AMERICAN UNIVERSITY OF BEIRUT

A COMPARATIVE STUDY OF THE FARMING SYSTEMS IN UGANDA, KENYA, AND TANZANIA TO ENHANCE PRODUCTIVITY

by
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ABSTRACT
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Title: A Comparative Study of the Farming Systems in Uganda, Kenya, and Tanzania to Enhance Productivity

Small-scale farming is the backbone of the agricultural sector in East Africa, contributing to food security, rural livelihoods, and poverty reduction. This study aimed to identify the challenges and opportunities facing small-scale farming in Uganda, Kenya, and Tanzania and provide practical recommendations to enhance farm productivity. The study employed a qualitative secondary data analysis approach, incorporating a comprehensive literature review of existing studies related to farming systems in the three countries, data from national Ministries of Agriculture databases, and virtual interviews with field agricultural extension officers in Uganda and Kenya. The findings revealed that small-scale farmers face numerous challenges that negatively affect farm productivity, including the use of unsustainable farming practices, inadequate access to markets, limited access to credit, and climate change. Additionally, the study found that ecological and geographical borders, as well as farmer literacy levels, influenced farming systems such as land use, crop choices, and livestock management. To enhance productivity, the study recommends promoting sustainable farming practices, improving access to credit, investing in infrastructure, and promoting youth involvement in agriculture to bridge the generational gap and allow knowledge exchange. Moreover, promoting literacy among small-scale farmers can help them access information on modern and advanced agricultural practices and technologies. It further recommends policies that optimize sustainable farming systems and improve market linkages to improve food access. The study concludes by highlighting the critical role of sustainable and innovative farming systems coupled with targeted interventions that address specific challenges facing small-scale farmers in enhancing farm productivity and promoting food security in East Africa.

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CHAPTER I

INTRODUCTION

The global population growth rate, estimated at around 1.05% per year, has a significant impact on current food systems, which affects the productivity and sustainability of farming systems. With the current global population of 8 billion people, the world's population continually grows by approximately 81 million people each year (Borlaug, 2002; Sakschewski et al., 2014). The increasing number of people thus places more strain on natural resources, especially water, and land, in search of producing more food to feed the fast-growing global population while also ensuring that food is affordable, accessible, and nutritious (Schneider et al., 2011). Moreover, as the global population grows, inequalities in food insecurity also increase, especially in distribution and productivity, with some regions and populations experiencing greater vulnerability to food shortages and malnutrition including sub-Saharan Africa (McGuire, 2013). According to the United Nations food program and FAO (2020), one in every seven individuals today lacks access to nutritious food, which is partially due to food wastage along the supply and production food system chains as well as due to unsustainable farming systems thus low farm yields. Unsustainable farming systems that lead to resource scarcity, such as water shortages, soil degradation, and loss of biodiversity, contribute to food insecurity by reducing the productivity potential and resilience of agricultural systems among farming communities. Therefore, it is important to study the various farming systems practiced by farmers to enhance farm productivity (Canton, 2021; Meuwissen et al., 2019).

To address the challenges of unsustainable farming systems, there is a need for more sustainable, resilient, and equitable food systems that can provide nutritious food to the growing population. This requires a range of interventions, such as promoting agroecological practices, reducing food waste, and strengthening the capacity of farming communities with local food production to modify traditional farming practices and adopt sustainable farming practices that will increase farm yields (Snapp & Pound, 2017). This will result in the formation of food-resilient communities, addressing food security pillars including availability, access, utilization, and stability while practicing sustainable agriculture systems. Sustainable farming systems have a significant positive impact on farm productivity (Kılıç et al., 2020).

A. Farming in Uganda, Kenya, and Tanzania

This research paper studies farming systems in sub-Saharan Africa, specifically in East Africa. Approximately 60% of the farm produce in East Africa is contributed by small-scale farmers; however, low farm yields are a significant challenge among small-scale farming communities, which can be attributed to poor farming systems (Abtew et al., 2014; Muhanji et al., 2011). Despite the farmers' tremendous farm work, 65 % of the farm yields remain constant while another 35% decline; therefore, there is a need to study the various farming systems practiced by the farmers in East Africa (Kansiime et al., 2018). In this research study, the focus was on Uganda, Kenya, and Tanzania, as they have significant similarities in climate, commercial activities, and farming systems. English and Swahili are the official languages spoken across the countries, although each country has over 50 dialects (Mukuthuria, 2006). Tanzania is the largest in East Africa with an area of 365,756 mi^2 and a population of 64 million people (2021), followed by

Kenya with an area of 224,081 mi² and a population of 55 million people by 2021, and Uganda is the smallest of the three with an area of 93,065 mi² and a population of 46 million by 2021, according to the World Bank. Agriculture plays a significant role in the economies of Uganda, Kenya, and Tanzania, contributing to food security and providing employment for approximately 80 percent of the population. However, farming systems in these countries differ in terms of technology adoption, crop choices, and production methods (Salami et al., 2010). A comparative study of these farming systems can reveal insights into how to enhance productivity in each country.

1. Agriculture in Uganda

Agriculture is the backbone of Uganda's economy, and the country has a diverse range of traditional farming systems due to its varied agroecological zones. The sector contributes approximately 24% of the country's GDP and employs 90% of the total population in the country. 60% of the total farming population are small-scale farmers in rural areas, contributing over 75 percent to the country's economy. In Uganda, 36% of the total land area is under agricultural production, 5% is under forest cover, and the rest is under nonagricultural activities and mineral deposits. Agriculture in Uganda is characterized by small-scale subsistence farming, with farmers typically growing food crops such as maize, beans, cassava, bananas, sweet potatoes, and vegetables, while major cash crops include coffee, tea, and cocoa (Ronner & Giller, 2019). Livestock farming is also practiced, with cattle, goats, and pigs being the most common animals raised.

Agriculture in Uganda is heavily dependent on the country's climate, which is characterized by a tropical climate with average temperatures ranging from 25°C to 29°C and regular rainfall of 1282 mm annually. Historically, Uganda has had more rainfall than

neighboring Kenya and Tanzania due to its humid, tropical climate, which is a major support for Ugandan agriculture. Uganda has two rainy seasons: March to May and September to November (Ssentongo et al., 2018). Moreover, Uganda is located at the equator and is therefore characterized by having equatorial-type vegetation. The combination of Ugandan weather, location, and vegetation greatly influences the agricultural sector, as evidenced by more than 80% of Ugandan farmers relying on rain-fed agriculture for food and income. Most soils in Uganda around the equator are deep, well-drained loam soils with a high content of organic matter and a soil pH ranging from about 5.6 to 7.5(Rehm & Grashey-Jansen, 2016).

2. Agriculture in Kenya

Kenya's agricultural sector has been growing at an average annual rate of 5% in the past five years and 48% of the total land area is under agricultural production while the rest is under nonagricultural activities and mineral deposits. Kenya has a coastline with the Indian Ocean, which supports the country's economy, while agriculture also employs over 60% of the total population (Chauvin et al., 2012). According to the Ministry of Agriculture and Livestock Development in Kenya, agriculture contributes 40% to Kenya's Gross Domestic Product (GDP), and an increase in agricultural production helped reduce extreme poverty from 44% to 36% between 2005 and 2018.

While agriculture is an important source of employment for rural people (75% are rural small-scale farmers), it also accounts for more than one-third of export earnings and a significant share of government revenues (Faling, 2020). The sector is dominated by smallholders, who make up two-thirds of the total farm area and grow crops including tea, coffee, maize, beans, wheat, sugarcane, and horticultural crops such as flowers and

vegetables like kale, locally known as sumawihci. Livestock rearing is also a significant aspect of agriculture, with cattle, goats, sheep, and poultry being the most kept animals. Agriculture in Kenya is also highly dependent on the natural climate, as most farmers rely on rainfall farming (Sibiko & Qaim, 2020).

Kenya is characterized by having forest, mountain grassland, savannah, and semi-arid grassland types of vegetation. The country has a tropical climate characterized by two rainy seasons, typically from March to May and from October to December, while the dry seasons are from January to February and from July to September (Salami et al., 2010). The combination of Kenya's location and the vegetation provides it with a temperate subtropical climate in the west and southwest highlands, with temperatures averaging between 10°C and 26°C. In coastal areas, such as Mombasa, temperatures range from 22°C to 30°C, making it hot and humid throughout the year, while it is hot and dry in the northern and eastern regions, including parts of the Rift Valley and northern Kenya, with an average temperature of 26°C. These climate changes affect the distribution of agriculture, water resources, and biodiversity. Most agricultural soils in Kenya are fertile clay loam with poor drainage, making them prone to flooding during the rainy season, and the soil pH ranges from about 6 to 7 (Kogo, Kumar, & Koech, 2021).

3. Agriculture in Tanzania

In Tanzania, 45% of the total land area is under agricultural production, and the rest is under nonagricultural activities. Tanzania also has a coastline, with the Indian Ocean contributing to the country's economy; however, agriculture accounts for about 30% of the country's GDP and employs about 75% of the population, of which 50% of the agricultural population are rural small-scale farmers. Tanzania's farming system is

like Uganda's, with many smallholder farmers who rely on subsistence farming. The country's major crops include maize, beans, wheat, and rice (Mkonda & He, 2017). Tanzania is also known for its production of sisal, a fiber crop used for making rope and twine Livestock, including cattle, goats, and sheep, are also important to the economy (Kangile et al., 2021; Ronner & Giller, 2013).

Tanzania has a tropical climate with varying temperatures depending on the region; the average coastal area temperatures average around 30 °C, and the inland highlands temperatures average around 20°C, especially in the mountainous regions. The country has two main rainy seasons: from March to May and then from October to December (Kaganzi et al., 2021). The soil pH is slightly acidic, ranging between 4.5 and 7.5, due to the increased concentration of sulfur and nitrogen compounds in the soil because of volcanic activity in the area, especially in the northern region (Mohamed et al., 2021).

Agriculture is a vital sector in Uganda, Kenya, and Tanzania providing a source of livelihood for 80% of the population in the region. Despite having relatively similar natural resources, each country may have unique farming systems that affect productivity differently. Moreover, the study explored the differences and similarities in farming practices by comparing the strengths and weaknesses of each system to provide valuable insights that can improve productivity in East Africa's agricultural sector.

B. Objectives of the study

This comparative study sought to investigate and analyze the farming systems in Uganda, Kenya, and Tanzania to enhance productivity. To achieve this, the following research objectives were developed.

Firstly, the study aimed to identify the farming system gaps in Uganda, Kenya, and Tanzania. The introduction highlights that despite the three countries having similar natural resources, they have unique farming systems that affect productivity differently. Hence, the study sought to analyze the farming systems to identify the gaps and how they impact productivity.

Secondly, to enhance farm productivity, the second research objective aimed to recommend better farming practices to fill the identified gaps. The study sought to identify the strengths and weaknesses of each farming system to provide insights into how farmers can optimize their farming practices to address the identified gaps to maximize production.

Thirdly, the study sought to develop a farming system guide for small-scale farmers with practical recommendations for farmers to enhance productivity. The guide provides valuable insights for farmers and other stakeholders on how to optimize their farming systems.

C. Research Question: How can sustainable farming systems enhance farm productivity?

The research question focuses on exploring the potential benefits of sustainable farming systems in enhancing farm productivity. It seeks to investigate the various strategies of sustainable agriculture that contribute to increased productivity on farms. By examining the relationship between sustainable farming practices and productivity, the research aims to uncover specific interventions that can be implemented to maximize agricultural output while maintaining ecological balance and resource efficiency.

Moreover, the research question opens avenues for investigating the specific components of sustainable farming systems that positively impact productivity, such as

soil health management, integrated pest management, and conservation practices. It also allows for studying the potential socio-economic and environmental benefits associated with sustainable farming, such as improved crop yields, reduced input costs, enhanced resilience to climate change, and minimized negative impacts on ecosystems.

By addressing this research question, the study contributes to the existing knowledge on sustainable agriculture and provides insights into practical approaches that farmers and policymakers can adopt to optimize productivity while prioritizing long-term sustainability at individual farms over regional or national agricultural systems.

CHAPTER II

METHODOLOGY

To explore how sustainable farming systems enhance farm productivity, a comprehensive methodology was employed to ensure the reliability of the findings on the relationship between sustainable farming systems and farm productivity in Uganda, Kenya, and Tanzania.

A. Data Source

In this study, a qualitative secondary data analysis approach was used to compare the farming systems in Uganda, Kenya, and Tanzania. The data used was obtained from the existing literature and reports from various sources, including government publications, academic journals, and non-governmental organizations. The data collection process involved conducting a comprehensive literature review of existing studies related to farming systems in the three countries and identifying the challenges and opportunities facing small-scale farmers. The information was also obtained from national Ministries of Agriculture databases in Uganda, Kenya, and Tanzania on the farming systems used in each country and the impact they have on productivity, including land use, crop choices, livestock management, and programs implemented by the government to support small-scale farmers.

In addition to the use of existing literature and data from national Ministries of Agriculture databases, this study incorporated virtual information interviews with field agricultural extension officers in Kenya and Uganda. The interviews were conducted using online platforms, including Zoom and WhatsApp calls, and consisted of open-

ended questions to collect information on the farming systems used, the challenges faced, and the existing government programs to support small-scale farmers. The field extension officers had extensive experience working with small-scale farmers in rural areas and provided valuable insights into the farming systems used by farmers.

The findings from the virtual informational interviews were combined with the data from the literature review and national Ministries of Agriculture databases to provide a comprehensive understanding of the farming systems used in Uganda, Kenya, and Tanzania. The collected data were analyzed thematically, focusing on identifying the similarities and differences in the farming systems used in each country. The analysis also identified the challenges facing small-scale farmers to identify gaps and develop practical recommendations on how to optimize their farming systems for maximum productivity.

B. Study Population

The study focused on the population of small-scale farmers in Uganda, Kenya, and Tanzania because small-scale agriculture is the main source of livelihood for a significant portion of the population in these countries. In this study, small-scale farmers are individuals involved in agricultural activities on less than four hectares (10 acres) of land with limited resources, such as land, labor, and capital, and thus use traditional farming methods and low-input technologies. They practice subsistence farming, and the surplus is sold in the local markets located in rural areas.

According to the Food and Agriculture Organization (FAO), smallholder farmers produce over 80% of the food consumed in sub-Saharan Africa, and in Uganda, Kenya, and Tanzania, small-scale farmers make up 80% of the agricultural sector. However, small-scale farmers often face several challenges that limit their productivity. Therefore,

studying the farming systems used by small-scale farmers in Uganda, Kenya, and Tanzania and the challenges they face is essential to developing better farming practices to enhance their productivity and livelihoods.

CHAPTER III

FINDINGS AND DISCUSSION

This section presents the outcomes of the study, highlighting the key discoveries and insights gained from the investigation into the relationship between sustainable farming systems and farm productivity. The discussion discusses how specific sustainable farming practices contribute to increased productivity as well as potential challenges and opportunities associated with implementing sustainable farming systems.

A. General farming information In Uganda, Kenya, and Tanzania

The study found that small-scale farming is the dominant agricultural system in Uganda, Kenya, and Tanzania, with about 70% of the population living in rural areas. The primary goal of small-scale farming is subsistence, with ready local markets for the surplus (Kristjanson et al., 2012). The farmers practice traditional farming systems that rely on rain-fed agriculture, family labor, minimal external inputs, and low farm productivity. Women and children contribute 65% of the agricultural labor force, from planting and weeding to harvesting and processing. Yet women face significant challenges, such as cultural barriers that limit their access to land, credit, and market area.

The growing season of the major food crops in Uganda, Kenya, and Tanzania is typically from March to October, relying on intercropping to maximize productivity, with variations depending on the specific crop and region (Salami et al., 2010). Moreover, communal farming is a common practice and farmers share their resources and work together. It is important to note that most small-scale farmers face limited access to education and extension services, which limits their ability to adopt new farming practices

and technologies (Paul et al., 2020). Rain-fed agriculture is the most common farming system in Kenya as well as in Uganda and Tanzania, where farmers depend on seasonal rainfall, which makes them vulnerable to climate variability. (Rockström et al., 2010).

In Uganda, small-scale farmers produce over 90% of the country's agricultural output, while in Kenya, small-scale farmers contribute about 70% of the country's agricultural output, and in Tanzania, small-scale farmers produce about 75% of the country's agricultural output. The study found that small-scale farmers in Uganda, Kenya, and Tanzania face food security challenges due to low farm productivity. (Adhikari et al., 2015).

The findings were grouped into two main categories: food security and the farming systems in Uganda, Kenya, and Tanzania.

B. Food security in Uganda

Despite progress in recent years, food security remains a significant challenge in Uganda, with an estimated 26% of the population experiencing chronic food insecurity in 2021. The far northern region of Uganda is particularly vulnerable to food insecurity due to long droughts and other social-ecological and economic factors, such as depending on pastoralism for livelihood (Shively & Hao, 2012). An estimated 20% of the population in this region is food insecure, and about 60% of the population lives in poverty, thus experiencing periods of famine and economic crisis in the last 5 years. Furthermore, climate change also exacerbates food insecurity in Uganda (Tusiime et al., 2013). However, with support from the government and NGOs, an estimated 74% of Ugandans in the East, Central, and South are currently food secure, indicating that targeted strategies have had a significant impact on reducing food insecurity. Moreover, small-scale farmers

in Uganda face significant challenges related to low farm productivity challenges and poor access to markets, which can limit their ability to grow enough food (Shively & Hao, 2012).

To improve food security in Uganda, it will be necessary to address both the immediate needs of small-scale farmers and the underlying social and economic factors that contribute to food insecurity. For example, efforts to improve food security must also address poverty, resource allocation inequality, and limited access to education and health care (Tusiime et al., 2013). Ugandan farmers with support from the government and other stakeholders have the potential to improve food security through investments in agricultural research, extension services, and infrastructure, as well as policies that promote sustainable and equitable growth in the agricultural sector (K. Ogwang, personal communication, December 4, 2022).

1. Farming systems in Uganda

Uganda is a country with diverse agroecological zones, which has led to the development of a range of farming systems. Subsistence farming is the dominant farming system among small-scale farmers in Uganda to meet food needs, growing a variety of food crops, including maize, beans, sweet potatoes, cassava, and bananas, and keeping livestock for milk, meat, and manure (Ebanyat et al., 2010). However, some small-scale farmers also engage in cash crop farming, such as coffee, tea, cocoa, cotton, and tobacco, on land less than 5 hectares as a means of generating income. Some small-scale farmers also practice agroforestry to improve soil fertility, enhance biodiversity, and provide a range of products, such as timber, fruits, and fuelwood, through the integration of trees and crops on the same land (K. Ogwang, personal communication, December 4, 2022).

Moreover, Uganda's many lakes and rivers provide opportunities for farmers to practice aquaculture, raising fish such as tilapia and catfish for the local market (Ebanyat et al., 2010).

It is important to note that diversified agriculture is an emerging farming system in Uganda to improve food security and increase income through the production of a variety of crops and livestock on the same farm. The small-scale farmers have adopted this system using conservation agriculture techniques, such as intercropping and crop rotation, to improve soil health and reduce reliance on external inputs, especially agrichemicals. The farming systems in Uganda reflect the country's diverse ecological, cultural, and social contexts, with each system offering unique opportunities and challenges for small-scale farmers (Shively & Hao, 2012).

Ecological and Geographical Features Affecting Farming Systems in Uganda

The ecological and geographical borders of Uganda play a crucial role in shaping farming systems and farm productivity. The country's varied geography has resulted in diverse agroecological zones, which support different crop and livestock production systems. Uganda is in the African Great Lakes region, which is characterized by a tropical climate, abundant rainfall, and fertile soils, making it suitable for a variety of crops. (K. Ogwang, personal communication, December 4, 2022). The highlands in the east and south-central regions are suitable for coffee, tea, and dairy farming, while the lowlands in the north and northeast are suitable for sorghum, millet, and livestock production. However, the highlands are also prone to soil erosion, landslides, and flooding due to their hilly and mountainous topography, including the Rwenzori Mountains, which negatively impact farm productivity (Jacobs et al., 2016). In the country's tropical rainforest in the central and west, where the rainfall is high and the soil is fertile, for

example, the Buganda region is known for its coffee production, and the government has invested in supporting coffee farmers through programs like the Uganda National Coffee Strategy (Agea et al., 2008). On the other hand, in savannas in the north, where the rainfall is lower, farmers rely on pastoralism as their main source of livelihood. The savannas provide ample grazing land for livestock farming systems in this region as well as the semi-arid climate. However, climate change has a negative impact on pastoralism in the region, especially prolonged droughts leaving livestock with no water (Mkutu, 2009).

Moreover, Uganda's significant swamps provide suitable conditions for rice cultivation, and rice farming is an important source of income for some farmers, particularly in the Pallisa district in eastern Uganda. The wetland soils are rich in nutrients, and the swamps provide natural irrigation, reducing the need for artificial irrigation systems. However, there are concerns about the impact of rice farming on wetland ecosystems, and efforts are being made to promote sustainable rice farming practices (Oonyu, 2011). It is also an important part of Uganda's agriculture sector, with farmers fishing local species such as mudfish and catfish in the swamps, specifically in eastern Uganda. In addition, Uganda is also home to several lakes, including Lake Victoria and Kyoga, which provide a valuable source of freshwater fish like African tilapia, Nile perch, silverfish, and catfish for local communities. They are often caught using local fish traps and fishing nets. Aquaculture has the potential to provide a sustainable source of protein and income for many people, but there are concerns about the impact of fish farming on the environment, especially swamps, and unsustainable fishing on wild fish populations (Isyagi et al., 2009).

In terms of farm productivity, ecological and geographical factors also influence the yield and quality of crops and livestock. The fertile soil in the west of Uganda results

in high yields of crops, while the semi-arid conditions in the north result in lower yields. Similarly, the availability of water resources such as the Nile River and Lake Victoria in Uganda's central and eastern regions has led to the development of irrigation systems, which have increased farm productivity in these areas (Snapp & Pound, 2017).

C. Food security in Kenya

According to the Kenyan Ministry of Agriculture, approximately 75% of the population is food secure, while 25% of the population in Kenya is food insecure, with the highest prevalence of food insecurity in the arid and semi-arid areas of the country. The Masaai and Turkana are particularly affected by chronic drought and internal conflicts that have also contributed to the problem of food insecurity in these communities (Huho & Mugalavai, 2010). Moreover, farm productivity has decreased by 0.4% annually in the last five years. This is attributed to a variety of factors, including the fact that, in Kenya, traditional farming practices such as burning and planting are still common among small-scale farmers, leading to soil degradation and thus low farm productivity. Additionally, the country has experienced several shocks, including droughts, floods, and locust invasions, which have also impacted agricultural production and food availability, in addition to internal conflicts in some parts of Kenya destroying crops and infrastructure (Kogo, Kumar, & Koech, 2021).

However, despite these challenges, the Kenyan government, along with NGOs and international organizations, has implemented a range of initiatives aimed at improving food security in the country. For example, the government has invested in irrigation infrastructure, expanded access to credit and inputs for small-scale farmers, and implemented policies aimed at promoting sustainable agriculture practices (Boulanger et

al., 2018). While these initiatives have shown some promise, food security in Kenya is still threatened by other factors, including climate change, limited access to markets and storage facilities, and persistent poverty in rural areas (Kogo, Kumar, Koech, et al., 2021).

Addressing these challenges requires continued investment in sustainable agriculture practices and policies that promote economic growth as well as peace and stability in conflict-prone regions through conflict resolution mechanisms, the provision of humanitarian assistance to affected communities, and the restoration of damaged infrastructure and agricultural systems (Measham & Lumbasi, 2013). This improves food access and reduces food insecurity. Also, increasing access to credit and financial assistance for farmers, particularly those in drought-prone regions, and promotion alternative livelihoods will reduce pressure on natural resources and diversify income sources for small-scale farmers (Sibiko & Qaim, 2020).

2. Farming systems in Kenya

In Kenya, the dominant farming systems among small-scale farmers are mixed farming, pastoralism, and agroforestry. These farming systems are prevalent in different regions, depending on the ecological zones and climatic conditions. Irrigation farming on a small scale is practiced in areas where rainfall is inadequate to support production. The government of Kenya has invested in irrigation schemes, such as the Perkerra Irrigation Scheme in the north Rift Valley, to provide water for the cultivation of crops such as rice and maize and has improved food security in these areas (Odhiambo et al., 2021). Livestock farming is also practiced in both arid and semi-arid regions of Kenya majorly the Turkana and the Masaai. In addition, other systems, such as beekeeping, forestry, agroforestry, and aquaculture, are also practiced by small-scale farmers in Kenya.

Agroforestry is an important farming system in Kenya, particularly in areas where the soils are degraded, and the climate is harsh. For example, in the drylands of eastern Kenya, farmers practice agroforestry by planting trees such as acacia, mango, and neem alongside crops such as sorghum, millet, and cowpeas (J. Otieno, personal communication, December 4, 2022).

Ecological and Geographical Factors Affecting Farming Systems in Kenya

Kenya is known for its diverse geography, including mountains, savannas, and coastal regions, and thus diverse agro-ecological zones that support different crop and livestock production systems. The highlands of Kenya, including the central highlands and the Rift Valley, have fertile soils and a temperate climate suitable to produce crops. For example, the central highlands are the country's main tea-growing region, with over 60% of the tea produced in Kenya coming from this area (Mugwe et al., 2009).

The savanna region of Kenya has an arid and semi-arid climate, particularly in the north and northeast. Low and erratic rainfall makes crop production difficult; therefore, pastoralism is a dominant form of agriculture with livestock. However, climate change and social factors have had a negative impact on pastoralism, with droughts and conflicts over grazing land leading to livestock losses and the displacement of pastoral communities. The savannah region is also home to many indigenous communities in Kenya, like the Maasai, Samburu, and Turkana, who have developed traditional practices for managing natural resources in these harsh environments (Nyariki & Amwata, 2019).

The coastal region of Kenya, including Mombasa and Malindi, has a warm and humid climate that supports the production of crops such as coconuts, cashews, and mangoes. Additionally, fishing is an important economic activity in these areas, with

coastal communities relying on the presence of the Indian Ocean for their livelihoods and other marine resource (Wachira, 2017).

In terms of productivity, the ecological and geographical factors in Kenya also have a significant impact on the yield and quality of crops and livestock. The fertility of the soils in the highlands enables farmers to achieve high yields of tea and coffee, while the semi-arid conditions in the savannas result in lower yields of crops and livestock. Additionally, climate change and environmental degradation are affecting agricultural productivity in some parts of the country, with increased water scarcity and soil erosion reducing farmers' ability to produce crops and raise livestock (J. Otieno, personal communication, December 4, 2022).

D. Food security in Tanzania

Food security in Tanzania faces significant challenges, with about 33% of the population being food insecure, especially in the leeward Kilimanjaro, Dodoma, Tabora, and Singida regions, which are more prone to food insecurity with low agricultural productivity. These regions are characterized by a dry and semi-arid climate, which affects agricultural productivity; chronic droughts; and internal conflict droughts, which negatively affect farm productivity (Fairman Jr et al., 2011; Kaganzi et al., 2021). According to the Ministry of Agriculture in Tanzania, Farm productivity in Tanzania has been declining over the past 4 years, with an average annual decline of 0.5%. This decline is attributed to several factors, including land degradation, inadequate access to agricultural inputs, pests, and diseases, and limited financial assistance to farmers (Kaganzi et al., 2021). The excessive use of agrochemicals in Tanzania has led to the accumulation of toxins in soil, water, and food, posing significant health risks to both

farmers and consumers which is also contributing to food insecurity. Likewise, the abandonment of improved planting materials and a lack of knowledge of skilled agronomic practices further contribute to low agricultural productivity and reduced food security (Chianu et al., 2012; Reincke et al., 2018). Moreover, Tanzania is heavily reliant on imports; around 60% of the food consumed is imported and the country's reliance on food imports is a significant threat to food security, especially during periods of global food shortages and rising food prices. About 25% of the Tanzanian population is undernourished due to low food availability, accessibility, and utilization (Wenban-Smith et al., 2016).

To improve food security in Tanzania, sustainable farming systems need to be adopted particularly environmentally friendly farming practices that reduce the reliance on agrochemicals, improve the quality of the soil and water, and increase crop yields. Additionally, there is a need to promote the adoption of improved planting materials, provide training on modern agronomic practices, and enhance farmers' access to credit facilities to boost farm productivity. Furthermore, sustainable farming practices build resilience against climate change to improve the stability of food production and reduce vulnerability to food insecurity (Boulanger et al., 2018; J. Otieno, personal communication, December 4, 2022).

1. Farming systems in Tanzania

Irrigation farming is also practiced, but on a smaller scale especially in areas with perennial rivers to supply water to crops in dry areas using different methods, including sprinkler, drip, and flood irrigation (Abang et al., 2007). The government of Tanzania has invested in irrigation schemes in various parts of the country, such as the

Kilombero irrigation scheme. However, access to irrigation technologies and infrastructure remains a challenge for most small-scale farmers due to the high initial costs of irrigation equipment and limited access to water resources since farming depends on climatic conditions, which are becoming increasingly unpredictable due to climate change (Mbande, 2022).

Livestock farming, especially cattle rearing, is a dominant farming system in pastoralist communities with arid and semi-arid climates. However, livestock farming in Tanzania faces various challenges, including limited access to veterinary services, diseases, and inadequate markets for livestock products. Furthermore, shifting cultivation is also practiced in the rural agropastoral areas of Tanzania, where farmers clear a piece of land, cultivate it for a few years until the soil fertility declines, and then move to a new piece of land (Mnenwa & Maliti, 2010). Other farming systems, such as agroforestry, horticulture, and mixed farming, among others, mainly in the highland regions with fertile soils, cooler temperatures, and adequate rainfall. are also significant (Mkonda & He, 2017).

Ecological and Geographical Factors Affecting Farming Systems in Tanzania

Ecological and geographical factors like climate, soil, topography, water availability, and wildlife conservation areas have a significant impact on farm productivity. Tanzania has various natural water resources like Lakes Victoria, Tanganyika, and Nyasa, as well as many rivers and streams that provide water for irrigating crops and support livestock, particularly in areas where rainfall is irregular. Additionally, Tanzania's coastal areas along the Indian Ocean also provide water resources for agriculture and fishing activities, which enhance farm productivity (Seeteram et al., 2019). In the highland areas with cooler temperatures, farmers practice

mixed farming, where they grow coffee, tea, vegetables, and livestock, while in the lowland areas with warmer temperatures, farmers practice rain-fed agriculture, where they grow crops like maize, sorghum, and rice (Mkonda & He, 2017).

Tanzania's coastline along the Indian Ocean supports the fishing industry, which is an important source of income for many coastal communities. Also, the coastal areas provide favorable growing conditions for crops like coconut, cashew nuts, and spices (Zella Adili & Antonia, 2017).

The dry and semi-arid regions, especially on the leeward side of the Kilimanjaro region, have nutrient-poor soil. Farmers practice rain-fed agriculture due to low water availability and grow crops such as sorghum and millet, which are drought-resistant. On the other hand, the windward side of the Kilimanjaro Region receives more rainfall and has fertile volcanic soils that support most agricultural activities (Fairman Jr et al., 2011).

Tanzania is home to several national parks and wildlife reserves, which are important for biodiversity conservation and important tourist attractions, however, the conservation status of these limits the amount of land available for farming in the surrounding areas to lower farm productivity. For example, farmers in the Serengeti National Park and the Ngorongoro Conservation region cannot practice farming in the park and as a result, farmers have turned to alternative livelihoods like beekeeping and tourism-related activities to supplement their income (Charnley, 2005). Access to water for irrigation, climate, soil type, and biodiversity influence the crops that can be grown and their yields therefore farmers should adapt their farming practices to the specific conditions to maximize productivity and sustainability.

E. Impact of identified farming systems on on-farm productivity.

The impact of farming systems on farm productivity varies depending on the specific system used. Subsistence farming, which is the dominant system among small-scale farmers in Uganda, Kenya, and Tanzania, relies on traditional farming practices and limited inputs, as well as limited access to extension services, markets, and credit, resulting in low farm productivity. Moreover, the traditional burn and plant system in Kenya, which involves first burning the previous farm residues to clear land for farming, leads to reduced fertility and crop yields over time (Canton, 2021; Davis et al., 2012). About 40% of farmland in Uganda, Kenya, and Tanzania is degraded due to poor farming practices, such as improper land management practices and excessive use of agrochemicals, especially in Tanzania, which have led to the accumulation of toxins in soil, food, and water sources, affecting the quality and safety of crops and reducing farm yields. In addition to unsustainable practices such as deforestation and overgrazing cause low farm yields due to soil nutrient depletion and environmental degradation, affecting the ecosystem and the sustainability of farming systems. Also, poor natural soil fertility is a major challenge for farmers. For example, in the maize-growing regions of western Kenya, farmers face challenges in maintaining soil fertility due to the acidic soils and low organic matter content (Chauvin et al., 2012).

Cash crop farming, on the other hand, is more profitable and provides a source of income for small-scale farmers. However, the reliance on a single crop leaves farmers vulnerable to local market fluctuations, especially during the oversupply of one crop like coffee when the price drops, resulting in a loss for farmers who have invested heavily in coffee cultivation. Moreover, the lack of adequate storage facilities forces farmers to sell crops immediately after harvest, even if the market price is low, to avoid spoilage and

waste as they are unable to store the harvest for sale later, yet harvesting too late reduces crop shelf life (Canton, 2021). Furthermore, due to inadequate storage facilities, especially after harvesting, post-harvest losses are estimated at 30–50% due to pest and disease infestation losses in grains. Staple foods in the region, particularly maize, and beans are susceptible to weevil storage pests due to poor storage facilities. It is also important to note that inadequate post-harvest management practices like threshing and winnowing, if not done properly, result in physical losses thus low product quality (Chauvin et al., 2012).

Diversified agriculture has the potential to improve on-farm productivity by increasing crop and livestock diversity, reducing risk, and improving soil health. However, it requires more knowledge and resources than subsistence farming, and many small-scale farmers lack the necessary training and input to implement it effectively. The lack of knowledge and skills in good agronomic practices, including the abandonment of improved planting materials, results in low agricultural productivity, limiting the potential for increased yields. Also, the lack of access to certified and high-quality seeds is a significant factor contributing to losses.

Communal farming is a common practice among small-scale farmers in Uganda, Kenya, and Tanzania, where farmers share resources such as land, tools, and labor to cultivate crops collectively. While communal farming has several advantages, including increased efficiency in resource use and the ability to access credit and market information, it also poses a significant risk of spreading pests and diseases from one farm to another, leading to widespread farm losses (Canton, 2021; Chauvin et al., 2012).

Climate change exacerbates low farm productivity in Uganda, Kenya, and Tanzania, with increasingly unpredictable weather patterns leading to crop failures and

making it difficult for farmers to plan their planting and harvesting cycles (Huho & Mugalavai, 2010). This results from the increasing effects of climate change, such as prolonged droughts and floods since the farmers rely on natural weather for agriculture. In 2019, the long rainy season experienced in most parts of Kenya led to crop failure due to nutrient leaching and floods (Adhikari et al., 2015).

In addition to the farming systems, other factors causing farm losses in Uganda, Kenya, and Tanzania include limited access to financing and credit that hinders farmers from purchasing the necessary inputs, such as improved seeds and fertilizers, resulting in low yields and reduced incomes, perpetuating the cycle of food insecurity. Another significant cause of yield loss is pests and diseases. The most common pests across the region include locusts and armyworms. For instance, in 2020, Uganda and Kenya experienced the worst locust infestation in decades, which led to significant crop losses (Chauvin et al., 2012).

Also, small-scale farmers face challenges related to limited access to water markets, and the high cost of inputs, which result in low prices and limited opportunities for selling their produce, discouraging farmers from investing in their farms and leading to reduced farm yields. Moreover, due to a lack of agricultural extension services, 90% of the small-scale farmers in the region lack access to training and mentoring programs that could help them improve their farming practices and increase productivity (K. Ogwang, personal communication, December 4, 2022).

It is also important to note that small-scale farmers in Uganda, Kenya, and Tanzania are highly vulnerable to economic crises, as they often lack the resources to absorb the impact of rising production costs. Economic crises, such as inflation and currency devaluation, lead to increased input costs, especially such as seeds, and

agrochemicals, which directly affect the farmers' profitability and productivity. Small-scale farmers who cannot afford the increased input costs resort to using low-quality inputs, which leads to decreased crop yields and lower-quality produce (J. Otieno, personal communication, December 4, 2022).

Moreover, economic crises often lead to reduced demand for agricultural products, which further increases the risk of food insecurity. In addition, small-scale farmers in Uganda, Kenya, and Tanzania often rely on credit to finance their farming operations. Economic crises lead to increased interest rates and reduced availability of credit, which limits farmers' access to finance, resulting in reduced investment in their farming operations and decreased productivity (Chauvin et al., 2012).

Incorporating a food systems approach is crucial to addressing the identified gaps in the farming systems and promoting the food security of Uganda, Kenya, and Tanzania. This approach involves looking at the entire food system, from production to consumption, considering the four pillars of food security, and understanding the relationships between different elements in the system. The approach is guided by pillars including food availability, food access, food utilization, and food system stability (Wenban-Smith et al., 2016; White, 2020). Moreover, in terms of food availability, the identified gaps in the farming systems affect the production and supply of food, leading to food shortages. Thus, farmers need to adopt sustainable farming practices to increase yields and ensure a steady supply of food. Regarding food access, the identified gaps in the farming systems affect the affordability and accessibility of food, especially in rural areas. Policies that promote investment in rural-to-urban infrastructure and improve market linkages to improve food access (Davis et al., 2012).In terms of food utilization, the identified gaps in the farming systems affect the nutritional value and safety of food,

leading to malnutrition and foodborne illnesses. Promoting good agricultural practices and proper post-harvest management improves the quality of food (Ellis-Jones et al., 2000).

F. Improving Farm Productivity through Sustainable Farming Systems

Addressing the identified impacts of various farming systems on farm productivity requires a collaborative effort from all stakeholders, including government, non-governmental organizations, and private sector players, promoting the adoption of sustainable farming systems like appropriate storage, and harvesting practices, and providing access to improved inputs and market opportunities (Canton, 2021; Cleaver, 2007). This requires investments in agricultural extension services, including capacity training for small-scale farmers with the knowledge and skills needed to adopt sustainable farming systems. Also, practices that promote sustainable and equitable growth in the agricultural sectors such as water harvesting and conservation practices among others, prioritize the health of the soil, increase the efficiency of water and nutrient use in the ecosystem, and aim to improve farm productivity. By adopting these practices, small-scale farmers can produce more food per unit of land while also reducing negative impacts on the environment (Boulanger et al., 2018; Davis et al., 2012).

Small-scale farmers need to adopt the use of integrated pest management practices, sustainable use of agrochemicals, and alternatives like biopesticides and natural enemies, to reduce the impact of pests and diseases on crop yields by reducing pest buildup and disease incidence (Chauvin et al., 2012). A study conducted by IFAD in Kenya in 2018 in western Kenya showed that farmers who practiced agroforestry reported an increase in crop yields of up to 35% compared to monoculture systems. This was

attributed to improved soil fertility, better water retention, and reduced pest effects. Additionally, the trees provided shade for crops, which helped reduce water stress during periods of drought. Moreover, organizations such as the Alliance for a Green Revolution in Africa have been working to provide farmers in East Africa with access to high-quality farm inputs, including improved seeds, as well as training on how to use them effectively (Faling, 2020).

Access to better land and water management techniques is crucial to reducing farm losses. Techniques such as conservation agriculture, drip irrigation, and water harvesting help farmers manage water resources efficiently and reduce soil erosion (Muoni, Koomson, et al., 2019). Also, FAO is working with the governments of the regions to improve irrigation infrastructure to reduce dependence on rain-fed agriculture, which is prone to the effects of climate change (Chauvin et al., 2012).

It is important to address the impact of economic crises on small-scale farmers' productivity by implementing policies and interventions that address the root causes of the crises, such as inflation, currency devaluation, and reduced demand for agricultural products. Additionally, increasing access to affordable credit through smallholders' access to markets will help mitigate the impact of economic crises on farm productivity (Gumisiriza et al., 2022).

Communal farming increases the risk of spreading farm pests and diseases. Henceforth, farmers should avoid sharing farm materials and instead have individual farm tools and equipment to prevent the spread of pests and diseases. As well as the adoption of sustainable agriculture practices such as crop rotation and crop diversification to reduce the risk of disease and pest infestations. in addition to development efforts to identify

strategies for improving farm productivity in communal farming to promote long-term sustainability and resilience (Muoni, Barnes, et al., 2019).

Also, the establishment of well-equipped storage and processing facilities and training farmers in good harvesting practices using appropriate tools will reduce post-harvest losses and provide better market access, maximizing farm output (Chauvin et al., 2012).

It is also important to invest in continued research and development in the agricultural sector to develop new and improved farming practices, technologies, and improved crop varieties like drought-resistant seeds that are better adapted to local conditions while promoting climate-smart agricultural practices like hydroponics to mitigate the effects of climate change and reduce the risks of crop losses (Adhikari et al., 2015; Doyle et al., 2019).

Improving market infrastructure as well as market access for farmers to have better market access through the development of transportation infrastructure, as well as the creation of farmer cooperatives and other collective marketing initiatives to increase access to the market for farmers' surplus products (Boulanger et al., 2018).

Promoting gender roles in agriculture helps increase productivity and reduce losses by empowering women to also participate in productive farm roles. (Basu & Galiè, 2021; Tavenner et al., 2019).

It is essential to promote policies that enhance the resilience of the food system to external shocks such as climate change and pandemics. The promotion of sustainable farming systems in Uganda, Kenya, and Tanzania helps small-scale farmers enhance farm yields, reduce losses, and improve their livelihoods. This can be achieved through farmers' education, training, and support from the government and NGOs. Integrating the

food systems approach into the study's findings helps to identify gaps in the entire food system, including pre-farming, on-farm, and post-harvest management (McGuire, 2013).

Sustainable farming systems help build more resilient and productive food systems that can better meet the needs of a growing global population while ensuring that the natural resources and ecosystems that support agriculture are conserved for future generations (Doyle et al., 2019). By adopting sustainable agriculture practices, farmers improve the resilience and productivity of their agricultural production over the long term, reducing the risk of crop failures and losses due to environmental stressors such as droughts and floods. As well as helping diversify agricultural production and income streams, improving the overall economic and food security of farmers and their communities (Faling, 2020; Paul et al., 2020). Sustainable farming systems offer a holistic approach that addresses various aspects of agriculture, including soil health, climate resilience, market access, post-harvest management, and consumer education. By integrating these practices, Farmers unlock the full potential of the agricultural systems and ensure a more sustainable and resilient food future (Abang et al., 2007).

G. The role of sustainable farming systems in food security

Sustainable farming systems have the potential to have a significant positive impact on food security by contributing towards meeting Sustainable Development Goal 2 of zero hunger. Sustainable farming management systems are vital components contributing to food-secure communities by increasing food availability, accessibility, stability, and utilization.

Sustainable farming systems aim to increase agricultural productivity while improving the quantity, accessibility, and stability of food produced to improve food security for communities. Enhanced farm productivity and stability are essential components of achieving food security by ensuring more food is produced from the same amount of land, allowing small-scale farmers to meet the growing demand for food as populations increase. Therefore, increased food availability as well as the provision of a reliable source of food for local markets to reduce the risk of food shortages and price fluctuations. This results in the stabilization of food prices, making food more affordable and accessible for consumers (Muoni, Barnes, et al., 2019).

Improved farm productivity increases access to food for vulnerable populations by reducing food insecurity and malnutrition, particularly in rural and low-income communities, through increasing the quantity of production in addition to improving the nutritional quality of food by reducing micronutrient deficiencies, reducing the incidence of foodborne illnesses, and improving public health. For example, agroforestry systems help diversify diets by providing a range of fruits, nuts, and other non-timber forest products. By incorporating a variety of crops and livestock, farmers also provide a more balanced and diverse range of nutrients through diversified food production (Paul et al., 2020).

Furthermore, sustainable farming systems enhance farm productivity by improving the resilience of diversified agricultural production. Diversifying crops, in addition to incorporating livestock production, promotes biodiversity and provides agroecosystem services that support food production, such as pollinators and other beneficial insects essential for production cycles. Furthermore, the incorporation of integrated pest management practices, which use a range of strategies to control pests and

reduce the reliance on chemical input, improves crop yields and reduces the risk of crop losses (Abang et al., 2007; Ellis-Jones et al., 2000).

Sustainable farming systems promote farm production stability by improving soil fertility through the adoption of practices that improve soil structure, reduce soil erosion, and increase the availability of nutrients for crops by optimizing nutrient cycling within agroecosystems. This results in the long-term health and productivity of the land, therefore increasing crop yields and providing a stable and reliable food supply, ensuring the long-term sustainability of agricultural production (Muoni, Koomson, et al., 2019).

Sustainable farming systems enhance soil carbon sequestration, which helps mitigate climate change by removing carbon dioxide from the atmosphere and storing it in the soil, therefore improving soil health and fertility. This improves nutrient cycling between the plants and the soil, therefore reducing the dependence on synthetic fertilizers leading to increased crop yields, thus increasing food availability. Also, sustainable farming systems emphasize adaptive measures to cope with changing climatic conditions, where farmers adopt practices like adjusting planting dates, selecting climate-resilient crop varieties, and implementing agroforestry systems to use shade structures to mitigate heat stress (Adhikari et al., 2015; Doyle et al., 2019).

Sustainable farming systems also have positive social and economic impacts on food security by providing farmers with access to markets, training, and finance in rural areas. Sustainable farming systems often emphasize local and regional markets, promoting direct relationships between farmers and consumers. By facilitating direct market access, farmers improve their entrepreneurial skills, receive fair prices for their products, and establish stable market channels. This reduces the reliance on

intermediaries, increases farmers' income, and enhances food security by ensuring steady food utilization (Wachira, 2017).

Sustainable farming systems also reduce food waste by improving post-harvest handling and storage practices to ensure that more of the food produced is available for consumption. Sustainable farming practices emphasize proper harvesting techniques and appropriate storage facilities to minimize damage to crops during harvest and maintain optimal conditions for preserving the quality of harvested crops, thereby extending the shelf life of crops, minimizing wastage, and increasing food availability (Wachira, 2017). This reduction in food waste along the production chain has positive environmental, economic, and social implications, including minimizing the strain on natural resources, reducing greenhouse gas emissions associated with food waste, and ensuring more efficient use of agricultural inputs. Additionally, by reducing food waste, sustainable farming systems contribute to addressing food security challenges and promoting a more sustainable and resilient food system (Wellesley et al., 2015).

Additionally, improving the productivity and livelihoods of small-scale farmers has significant implications for poverty reduction, food security, and sustainable development in these countries. Therefore, this study's findings and recommendations inform stakeholders on how to optimize the farming systems used by small-scale farmers for maximum productivity and sustainability, ultimately contributing to poverty reduction, food security, and sustainable development in Uganda, Kenya, and Tanzania (Galiè et al., 2019).

H. literacy levels of small-scale farmers in Uganda, Kenya, and Tanzania

Small-scale farmers in Uganda, Kenya, and Tanzania have varying levels of literacy, which impacts their agricultural knowledge and practices. In Uganda, the literacy rate for adult farmers is around 25%; in Kenya, it is around 37%; and in Tanzania, it is around 21%. Despite these relatively low literacy rates, the correlation between literacy and agricultural knowledge and practices is not straightforward in these countries (Agea et al., 2008). It's worth noting that these literacy rates vary among small-scale farmers depending on factors such as location, gender, and socio-economic status. Furthermore, access to education is not equitable, with certain groups, such as male farmers, cash crop farmers, and farmers near road networks, having more access to education and training related to agriculture. Factors such as gender, ethnicity, and socioeconomic status also play a role in accessing education and training among small-scale farming communities (Tavenner et al., 2019). Moreover, most small-scale farmers have not received formal education but have extensive practical knowledge of agriculture gained through years of hands-on experience and practical observation experience as well as traditional knowledge of farming practices that have been passed down through generations (Baird et al., 2021). Therefore, while literacy is an essential aspect of learning and acquiring knowledge, it does not always translate to practical expertise in agriculture. Literacy enhances access to modern agricultural knowledge, (K. Ogwang, personal communication, December 4, 2022). Hence, it is important to recognize and value the traditional knowledge and skills that small-scale farmers possess and incorporate them into agricultural programs and policies to enhance productivity and food security. Traditional knowledge and practices that have been passed down through generations also play a significant role in enhancing farm productivity. However, it is still crucial to

promote literacy among small-scale farmers, as it enables them to access information on modern and advanced agricultural practices and technologies (Agea et al., 2008). This can be achieved through training programs that are translated into local languages that the farmers understand better. also, through extension services, farmer field schools, and other forms of capacity-building programs that prioritize practical learning and demonstration rather than written materials (Davis et al., 2012).

Furthermore, 80% of small-scale farmers in rural areas are of the older generation, since most youth resort to urban centers in search of industrialized jobs. Involving youth in agriculture bridges the generational gap in farming practices and enhances productivity. However, it's also important to note that some youth may not be interested in pursuing agriculture as a career due to perceptions of low returns, limited opportunities for innovation, and a lack of access to capital and resources. To bridge the generational gap and involve the youth in agriculture, there is a need to invest in education and extension services that provide practical and advanced knowledge (Davis et al., 2012). For example, governments in Uganda, Kenya, and Tanzania can partner with educational institutions and private sector organizations to provide tailored agricultural training to youth and small-scale farmers. Also, through policies that provide incentives for youth involvement in agriculture and create linkages with universities and technical institutions to offer training and mentorship programs for young people and provide a platform for knowledge exchange, this can be done through initiatives such as mentorship programs, which enable experienced farmers to share their knowledge and skills with the younger generation (Agea et al., 2008;White, 2020).

Moreover, addressing the low literacy levels among small-scale farmers is crucial to promoting sustainable farming practices and enhancing farm productivity. Illiteracy

and limited access to education hinder farmers from acquiring the knowledge and skills necessary to adopt sustainable techniques. Establishing agricultural schools and educational programs tailored to the specific needs of small-scale farmers will bridge the knowledge gap and empower farmers with the tools to improve their farming practices. Agricultural schools will provide basic literacy and numeracy training along with specialized agricultural education. Considering that farmers in Uganda, Kenya, and Uganda are multilingual, offering courses in local languages while emphasizing experiential learning and hands-on training will impart knowledge and skills that can be immediately applied on the farm. By focusing on sustainable farming methods tailored to each country's diverse agro-ecological zones, soil types, and climatic conditions, these schools can educate farmers on environmentally friendly practices such as integrated pest management, soil and water conservation techniques, and natural resource management, enabling them to make informed decisions that promote long-term sustainability and productivity.

Furthermore, agricultural schools can serve as platforms for knowledge sharing and peer-to-peer learning by fostering a collaborative environment where farmers exchange experiences, share success stories, and collectively address common challenges. This not only enhances the learning process but also strengthens social networks and community resilience in agriculture. Agricultural schools provide a holistic approach that targets low literacy levels among small-scale farmers to effectively break the cycle of limited knowledge constraints through the incorporation of both traditional and modern agricultural knowledge sharing. By promoting sustainable practices tailored to the local agricultural landscapes, providing accessible education, and integrating technology and practical training, the schools can empower farmers and contribute to the

overall enhancement of farm productivity, ensuring food security, economic growth, and environmental conservation.

CHAPTER IV

CONCLUSION

This comparative study has identified the farming system gaps in small-scale farming practices in Uganda, Kenya, and Tanzania. With reference to the first objective, the findings indicated that the identified gaps per country might overlap in all the countries, but they predominate in one country over another.

Identified gaps in the farming systems		
Uganda	**Kenya**	**Tanzania**
Inadequate access to extension services	Inadequate access to credit facilities	Limited access to farm inputs
Poor soil fertility management	Limited market access	Inadequate knowledge of sustainable farming practices:
Inefficient use of water resources	Poor post-harvest management practices	Poor infrastructure

Generally identified gaps in the farming systems across Uganda, Kenya, and Tanzania include.

Identified gaps in the farming systems across Uganda, Kenya, and Tanzania
Inadequate storage facilities
Inadequate land preparation techniques
Poor handling and storage techniques
limited knowledge of value-addition techniques
limited market information and access to markets
Inadequate pest and disease management practices
Weak market linkages leading to low prices for agricultural products
Limited access to high-quality inputs like seeds and fertilizers
Inadequate training in sustainable farming techniques and technologies
limited access to irrigation systems particularly in the pastoralist regions
unpredictable weather patterns
unsustainable farming practices, like slash-and-burn agriculture and excessive use of agrochemicals

Referring to the second objective of the study, which is to recommend better farming practices to fill the identified gaps, it is recommended that governments in Uganda, Kenya, and Tanzania develop and implement policies and programs that promote sustainable farming practices and enhance food security. This includes providing financial support for small-scale farmers, investing in transport and market infrastructure, and providing farmers with information on market opportunities. Furthermore, through extension services, small-scale farmers should be encouraged to adopt sustainable farming practices such as conservation agriculture. These practices improve soil health, increase productivity, and reduce reliance on agrichemicals. Also, provide farmers with training on proper post-harvest handling, appropriate storage techniques, pest and disease management practices, and value addition to reduce food loss and waste. In addition to encouraging small-scale farmers to form cooperatives to collectively market their products to achieve better market prices,

In conclusion, the comparative study of farming systems in Uganda, Kenya, and Tanzania provided valuable insights into identifying major causes of low farm yields and recommended better farming practices to fill the identified gaps along the production chain. Inefficient unsustainable food production systems influenced by ecological and geographical borders are the main causes of low farm productivity in Uganda, Kenya, and Tanzania. Sustainable farming management systems are vital components contributing to food-secure communities by increasing food availability, accessibility, stability, and utilization. Therefore, a move towards the achievement of Sustainable Development Goal 2: Zero Hunger. This study contributes to this goal by providing a farming system guide with practical recommendations for small-scale farmers in Uganda, Kenya, and Tanzania, in addition to highlighting the importance of sustainable farming

systems in enhancing farm productivity and promoting food security. It is crucial to note that sustainable farming systems cannot be adopted in isolation. A comprehensive approach that considers the entire food value chain, from production to consumption, is needed. This approach should include policies that support small-scale farmers, promote the use of improved planting material, and training programs to build the capacity of farmers to adopt sustainable farming systems to enhance farm productivity.

APPENDIX

A farming system guide for small-scale farmers in Uganda, Kenya, and Tanzania with practical recommendations based on the identified challenges to enhance productivity.

Introduction: This guide aims to provide practical recommendations for small-scale farmers in Uganda, Kenya, and Tanzania to enhance their farming practices and increase productivity based on identified challenges. Sustainable farming practices are crucial to addressing food security challenges and ensuring long-term agricultural sustainability.

1. Land and Water Management

- Use conservation agriculture practices such as minimum tillage, crop rotation, intercropping, contour farming, and mulching to enhance soil health and reduce soil erosion.
- Use improved irrigation techniques such as drip irrigation and sprinkler irrigation.
- Harvest and store rainwater during the rainy season for use during the dry season to reduce dependence on rain-fed agriculture.
- Use agroforestry to enhance soil fertility and biodiversity.
- Conduct soil tests and apply appropriate amounts of fertilizers to avoid under- or over-application of nutrients.
- Proper soil management practices to increase soil fertility and prevent soil erosion, like crop rotation and intercropping, prevent soil depletion.
- application of lime to acidic soils to adjust the soil pH and increase nutrient availability to the crops.

2. Pest and Disease Management

- Use integrated pest management (IPM) practices such as the use of biocontrol agents, introducing beneficial insects, and using physical barriers.
- Use resistant crop varieties and early warning systems to detect and respond to pest and disease outbreaks.
- Proper disposal of crop residues is necessary to prevent pests and disease spread.
- Practice proper crop sanitation and hygiene to prevent the spread of pests and diseases.
- Use crop rotation and intercropping techniques to disrupt pest cycles and prevent the buildup of pests in the soil.
- Planting natural barriers on the perimeter of farms to repel pests and diseases Plants like marigolds and Lantana camara contain compounds that repel pests.
- Herbs and spices like basil and rosemary contain compounds that have antimicrobial properties and help prevent the spread of diseases.

- Regular cleaning and maintenance of farm equipment are necessary to prevent the spread of pests and diseases.

3. Sustainable Use of Agri-chemicals

- Use agrochemicals appropriately to avoid negative impacts on soil health, water quality, and human health.
- Use alternative methods such as crop rotation, intercropping, and mixed farming to reduce dependence on chemical fertilizers and pesticides.
- Use organic inputs such as compost, manure, and green manure to enhance soil fertility and reduce reliance on chemical fertilizers.
- Using natural pest prevention such as neem oil or garlic spray can be an effective alternative to synthetic chemical pesticides.
- Using organic inputs such as compost, manure, and covering crops can improve soil health and fertility, making plants stronger and more resistant to pests and diseases.
- Organic pesticides like neem, garlic, and pepper extracts are safer for the environment and human health than synthetic chemical pesticides.

4. Harvest and post-harvest management

- Harvest crops at the appropriate maturity stage to ensure maximum yield and quality.
- Use appropriate tools and equipment during harvesting to prevent damage to crops.
- Store crops in appropriate storage facilities, such as granaries and silos, to prevent losses due to pests and diseases.
- Practice value additions such as drying, processing, and packaging to increase shelf life and value.

5. Diversification

- Diversify crop production to reduce the risk of crop failure due to pests, diseases, or extreme weather conditions.
- Incorporate crops with high nutritional value, such as legumes, fruits, and vegetables, to enhance food and nutrition security.
- Participate in value chain development programs to access new markets for diversified crops.
- Integrate livestock into crop production systems to provide manure for soil fertility and diversify income streams.

6. Smart agriculture

- use of hydroponics to maximize land use and reduce water consumption.
- use of precision agriculture technologies to optimize crop production.

- Training and education on sustainable farming practices and innovative technologies.

7. Market and Financial Resources

- Join farmer organizations and cooperatives to access collective bargaining power and negotiate better prices.
- Access agricultural credit facilities to invest in farm inputs and services.
- Participate in market-oriented agriculture programs that provide market information and linkages to buyers and processors.
- Practice good financial management, such as keeping financial records.

8. Sustainable practices

- Adoption of modern technology
- adoption of improved crop varieties like drought-resistant and disease-resistant crop varieties to increase yields and reduce losses.
- Use certified disease-free seed and disease-resistant varieties of crops.
- Incorporate agroforestry and conservation farming practices such as minimum tillage, mulching, and intercropping.
- Training farmers on sustainable farming practices to enhance skills and knowledge through farmer field schools, extension services, demonstration farms, farmer-to-farmer knowledge sharing, and community-based workshops.

9. Policy and Governance

- Advocate for policies that support sustainable agriculture.
- Participate in decision-making processes and community forums.
- Seek out and utilize government support programs, including extension services, credit facilities, and subsidies.
- Government-supported extension services like increasing access to credit for smallholders.
- Provision of affordable credit facilities and microfinance services to enable farmers to purchase inputs and implements.
- Youth-friendly policies and programs that support involvement in agriculture, like providing access to land and credit,

10. Promoting gender roles in agriculture

- Encouragement of women's participation in agriculture through access to land, credit, and education
- promotion of gender-sensitive policies and programs that address the specific needs and challenges of women farmers.

11. Youth Involvement

- Training youth in sustainable farming practices and technologies to bridge the generational gap and promote the adoption of modern agricultural practices.
- Encourage youth involvement in agri-entrepreneurship farming by providing access to credit to create new income-generating opportunities and reduce youth unemployment.

Agroforestry: This is a land use management system that combines trees and shrubs with crops and/or livestock. It provides multiple benefits, such as increased soil fertility, improved water management, and diversified income streams.

Conservation agriculture: This is a set of practices that aim to reduce soil disturbance, maintain soil cover with crop residues or cover crops, and rotate crops to improve soil health and reduce erosion.

Integrated crop-livestock systems: These systems combine crop production with livestock rearing, allowing for efficient use of resources and diversified income sources.

Organic farming: This system relies on ecological processes, such as composting and crop rotation, to maintain soil fertility and control pests and diseases.

Water harvesting and management: This involves capturing and storing rainwater to reduce dependence on rainfall and provide water for irrigation.

Conclusion: By adopting the recommendations outlined in this guide and working collaboratively, small-scale farmers in Uganda, Kenya, and Tanzania can enhance their productivity and contribute to global food security.

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