	0.914	0.421	**0.000***	0.143	0.144
Access to inputs	*X2*	0.820	0.402	4.595	0.020	16.625	0.767	0.499
	p	0.365	0.526	**0.032***	0.887	**0.000***	0.381	0.480
Access to credit	*X2*	0.010	0.261	1.384	5.056	9.749	0.156	3.778
	p	0.920	0.610	0.239	**0.025***	**0.002***	0.693	0.052
Small land holdings	*X2*	0.174	0.204	1.255	2.880	6.300	1.462	0.024
	p	0.677	0.652	0.263	0.090	**0.012***	0.227	0.877
Investment cost	*X2*	2.203	4.933	0.763	5.158	9.977	0.447	0.005
	p	0.138	**0.026***	0.382	**0.023***	**0.002***	0.504	0.941

The prediction of how the maize farmers across the two AEZs are affected by the factors influencing their choice of land management practices was assessed based on the selected demographic factors to analyze their different levels of vulnerability. Accordingly, Table 4.6 shows that the two study areas are influenced differently by the determinants of land management practices. For instance, there is a significant positive effect of location on low soil fertility, soil erosion, and drought. The Kyoga plains in the Pallisa districts are likely to be affected by low soil fertility and drought and thus, maize production than those in the highland AEZs, while in the highland AEZs, soil erosion and rainfall variability are predicted to highly affect maize production. The age of the farmer is significantly affected by prolonged drought, and results further indicate that older farmers are less likely to be affected by prolonged drought across the two AEZs. Farmers with limited access to land for farming are significantly likely to be affected by rainfall variability and Prolonged drought thus, increasing their vulnerability to climate impacts and land degradation due to the low uptake of the land management practices.

Table 4.6: Analysis of demographic characteristics using Binary Logistic regression Model results for determinants/factors

Demographic characteristics	Statistics	Low soil fertility	Soil erosion	Pests and diseases	Rainfall Variability	Drought
Location	*B*	0.566	-1.583	0.543	-0.298	0.620
	p-value	**0.030***	**0.000***	0.077	0.315	**0.018***
Gender	*B*	-0.158	0.032	0.186	-0.486	-0.218
	p-value	0.545	0.903	0.443	0.065	0.392
Age	*B*	0.004	-0.011	0.005	-0.004	-0.027
	p-value	0.621	0.151	0.531	0.387	**0.009***
Household size	*B*	0.043	0.060	0.005	-0.076	0.009
	p-value	0.231	0.071	0.865	**0.049***	0.803
Experience in	*B*	0.000	0.005	-0.022	-0.012	0.002
maize farming	*p-value*	0.995	0.677	0.080	0.350	0.812
Access to land	*B*	0.027	-0.307	0.406	0.993	0.753
for farming	*p-value*	0.947	0.451	0.350	**0.014***	**0.050***

4.5 Effect of adopted LMPs on maize yields within Kyoga Plain and Highland agro-ecological zones.

Figure 4.2 presents a comparison of maize yields between the highland agroecological zone and the Kyoga plain AEZ**.** Results reveal a distinct difference in maize yields between the two-agroecological zones (AEZs) in eastern Uganda. The Kyoga plains AEZ outperforms the Highland AEZ with a mean yield of 986.7 Kg/ha, which is significantly higher than the Highland's yield of 721.1 Kg/ha. This disparity suggests that the Highland AEZ experiences severe soil erosion leading to soil degradation, erratic rainfall, suboptimal practices, and environmental constraints compared to the Kyoga plains with various land management practices such as pesticide control, which contributed to this high yield. The ANOVA results revealed significant differences (F = 8.761, p = 0.003) in the maize yields between the AEZs (Table 4.7). Specifically, the variation between AEZs contributed significantly to the overall variance.

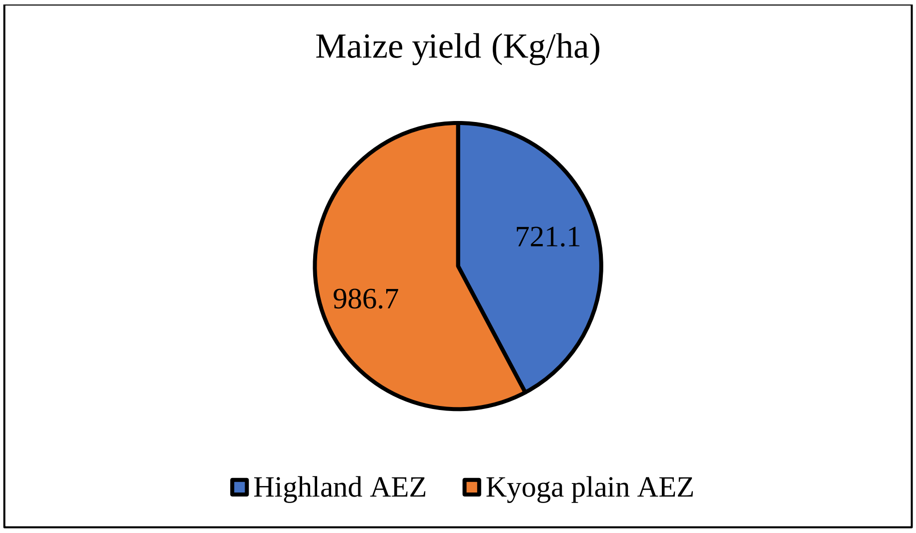

Figure 4.2: Mean maize yield across the two AEZs in eastern Uganda

Table 4.7: (ANOVA) of maize yield between the AEZs

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6203997.713	1	6203997.713	8.761	.003
Within Groups	249975739.262	353	708146.570		
Total	256179736.975	354			

Table 4. 8 indicates the analysis of maize yield data across the Highland and Kyoga plain Agro-Ecological Zones (AEZs) was conducted using the one-way ANOVA method to determine if there were significant differences in yield between the AEZs using various land management practices. The results show that the use of inorganic fertilizer and pesticide applications significantly increases yield in the Kyoga plain AEZ compared to the Highland AEZ, with p-values of 0.001 and 0.004, respectively. However, other land management practices such as organic fertilizer application; cover crops, mulching, and agroforestry show no significant difference in yield between the two AEZs.

Table 4.8: Effect of land management practices on maize yield across the two AEZs

Land management practice	**Maize yield (Kg/ha)**		***P-value($LSD_{0.05}$)***
	Highland AEZ	***Kyoga plain AEZ***	
Organic fertilizer application	840.3	840.6	0.999
Inorganic fertilizer application	736	1046.7	**0.001***
Pesticide application	654.9	930.5	**0.004***
Cover crops	873.6	837.2	0.804
Mulching	881.7	724.8	0.136
Agroforestry	848.4	827.5	0.833

*Note. * Means there is a significance difference at 5% LSD*

CHAPTER FIVE: DISCUSSION

5.0 Introduction

This chapter presents a comprehensive discussion of the study findings in relation to the stated research objectives. By systematically analyzing and interpreting the data collected, this chapter aims to provide a deeper understanding of the key aspects investigated in the study. The discussion focuses on the demographic characteristics of maize farmers in the highland AEZ and Kyoga plain AEZ, including household size, land for crop production, land ownership for maize, gender, and farming experience. Additionally, it will explore the land management practices implemented by these farmers, such as the integration of maize with cover crops, minimum tillage, pesticide application, construction of trenches, application of organic manure, application of inorganic fertilizers, agroforestry, and mulching.

5.1 Discussion

5.1.1 Characterization of the LMPs adopted by maize farmers in Kyoga Plain and Highland agroecological zones.

The demographic characteristics of maize farmers in the Kyoga plains and Highland agro-ecological zones (AEZs) reveal significant differences in household size and total land for crop production, while other variables such as age and farming experience show no significant differences. Specifically, the average household size in the Highland AEZ is significantly smaller (7.32) compared to the Kyoga plain AEZ (9.30), with respective standard deviations of 3.20 and 4.85. This finding implies that the Kyoga plains support larger family structures, which could be attributed to socio-cultural and economic factors prevalent in the region. Larger households in the Kyoga Plain AEZ could potentially provide more labour for farming activities, enhancing productivity but also increasing the dependency ratio. However, smaller households in the Highland AEZ may face labor constraints, affecting their farming activities and productivity.

This aligns with findings from Manda et al. (2016), who reported that larger household sizes in rural Africa often correlate with increased labour availability for farming activities. Additionally, Masanjala (2015) in "The Paradox of Household Size and Agricultural Productivity in Malawi," discussed the implications of household size on agricultural productivity and resource allocation. Results indicated that while larger households provide more labor, they also have higher consumption needs, which can strain resources. Furthermore, Anríquez & Stloukal (2015) highlighted the relationship between household size and labour availability in rural agricultural settings. The findings indicated that larger households are better able to diversify labour across various agricultural tasks. Additionally, maize farmers in the Kyoga Plain AEZ have significantly larger land holdings for crop production (3.08 acres) compared to those in the Highland AEZ (2.32 acres). This difference could influence the scale of agricultural operations and potentially affect the implementation of land management practices. Larger land holdings may facilitate more diverse and extensive farming practices, possibly contributing to higher overall production in the Kyoga Plain AEZ. Jayne et al. (2018), who found that larger land sizes in African farming communities tend to support more diverse agricultural practices and higher productivity, made similar observations. Furthermore, Pender et al. (2014) and 'On Determinants of Smallholder Farmer Participation in Sustainable Land Management Practices in Uganda" noted that larger land holdings are associated with higher productivity and better economic outcomes.

Equally, a larger proportion of land is dedicated to maize cultivation in the Kyoga Plain AEZ compared to the Highland AEZ. This implies that the larger land area dedicated to maize in the Kyoga plains indicates a focus on maize as a staple crop, which may be driven by favourable climatic conditions and market access. In contrast, the Highland AEZ may have more diversified cropping systems due to varying terrain and soil conditions. In comparison with other scholars (Suri, 2016). In "Selection and Comparative Advantage in Technology Adoption," conducted in Kenya, Suri found that land allocation to staple crops like maize is influenced by market access and profitability. This supports the finding that farmers in the Kyoga plains allocate more land to maize due to favourable market conditions. Besides, Minten et al. (2017): study on "Agricultural Productivity and Climate Change: Evidence from Ethiopia" discussed how climatic conditions influence crop choices and land allocation. Findings indicated that regions with favourable conditions for maize tend to allocate more land to its cultivation. Finally yet importantly, Holden & Lunduka (2016) highlighted that farmers allocate more land to maize when they have better access to inputs and markets. This is consistent with the findings in the Kyoga plains.

The analysis reveals significant differences in gender and land ownership for maize cultivation across the highland AEZ and Kyoga plain AEZ. The highland AEZ has a higher proportion of male farmers compared to the Kyoga plain AEZ. This gender disparity suggests that male farmers predominantly control maize farming activities, influencing access to resources, decision-making, and adoption of agricultural practices. Female farmers often face barriers such as limited access to land, credit, and extension services, which affects their productivity and ability to implement innovative practices. Additionally, there is a notable difference in land ownership for maize between the two regions. A larger proportion of farmers in the highland AEZ own their land compared to those in the Kyoga plain AEZ. This aligns with Doss et al. (2015), who found that women often face significant barriers in land ownership and agricultural decision-making, affecting their productivity. Similarly, Njuki et al. (2016) emphasized the gender gap in agricultural productivity in East Africa, noting that women farmers frequently have less access to resources compared to men. These findings highlight the critical role of gender dynamics and land ownership in influencing agricultural practices and productivity in different agro-ecological zones.

Although the average age and farming experience of farmers is not significantly different between the two AEZs, Highland farmers tend to be slightly older (44.85 years) compared to Kyoga plain farmers (42.67 years). The similarity in farming experience suggests that both regions have farmers with a considerable understanding of agricultural practices, which is crucial for the adoption of effective land management strategies. According to Asante et al. (2017), experience in farming is a critical determinant in the adoption of sustainable agricultural practices, as more experienced farmers tend to have better knowledge and resources. Although the total land utilized for maize cultivation is not significantly different, the Highland AEZ allocates more land to maize (2.09 acres) compared to the Kyoga plains (1.85 acres). This could reflect regional priorities or suitability for maize production, which might influence the types of land management practices adopted. This is supported by the findings of Abdoulaye et al. (2015), who noted that regional differences in crop allocation are often influenced by climatic conditions and soil suitability.

The study revealed several land management practices implemented by maize farmers, with significant variations between the two AEZs. These practices are crucial for sustainable land use, improving soil fertility, and boosting maize production. Integration of Maize with Cover Crops Findings indicated that 96% of respondents in the Highland AEZ and 81% in the Kyoga

Plain AEZ have integrated maize with cover crops to improve soil fertility and maize production. The high adoption rate of cover crops highlights farmers' strong awareness of soil fertility management and erosion control benefits. Cover crops can enhance soil structure, improve moisture retention, and suppress weeds, leading to better crop yields and sustainable land use. Rosenstock et al. (2019), in ‘The Climate-Smart Agriculture Papers support this’, where found that cover crops significantly enhance soil fertility and crop productivity. Similarly, Maitra et al. (2019), in their study "Cover Crops and Their Effects on Soil Health and Ecosystem Services," showed that cover crops improve soil physical properties, nutrient cycling, and biological activity Lal (2020), Last but not least, a study from Mulianga et al. (2021), emphasized the benefits of cover crops in improving soil health and productivity in various agro-ecological settings. The integration of findings from these scholars enhances the credibility and depth of the study. Their research supports the observed benefits of cover crops in the highland AEZ and Kyoga plain AEZ, providing a robust scientific foundation for the study's conclusions. By aligning with established research, the study's findings on the effectiveness of cover crops in improving soil fertility and maize production are strengthened, emphasizing the importance of adopting such practices for sustainable agriculture

Minimum tillage is adopted by 74.7% of respondents in the Kyoga plains and 70.5% in the Highland AEZs. This practice helps maintain soil structure, reduce erosion, and preserve soil moisture, making it vital for sustainable agriculture by lowering labour costs and fuel consumption, contributing to environmental conservation and economic efficiency. This aligns with the studies by Corbeels et al. (2018), which highlighted the widespread adoption of minimum tillage as a conservation agriculture practice in sub-Saharan Africa. Similarly, Derpsch et al. (2016), study highlighted the benefits of minimum tillage in reducing soil erosion, improving water infiltration, and increasing organic matter, supporting the adoption observed in the AEZs. They found that minimum tillage significantly reduces soil erosion by maintaining ground cover and reducing soil disturbance, which helps prevent the loss of topsoil and nutrients. The practice improves water infiltration rates by preserving soil structure, allowing water to penetrate more efficiently and reducing surface runoff. Additionally, minimum tillage increases soil organic matter by leaving crop residues on the field and minimizing disturbance, enhancing soil fertility and microbial activity. It also helps in preserving soil moisture by reducing evaporation rates, which is especially beneficial in dry regions for water conservation and crop productivity. Furthermore, Derpsch et al. (2016 noted the economic efficiency of minimum tillage, citing lower labour and fuel costs due to the reduced need for intensive ploughing, ultimately improving overall profitability for farmers.

Lal’s (2015) study, “Restoring Soil Quality to Mitigate Soil Degradation,” emphasized that minimum tillage is essential for soil conservation and enhancing soil organic carbon, aligning with the benefits reported by farmers in the AEZs. Giller et al.’(2017) study, "Tillage Effects on Soil Health and Crop Productivity," found that reduced tillage practices improve soil health and crop yields, corroborating the findings from the AEZs.

A significant portion of farmers in both AEZs reported using pesticides as part of their land management practices, indicating efforts to manage pest pressures and enhance crop yields. However, reliance on chemical pesticides can have environmental and health implications, emphasizing the need for integrated pest management (IPM) strategies. Pretty et al. (2018), in "Sustainable Intensification in Agricultural Systems," advocated for IPM practices that combine biological, cultural, and chemical controls to reduce pesticide reliance and environmental impact. Hessel et al. (2016), in "Pesticide Use and Risk Perceptions among Farmers," found that while pesticides are effective, their overuse can lead to resistance and environmental contamination, supporting the balanced use observed in the AEZs. Damalas & Koutroubas (2016), in "Farmers' Exposure to Pesticides: Toxicity Types and Ways of Prevention," highlighted the health risks associated with pesticide exposure, stressing the importance of safe use and alternative pest control methods. In contrast, higher pesticide usage in the Kyoga plains might be due to greater pest pressures in the flat, expansive farmlands. This observation concurs with the findings of Garming et al. (2016), who noted that pesticide application is often influenced by pest prevalence and the intensity of agricultural activities.

Construction of Trenches, farmers in both AEZs reported constructing trenches as a land management practice, highlighting its importance in controlling water flow, preventing soil erosion, and enhancing water conservation. This practice helps maintain soil structure and fertility, leading to sustainable agricultural production. Kaihura et al. (2016), in "Adoption of Soil and Water Conservation Technologies," found that trench construction significantly reduces soil erosion and improves water retention, aligning with the benefits observed by farmers in the AEZs. Teshome et al. (2016), in "Soil and Water Conservation Effects on Soil Properties in the Northwestern Ethiopian Highlands," demonstrated that trenches effectively reduce runoff and soil loss, supporting the findings in the AEZs. Nyssen et al. (2018), in "Soil and Water Conservation Through Watershed Management: Lessons From Tigray," emphasized the importance of physical soil and water conservation measures like trenches in improving land productivity and sustainability, which aligns with the practices reported in the AEZs.

Application of Organic Manure, farmers in both AEZs reported applying organic manure to their maize farms, emphasizing its importance for improving soil fertility, enhancing soil organic matter, and promoting sustainable crop production. Using organic manure reduces reliance on chemical fertilizers and improves soil health over the long term. Vanlauwe et al. (2016), in "Soil Fertility Improvement and Integrated Soil Fertility Management," highlighted the benefits of organic manure in enhancing soil fertility and crop productivity, supporting the findings in the AEZs. Njeru et al. (2016), in "Role of Organic Resources in Soil Fertility Management," found that organic amendments like manure significantly improve soil properties and crop yields, aligning with the practices observed in the AEZs. Ayuke et al. (2017), in "Soil Organic Matter and Soil Health," emphasized the role of organic manure in maintaining soil fertility and promoting sustainable agriculture, corroborating the findings from the AEZs.

Additionally, organic manure application is also influenced by gender, with male farmers more likely to adopt this practice, possibly due to greater access to resources and decision-making power. This is consistent with the work of Kiptot et al. (2015), who reported that agroforestry practices are more prevalent in regions where farmers have greater land tenure security and access to extension services. Higher education levels significantly correlate with adopting several land management practices, including minimum tillage, mulching, and the use of inorganic fertilizers and pesticides. This suggests that educated farmers are more aware of advanced agricultural techniques and their benefits, highlighting the importance of education in promoting sustainable farming practices. Teklewold et al. (2016), who found that education significantly enhances adoption of sustainable land management practices in Ethiopia, drew similar conclusions.

Mulching, farmers in both AEZs reported using mulching as a land management practice, which helps conservation soil moisture, reduce erosion, and improve soil fertility. This simple and effective practice contributes to sustainable land management and enhanced crop production. Thierfelder et al. (2016), in "Conservation Agriculture in Southern Africa: Advances in Knowledge," found that mulching significantly improves soil moisture retention and reduces erosion, supporting the findings in the AEZs. Zomer et al. (2017), in "Global Sequestration Potential of Increased Organic Carbon in Cropland Soils," emphasized the benefits of mulching in conserving soil moisture and improving soil health, aligning with the practices observed in the AEZs:

The findings underscore the importance of tailoring land management practices to specific regional conditions. The significant differences in household size, land holdings, and preferred practices between the AEZs suggest that interventions should be context-specific. For instance, larger households in the Kyoga plains might benefit from programs that optimize labor use, while the Highland AEZ might require more erosion control measures. Comparing these results with other studies, the emphasis on cover crops and minimum tillage aligns with global trends in sustainable agriculture to preserve soil health and improve resilience to climate change. Studies conducted by Kassie et al. (2015) and Ngoma et al. (2020) have similarly found that education and gender significantly influence the adoption of innovative farming practices, reinforcing the need for targeted educational and support programs to enhance agricultural productivity and sustainability. Overall, these results provide valuable insights for policymakers and agricultural extension services, emphasizing the need for region-specific strategies that consider demographic and socio-economic factors to effectively promote sustainable land management practices among maize farmers in different agro-ecological zones.

5.2 Factors that determine the adoption of LMPs among maize farmers in Kyoga Plain and Highland agro-ecological zones.

The study presented focuses on identifying factors influencing the adoption of land management practices among maize farmers in two distinct agro-ecological zones (AEZs) within the Lake Kyoga Basin: the Highland AEZ and the Kyoga Plain AEZ. The results indicate that soil fertility, erosion, and climate variability are significant determinants. Loss of soil fertility is a major concern across both AEZs, with a higher prevalence in the Highland AEZ (64% vs. 37%) in the Kyoga Plains. This indicates that the high rate of reported soil fertility loss highlights the critical need for interventions that restore and maintain soil health. This loss can lead to reduced agricultural productivity, prompting farmers to adopt various soil fertility management practices to sustain crop yields. Vanlauwe et al. (2015), in "Integrated Soil Fertility Management in Sub-Saharan Africa," stressed the need for soil fertility management to sustain productivity, which aligns with the AEZ findings that soil fertility loss is a crucial motivator for adopting soil management practices. Similarly, (Lal, 2016), in "Enhancing Soil Health to Mitigate Soil Degradation," emphasized the necessity of maintaining soil fertility for sustainable agriculture, supporting the observed practices among AEZ farmers. Additionally, (Nandwa & Bekunda, 2016), in their study "Research on Nutrient Flows and Balances in East and Southern Africa," found that soil fertility management is crucial for long-term productivity, corroborating the AEZ findings on the importance of addressing soil fertility loss.

Pests and Diseases, where 63.9% of respondents cited pests and diseases as significant factors influencing their land management practices. The prevalence of pests and diseases necessitates effective management strategies to ensure crop protection and productivity. Farmers' reliance on pesticides reflects a response to these pressures, but it also underscores the need for integrated pest management (IPM) to mitigate environmental and health risks. Pretty et al. (2018): In "Sustainable Intensification in Agricultural Systems," they advocated for IPM practices that reduce pesticide reliance, which aligns with the AEZ findings on the need for pest and disease management. Njuguna et al. (2019): Their study "Impacts of Pests and Diseases on Smallholder Agriculture in Kenya" emphasized sustainable pest control methods, supporting the AEZ findings on managing pest pressures. Savary et al. (2019): In "The Global Burden of Crop Pests and Diseases on Major Food Crops," they highlighted the significant impact of pests and diseases on yields, reinforcing the need for effective pest management observed in the AEZs.

Soil erosion significantly influences land management practices more in the Highland AEZ, indicating varying environmental pressures. Findings reveal that 60.5% of respondents identified soil erosion as a critical factor in adopting land management practices. Soil erosion can lead to significant land degradation, reducing agricultural productivity and increasing vulnerability to environmental stresses. Farmers' efforts to control erosion through practices such as trench construction especially in the highland AEZs, are essential for maintaining soil health and crop yields. Teshome et al. (2016): In "Soil and Water Conservation Effects on Soil Properties in the Northwestern Ethiopian Highlands," they found that soil erosion control measures are vital for sustainable land management, supporting the AEZ findings. Nyssen et al. (2018): In "Soil and Water Conservation through Watershed Management: Lessons from Tigray," they emphasized the role of soil erosion control in land productivity, aligning with the highland AEZ findings. Kaihura et al. (2016): Their study "Adoption of Soil and Water Conservation Technologies" highlighted the importance of erosion control measures, corroborating the AEZ findings.

Prolonged Drought and Floods where 43.1% of respondents indicated that prolonged drought and floods influenced their land management practices. The increasing frequency of extreme weather events, such as droughts and floods, drives farmers to adopt adaptive management practices to safeguard their crops and livelihoods. This highlights the need for climate-resilient agricultural strategies. Mertz et al. (2016), in "The Forgotten Problem of Agricultural Drought," stressed the impact of climate variability on agriculture, supporting the AEZ findings. Similarly, Giller et al., (2017), in "Tillage Effects on Soil Health and Crop Productivity," discussed adaptive practices for managing climate variability, aligning with the AEZ findings. Additionally, Kassie et al. (2018), in their study "Climate Variability and Change in Ethiopia: Exploring Impacts and Adaptation Options," emphasized the importance of adaptive management, corroborating the AEZ results.

The study findings also revealed that 40.6% of respondents reported low crop yields as a factor influencing their adoption of land management practices across the two AEZs. Low crop yields can jeopardize food security and farmers' incomes, prompting the adoption of practices aimed at enhancing productivity. This underscores the need for effective soil and crop management strategies to boost yields. Jayne et al. (2016), in "Land Access and Agricultural Productivity in Africa," highlighted the importance of land management in enhancing productivity, supporting the AEZ findings. Doss et al. (2018), in their study "Women and Agricultural Productivity: Reframing the Issues," discussed the impact of resource access on productivity, aligning with the AEZ findings. Additionally, Holden & Ghebru (2016) in "Land Tenure Reforms, Tenure Security and Farm Productivity," emphasized the role of secure land tenure in productivity, which supports the AEZ results.

Climate variability, including factors like rainfall variability and occurrences of prolonged drought and floods, also differs significantly between the two zones, affecting agricultural practices differently. 35.6% of respondents indicated rainfall variability as a factor influencing their land management practices. Rainfall variability significantly affects water availability for crops, influencing farmers' decisions to adopt water conservation and soil moisture management practices. This is crucial for maintaining crop yields and ensuring agricultural sustainability in the face of unpredictable weather patterns. Mertz et al. (2016), in "The Forgotten Problem of Agricultural Drought," emphasized the impact of rainfall variability on agriculture, supporting the AEZ findings. Similarly, Giller et al. (2017), in "Tillage Effects on Soil Health and Crop Productivity," discussed adaptive practices for managing rainfall variability, aligning with the AEZ findings. Kassie et al. (2018), in their study "Climate Variability and Change in Ethiopia: Exploring Impacts and Adaptation Options," highlighted the importance of adaptive management practices, corroborating the AEZ results. The implications for the AEZs are clear: farmers must implement resilient agricultural systems to cope with unpredictable rainfall patterns, ensuring sustainable productivity and food security.

Access to markets, agricultural inputs and services, credits, and land for agriculture production were identified as influential factors in the adoption of land management practices. Access to these resources enables farmers to implement and sustain effective land management practices, improving productivity and resilience. This emphasizes the need for supportive infrastructure and policies to enhance farmers' access to essential resources. Jayne et al. (2016), in "Land Access and Agricultural Productivity in Africa," highlighted the critical role of resource access in productivity, supporting the AEZ findings. Similarly, Doss et al. (2018), in their study "Women and Agricultural Productivity: Reframing the Issues," discussed the impact of access to resources on productivity, aligning with the AEZ findings. Additionally, Holden & Ghebru (2016), in "Land Tenure Reforms, Tenure Security and Farm Productivity," emphasized the importance of secure land tenure for productivity, supporting the AEZ results. The findings from the AEZs underscore the importance of ensuring that farmers have access to markets, inputs, services, and credits to sustain their land management practices and enhance agricultural productivity and resilience.

The study reveals several new insights and implications; notably, the differential impact by AEZ underscores the importance of tailoring agricultural interventions to local environmental conditions. While soil erosion and rainfall variability significantly influence land management practices universally, factors such as soil fertility and pest management vary significantly between the Highland AEZ and the Kyoga Plain AEZ. This differentiation is crucial for policymakers and extension services to prioritize interventions addressing specific environmental challenges in each AEZ. For instance, promoting soil conservation practices might be more critical in the Highland AEZ, while interventions focusing on improving soil fertility could yield better results in the Kyoga Plain. Furthermore, socio-economic constraints play a pivotal role in shaping farmers' choices. Improving access to markets, inputs, and credit could enhance the adoption of sustainable land management practices. Comparisons with other studies, such as those by Kiptot et al. (2015); Tittonell et al. (2019) highlight the role of environmental and socio-economic factors in influencing agricultural practices. However, this study adds granularity by providing specific insights into how these factors operate within different AEZs. Additionally, comparing findings with studies from nieghbouring regions (e.g., East Africa) could further elucidate regional differences in agricultural practices and their determinants, as seen in studies by Ngigi et al. (2017).

In conclusion, the study enhances our understanding of the nuanced factors influencing land management practices among maize farmers in the Lake Kyoga Basin's AEZs, providing a robust basis for targeted policy interventions aimed at improving agricultural sustainability and resilience in the face of climate change.

5.3 Effect of land management practices on maize yields within Kyoga Plain and Highland agro-ecological zones.

The study revealed significant differences in maize yields between the Highland AEZ and Kyoga Plain AEZ in eastern Uganda, with the Kyoga Plain AEZ achieving a mean yield of 986.7 Kg/yr., significantly higher than the Highland AEZ's yield of 721.1 Kg/yr. Several factors contribute to these differences. In the Highland AEZ, severe soil erosion leads to soil degradation, stripping away the fertile topsoil essential for crop growth and resulting in reduced soil fertility and water-holding capacity. Erratic rainfall patterns further disrupt planting schedules and affect crop growth, with inconsistent rainfall causing periods of drought and waterlogging, both detrimental to maize production. Suboptimal farming practices, such as inadequate use of fertilizers, poor seed selection, and insufficient pest and disease management, also contribute to lower yields. Additionally, the Highland AEZ faces environmental constraints, such as steep terrain, which exacerbates soil erosion and limits the effectiveness of certain farming practices.

Conversely, the higher yields in the Kyoga Plain AEZ can be attributed to the implementation of effective land management practices, such as pesticide control, which helps manage pest pressures and enhance crop yields. Other beneficial practices include soil fertility management, crop rotation, and the use of cover crops. The Kyoga Plain AEZ also benefits from more favorable environmental conditions, including relatively flat terrain and more consistent rainfall patterns, which support better maize production. These findings align with several other studies. Vanlauwe et al. (2015), in "Integrated Soil Fertility Management in Sub-Saharan Africa," emphasized the critical role of integrated soil fertility management in improving crop yields. Lal (2016), in "Enhancing Soil Health to Mitigate Soil Degradation," highlighted the importance of maintaining soil health to sustain agricultural productivity. Pretty et al. (2018), in "Sustainable Intensification in Agricultural Systems," advocated for adopting sustainable intensification practices to improve yields and resilience. Overall, the study underscores the importance of tailored land management practices and addressing environmental constraints to improve maize yields in different agro-ecological zones.

The results also indicated that the use of inorganic fertilizers and pesticide applications significantly increases yields in the Kyoga Plain AEZ compared to the Highland AEZ, with p-values of 0.001 and 0.004, respectively. The significant increase in yields associated with inorganic fertilizer use in the Kyoga Plain AEZ suggests that this practice effectively addresses soil fertility challenges specific to that zone. However, while beneficial for short-term yield increases, the long-term sustainability and environmental impacts of heavy reliance on inorganic fertilizers should be considered, including soil health degradation and water pollution risks. Studies by (Mueller et al., 2017; Sanchez et al., 2020) discuss the role of inorganic fertilizers in boosting crop yields, emphasizing their efficacy under specific soil and management conditions. These studies support the notion that inorganic fertilizers can enhance yields but caution against over-reliance due to environmental and economic sustainability concerns (Mueller et al., 2017; Sanchez et al., 2020).

Similarly, the significant yield benefits from pesticide applications in the Kyoga Plain AEZ indicate effective pest management strategies tailored to local pest pressures. However, the implications include the need for integrated pest management approaches that minimize pesticide use while maintaining crop protection and ecological balance. Research by (Goulson, 2019) and (Pretty et al., (2016) examines pesticide use and its impacts on biodiversity and ecosystem services, advocating for sustainable pest management practices. These studies underscore the need for integrated pest management approaches that balance productivity with environmental sustainability and human health concerns (Goulson, 2019; Pretty et al., 2016).

The study finding aligns with other studies conducted revealing consistent trends and some unique differences (Kiptot et al., 2015) found that the adoption of improved land management practices, including the use of fertilizers and integrated pest management, significantly enhanced crop yields in East African farming systems. This aligns with the study's findings of the effectiveness of inorganic fertilizers and pesticide use in the Kyoga Plain AEZ Tittonell et al. (2019) highlighted the importance of tailored land management practices to local environmental conditions, similar to the current study's emphasis on region-specific interventions. Their study also noted the detrimental impact of soil degradation on crop yields, which resonates with the challenges identified in the Highland AEZ. Ngigi et al. (2017) examined the role of climate variability and soil management in agricultural productivity across East Africa. Their findings corroborate the current study's observation that erratic rainfall and soil erosion significantly hinder maize yields in the Highland AEZ, emphasizing the need for climate-resilient agricultural practices.

Overall, this study enhances our understanding of how specific land management practices influence maize yields in distinct agro-ecological zones. The findings provide a robust basis for policymakers and agricultural extension services to develop targeted interventions aimed at improving agricultural sustainability and resilience, particularly in regions facing severe environmental constraints.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter presents the conclusion and recommendations. The recommendations cover areas related to policy and future research needs.

6.2 Conclusion

The study's findings provide valuable insights into the demographic characteristics, land management practices, and maize yields among farmers in the Kyoga Plain and Highland agro-ecological zones (AEZs) of eastern Uganda. It reveals significant differences in household size, land holdings, and the adoption of various land management practices between the two regions. These distinctions have direct implications for agricultural productivity and sustainability. The study achieved its primary objective of characterizing land management practices and their impact on maize yields while also identifying key factors influencing the adoption of these practices.

Farmers in the Kyoga Plain AEZ were found to have larger households and more extensive land holdings than those in the Highland AEZ. This contributed to greater labour availability and allowed for larger-scale farming operations. These demographic differences are crucial in understanding the implementation of land management practices, as larger households and farms tend to be better positioned to adopt labour-intensive practices like pesticide application and trench construction. This finding aligns with the study's aim of identifying how demographic and socioeconomic factors influence the adoption of land management practices.

The study also highlighted clear regional differences in the specific land management practices adopted by farmers. In the Highland AEZ, farmers focused more on cover cropping and trench construction, which are crucial for combating soil erosion and conserving water in the hilly terrain. On the other hand, farmers in the Kyoga plain AEZ relied more heavily on pesticide application, likely in response to greater pest pressures in the flat, expansive farmlands. This aligns with the study’s objective to assess land management practices suited to different environmental contexts, confirming the importance of region-specific interventions.

One of the most significant findings was the disparity in maize yields between the two AEZs. Farmers in the Kyoga plain achieved significantly higher maize yields (mean yield of 986.7 kg/ha) compared to those in the Highland AEZ (mean yield of 721.1 kg/ha). The higher yields in the Kyoga plains can be attributed to the effective use of land management practices, particularly inorganic fertilizers and pesticides, as confirmed by the statistical analysis (ANOVA results showing p-values of 0.001 and 0.004 for fertilizer and pesticide use, respectively). This result directly supports the study's aim of evaluating the effect of land management practices on maize yields. Conversely, the lower yields in the Highland AEZ are linked to severe soil erosion, erratic rainfall, and suboptimal farming practices, indicating the need for improved interventions to address these challenges.

The significance of this study lies in its contribution to the understanding of how land management practices, tailored to specific agroecological conditions, can enhance maize productivity and environmental sustainability. By demonstrating that demographic factors, such as household size and land holding, as well as region-specific challenges, like pest pressure and soil erosion, significantly influence the adoption and effectiveness of land management practices, the study offers practical insights for policymakers and agricultural extension services. It suggests that a one-size-fits-all approach to agricultural interventions may not be effective; instead, targeted strategies that address the unique conditions of different AEZs are essential for promoting sustainable maize farming.

The implications of the study are profound for efforts to increase food security and improve farmer livelihoods in eastern Uganda. The findings highlight the critical need for improved soil conservation techniques in the Highland AEZ to counteract soil degradation and enhance maize yields. For the Kyoga plain, continued support for pesticide use and other productivity-enhancing practices can sustain the higher yields observed. Additionally, the study underscores the role of demographic characteristics in shaping farming outcomes, emphasizing the importance of considering household size and land holding when designing agricultural policies and programs. In conclusion, the study successfully achieved its objectives by identifying the key factors determining the adoption of land management practices and assessing their impact on maize yields in the Kyoga Plain and Highland AEZs. The findings have significant implications for the development of tailored agricultural interventions that can promote both productivity and sustainability in maize farming systems in eastern Uganda.

6.3 Recommendations

Promote the adoption of soil conservation techniques in the Highland AEZ through training programs and financial incentives. Agricultural extension services and development organizations should lead these initiatives. Implementation integrated pest management practices reduce reliance on chemical pesticides and promote sustainable pest control methods is highly recommended since pesticide application is one of the practices mainly adopted by the maize farmers in the two study sites. Further, based on the findings, promotion of agroforestry in the Highland AEZ to enhance soil fertility and provide additional resources would improve the soil resources and fertility in the two AEZ to improve productivity. There is need to design gender-sensitive agricultural programs that provide equal access to resources and decision-making opportunities for both men and women. Finally, improving farmers' access to agricultural inputs through better supply chains, subsidies, and credit facilities can improve maize production in the two AEZ.

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APPENDICES

Appendix I: Survey Questionnaire

FARMER HOUSEHOLD QUESTIONNAIRE

Respondent ID

INTRODUCTION AND CONSENT

Before the beginning of the interview read out the following paragraph and ensure that the respondent understands before asking for consent.

Good morning/afternoon. I am **Nekesa Irene Egessa** and together with **Kisakye Angella**, we are conducting research on MODELING LAND PRODUCTIVITY AND CROP YIELDS UNDER CHANGING CLIMATE AND LAND USE MANAGEMENT USING ARTIFICIAL INTELLIGENCE IN LAKE KYOGA BASIN, UGANDA as masters' students from Kyambogo and Makerere University respectively. We would like to ask you some questions that should take no more than one hour of your time and will contribute to this research to improve soil productivity and thus, maize production across the district. *Your name will not appear in any data that is made publicly available. The information you provide will be used purely for research purposes and will remain confidential. Do you consent to be part of this study? You may withdraw from the study at any time and if there are questions that you would prefer not to answer then we respect your right not to answer them.*
Has consent been given? (1=Yes, 0=No) [__ __]

SECTION 1: Identification Particulars

Particulars	**Code/Name**			
District Name				
County Name				
Sub County Name				
Parish				
Enumerator's Name				
Date of Interview				
GPS Coordinate	Latitude		Longitude	
Record Reference year		2023		2022

District (1= Mbale, 2=Pallisa)

SECTION 2: HOUSEHOLD INFORMATION

Variable	Response	Codes
2.1 Name of the Respondent		
2.2 Gender of Respondent	[__ __]	1=Male 0=Female
2.3 Age of Respondent in years	[__ __]	
2.4 What is your relationship with the head of Household?	[__ __]	1 = Head 2= Spouse 3= Children 4= Parent 5= other relative 6= non-relative

2.5. Marital status	[__ __]	1=Single, 2=Monogamously married, 3=Polygamous married, 4=Widowed, 5=Separated/Divorced, 6=Other (Specify)
2.6 Education level of the Respondent 2.7 Education Level of Spouse	[__ __] [__ __] [__ __]	1=no formal education, 2=Adult education 3= primary education, 4=Junior 'O' Level education, 5=senior 'A' level education, 6=vocational training, 7=certificate, 8=Diploma, 9=Degree 10=PGD
2.8 Household size 2.9 How long has the household head been farming?	[__ __] [__ __]	Number of people in the household Number of years

SECTION 3: SOURCES OF LIVELIHOOD SECURITY

Variable	Response	Codes
3.1 What was your main economic activity in the last 12 months?	[__ __]	**1= Crop Production ,2= Livestock Production, 3= Fisheries, 4= Forestry ,5= Horticulture ,6=Apiary - Bee Keeping ,7= Trader ,8= Artisan - worker in a skilled trade ,9 = Agricultural paid job outside the household ,10= Non-agricultural paid job ,11= No activity ,12= Student ,13= Household work**
3.2 Which agricultural activity did you or your household engage in?		
2023	[__ __]	**1=crop growing, 2=livestock/poultry , 3 =Fish Farming , 4 = beekeeping , 5 = Agroforestry**
2022	[__ __]	
3.3 What Type of crops were grown in?		
2023	[__ __]	**1=Maize,2=Legumes, 3=Cassava, 4= Rice , 5=Fruits and Vegetables, 6= Coffee , 7= sugarcane,8= bananas**
2022	[__ __]	
3.4 What kind of livestock/poultry or fish farming was done?		
2023	[__ __]	**1=Large livestock (cattle, camels),2=small livestock (sheep, goats, pigs, donkeys),3=poultry, 4=fish farming**
2022	[__ __]	

Variable	Response	Codes
3.5 What is the business orientation of your farming activities?		
2023	[__ __]	**1= Subsistence/home consumption, 2=Sale/Trade , 3= Exchange and gifting , 4= cultural practice , 5= social capital , 6= environmental Conservation.**
2022	[__ __]	

SECTION 4: LAND SYSTEM

Variable	**Response**	**Codes**
4.1 Total land Owned by household?	[__ __]	Size in acres
4.2 What is the household's use right on this land?	[__ __]	**1=Owned 2=Rented for agreed amount of money 3=Rented for share of produce 4=Rented in exchange for services 5= Borrowed for free 6=Just walked in ,7 = Leased in**
4.3 What is the Land Tenure System?	[__ __]	**1= Freehold 2= Leasehold 3= Mailo 4= Customary 5= Public land 6= Don't know**

Variable	Response	Codes
4.4 Total Land Utilized for Crop Growing	[__ __]	Size in acres
4.5 Total land Utilized for animal farming	[__ __]	
4.6 Who in the household has access to this land?	[__ __]	**1= household head, 2= wife ,3= children, 4= relatives, 5= non**

SECTION 5: MAIZE PRODUCTION

Variable	Response		Codes
5.1 Total Land Size used for maize cultivation	[__ __]		Size in acres
5.2 Quantity of maize seed planted	[__ __]		Quantity in KGS
5.3 What Variety of maize seeds was planted in?	Season A	Season B	Season A (MAM) Season B (SOND)
2023			
2022			1= farmer saved seed, 2=Improved varieties ,3= indigenous varieties
5.4 What is the main source of the seed/seedling used for maize growing?	[__ __]		**1 = Local retail, 2 = Input supplier ,3 = Government (NAADS/Operation Wealth Creation), 4 =**

Variable	Response		Codes
			Farmer group, 5 = Research center 6 = Relative / Neighbor, 7 = Other farmer(s) ,8 = Non-Government Organization (NGO), 9 = Own farm/Garden
5.5 What is the Quantity of maize harvested in? 2023 -- 2022	Season A	Season B	Maize yield in kg. sack (120kgs), Basin is 25kgs
5.6 How much of the maize harvested did you sell? 2023 -- 2022	Season A	Season B	Maize yield in kg. sack (120kgs), Basin is 25kgs
5.7 What was the total value of sales of Maize in? 2023 -- 2022	Season A	Season B	Total Value in Ugandan Shillings

SECTION 6: KNOWLEDGE AND APPLICATION OF LAND MANAGEMENT PRACTICES

Variable	Responses						
Management Practice	Do you apply this practice?	Kind/Type of Practice Applied	How much do you apply?		Unit of measure of application	The cost incurred by practice application	How did you obtain the practice?
6.0 Fertilizer application	1=yes ,0=No	**1 = Commercial organic Fertilizer (e.g. Fertiplus, Biochar) 2 = Animal Droppings 3 = Animal Urine 4 = Chicken droppings 5 = Plant residue/compost 6 = green plant cover crops 7 = Ash 8 = Municipal waste 9 = Sewage/sludge**	Season A	Season B	**Kilogram(Kg)**	Total Cost in Ugx Shillings	**1=purchased 2=Received from govt 3=received from NGO 4=Received from research**
Organic Fertilizers			2023				
			2022				
	1=Yes 0= No	**1= CAN (Calcium Ammonium Nitrate),2= Urea,3= DAP (Diammonium Phosphate),4= SSP (Single Super Phosphate),5= TSP (Tipple Super Phosphate),6= MOP (Muriate of Potash),7= NPK (Nitrogen Phosphorous Potassium)**	Season A	Season B	**Kilograms,/ Litre**	Total Cost in Ugx Shillings	**1=purchased 2=Received from govt 3=received from NGO 4=Received from research**

In organic Fertilizers			2023				
			2022				
6.1 Pesticide Application	1=Yes ,0= No	**1= Herbicides 2= Insecticides 3= Fungicides 4= Rodenticides**	Season A	Season B	**1 = Kilograms, 2 = Litre ,3 = Mili Litre**	Total Cost in Ugx Shillings	**1=purchased 2=Received from govt 3=received from NGO 4=Received from research**
			2023				
			2022				
6.2 Cover crops	1=Yes ,0= No	**1=beans, 2=G nuts, 3= Rhizobia inoculation,4= other legumes**	Season A	Season B		Total Cost in Ugx Shillings	**1=purchased 2=Received from govt 3=received from NGO 4=Received from research**
			2023				
			2022				

6.3 Mulching	1=Yes ,0= No	**1=grass bands** **2 = shredded leaves** **3 = compost**	Season A	Season B	Total Cost in Ugx Shillings	**1=purchased** **2=Received from govt** **3=received from NGO** **4=Received from research**
			2023			
			2022			
6.4 Weeding	1=Yes ,0= No	**1=mechanical** **2=chemical**	Season A	Season B	Total Cost in Ugx Shillings	**1=purchased** **2=Received from govt** **3=received from NGO** **4=Received from research**
			2023			
			2022			
6.5 Irrigation	1=Yes ,0= No	1=**drip irrigation** **2=Sprinkler irrigation** **3= surface irrigation**	Season A	Season B	Total Cost in Ugx Shillings	**1=purchased** **2=Received from govt** **3=received from NGO** **4=Received from research**
			2023			
			2022			

6.6 Trenches	1=Yes ,0= No	**1=Contour trenches 2=diversion trenches 3=terracing trenches**	Season A	Season B	Total Cost In Ugx Shillings
			2023		
			2022		
6.7 Tillage	1=Yes ,0= No	**1= Minimum tillage , 2= conventional tillage,3=reduced tillage , 4=deep tillage , 5= no-tillage**	Season A	Season B	Total Cost in Ugx Shillings
			2023		
			2022		
6.8 Agroforestry	1=Yes ,0= No	**Type of tree planted**	**Acreage Planted**		
			2023		
			2022		

SECTION 7: ADOPTION OF LAND MANAGEMENT PRACTICES

Variable	Management Practice	Response	Code
7.0 What are the factors influencing the adoption of these practices	[__ __]		**1=Rainfall Variabilty,2 =soil erosion, 3= loss of soil fertility, 4= pests and diseases, 5 =low crop yield,6= droughts/Floods 7= high crop yield, 8= market access for produce, 9=agro input access, 10= lack of labor ,11=credit facilities access ,12= access to land ,13= low implementation costs,**
7.1 What are your sources of Information on management Practices?		[__ __]	**1=Government Extension workers, 3=Farmer Group members, 4=NGO (specify), 5=Other farmers, 6=Radio, 7=Demonstration/research sites**
7.2 Who in the household makes Decisions on the Choice of Management Practice		[__ __]	**1=Household head,2=wife , 3= both , 4= senior relative ,5= community**

THANK YOU FOR YOUR PARTICIPATION

Appendix II: Key Informant Guide

Name…………………………………………………………………………………

Position………………………………………………………………………………

Contact…………………………………………………..

Email…………………………………………………………………………..................

COMPONENT 1: LAND MANAGEMENT PRACTICES

1. As key informants, how do you perceive your role in promoting land management practices in maize farming?

2. In your opinion, what factors influence the adoption of these practices in the community?

3. What benefits have you observed from adopting the mentioned land management practices in maize farming?

4. What challenges if any, have you faced in adopting and implementing these practices in maize farming?

Please provide any additional comments or insights you would like to share regarding land management practices in maize farming.

COMPONENT 11: CROP YIELD AND SOIL TESTING

1. Have you observed any variations in maize crop yield since adopting land management practices?

☐ **Yes** ☐ **No**

1a) If yes, please describe the observed variations

2. How do you measure or estimate maize crop yield on your farm?

3. Have you conducted soil tests on your farm to assess soil properties?

☐ **Yes** ☐ **No**

4. Have you observed any changes in soil properties e.g. nutrient loss, or fertility levels since adopting land management practices?

☐ **Yes** ☐ **No**

4a) if yes, please describe the observed changes……………………………………………………………………

Appendix I11: Focus Group Discussion

Location details

a	District	
b	Sub-county	
c	Parish	
d	Village	

COMPONENT 1: LAND MANAGEMENT PRACTICES

1. As FGDs, how do you perceive your role in promoting land management practices in maize farming?

2. In your opinion, what factors influence the adoption these practices in community?

3. What benefits have you observed from adopting the mentioned land management practices in maize farming?

4. What challenges if any, have you faced in adopting and implementing these practices in maize farming?

Please provide any additional comments or insights you would like to share regarding land management practices in maize farming.