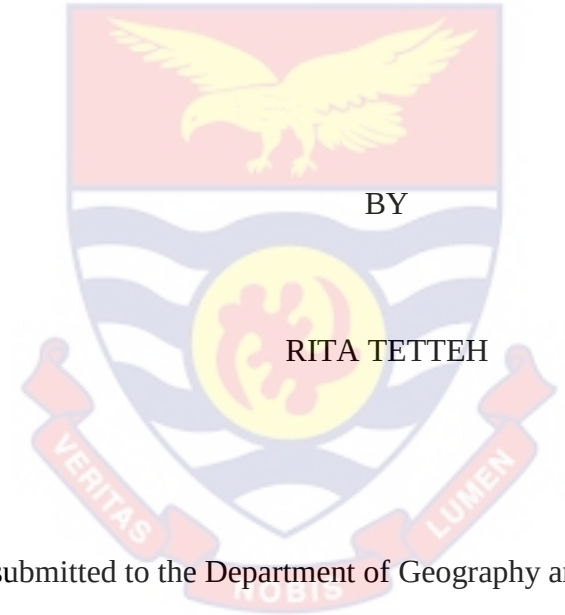
UNIVERSITY OF CAPE COAST

ASSESSING CIRCULAR AGRICULTURE PRACTICES BEHAVIOUR OF SMALLHOLDER FARMERS IN YILO KROBO MUNICIPALITY OF GHANA



BY

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature……Date……

Name: Rita Tetteh

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature…… Date……

Name: Dr. Jones Abrefa Danquah

ABSTRACT

The study assessed smallholder farmers' circular agricultural practices and behaviours in the Yilo Krobo Municipality. The study used a descriptive research design with simple random and purposive sampling techniques to interview 358 respondents from communities in the Yilo-Krobo Municipality. A questionnaire and interview guide was used to collect data in the study. The study revealed that smallholder farmers (66.8%) in Yilo-Krobo Municipality are hesitant to adopt circular agriculture practices such as using organic manure or compost, disease-resistant crops, and botanical or organic pesticides, largely due to doubts about their effectiveness and benefits. Financial constraints, limited market access, and inadequate technological infrastructure are major challenges hindering the widespread adoption of circular agriculture practices among farmers in the Yilo-Krobo Municipality. Most farmers in the Yilo-Krobo Municipality do not receive support from government agencies (93%), NGOs (100%), agricultural extension services (92%), and community associations (99%). Financial constraints, lack of modern technologies, inadequate market access, knowledge, training, and support gaps, insufficient market incentives, and varying social norms hindered the adoption of circular agriculture practices among smallholder farmers in the Yilo-Krobo Municipality. Hence, Government agencies and NGOs should collaborate to provide targeted educational programs that increase awareness of the benefits and effectiveness of circular agriculture practices. These programs should demonstrate the long-term benefits of such practices, including soil fertility and reduced chemical use.

KEYWORDS

Circular Agriculture

Smallholder Farmers

Circular Agricultural Practices

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DEDICATION

To my parents Mr. and Mrs. Tetteh and the entire family.

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ACRONYMS

GSS	Ghana Statistical Service
SDGs	Sustainable Development Goals
FAO	Food and Agriculture Organization of the United Nations
CAP	Circular Agricultural Practices
NGOs	Non-Governmental Organizations
TPB	Theory of Planned Behaviour
IDT	Innovation Diffusion Theory
CA	Circular Agriculture
MOFA	Ministry of Food and Agriculture

CHAPTER ONE

INTRODUCTION

Overview of Global Circular Agricultural Practices

The current global overview reflects a growing recognition of the urgent need to transition towards circular agriculture to address the environmental, economic, and social challenges associated with traditional agricultural practices (Liu & Ramakrishna, 2021). Circular agriculture is a farming technique that reduces external inputs and waste by regenerating soils, eliminating nutrient loops, and lowering environmental impact (Dagevos & Lauwere, 2021; Marinova & Bogueva, 2022). The negative impacts of conventional farming, such as soil degradation, water pollution, greenhouse gas emissions, and biodiversity loss, have prompted a shift in focus towards more sustainable and regenerative approaches. Researchers, policymakers, and practitioners worldwide have been actively studying and promoting circular agriculture in diverse contexts, encompassing developed and developing countries.

Europe has been at the forefront of circular agriculture practices, with several countries leading. The Netherlands, for instance, has made substantial progress in adopting innovative techniques such as vertical farming, aquaponics, and precision agriculture (Mir et al., 2022; AlShrouf, 2017). For instance, compared to traditional agriculture, the aquaponics system reduces water usage by 98%, fertiliser usage by 60% and pesticide usage by 100% while maximising crop yield (AlShrouf, 2017). These methods have been shown to uptake more minerals and vitamins, making the plants healthier and potentially more nutritious. Denmark has transitioned into circular agriculture

by combining precision farming, renewable energy and circularity (Elavarasan et al., 2022; Vasa, Angeloska & Trendov, 2017). These technologies include anaerobic digesters, converting agricultural waste into biogas and fertiliser, and are widely utilised.

Moreover, the United States, Canada, and China have seen the rise of regenerative agriculture as a critical approach to soil restoration and carbon sequestration (Marinova & Bogueva, 2022; Yang et al., 2022; Keske et al., 2020; Zhu et al., 2019). Farmers are implementing techniques like rooftop gardens, hydroponics, and community-supported agriculture (CSA) programs, cover cropping, conservation tillage, and holistic grazing management to improve soil health and increase carbon capture. These practices enhance food security, reduce environmental pollution, and promote sustainable resource utilisation.

Conventional agriculture in Sub-Saharan Africa has negative impacts. Excessive chemical fertiliser and pesticide use result in soil degradation, affecting 39% of agricultural land (Rashmi et al., 2022). Chemical runoff contaminates water sources, harming human health and aquatic ecosystems. Furthermore, reliance on fossil fuels in conventional agriculture contributes to greenhouse gas emissions and climate change (Singh, 2021b). Chemical fertiliser consumption in Sub-Saharan Africa has increased, but efficiency remains low due to inadequate knowledge and limited access to affordable options (Bjornlund, Bjornlund & van Rooyen, 2020; Tsujimoto, Rakotoson, Tanaka, & Saito, 2019). As a result, Sub-Saharan African countries recognise the need for more sustainable and resilient food systems. This is because they

aim to minimise waste, reduce inputs, and promote ecological balance while enhancing productivity and farmer livelihoods.

Nigeria launched initiatives like the Green Alternative Agriculture Promotion Policy, focusing on sustainable practices such as organic farming, agroforestry, and renewable energy (Lokpobiri, 2019). The policy aimed to reduce chemical inputs, conserve resources, and improve soil fertility. Circular economy principles are also encouraged, recycling agricultural waste into valuable resources like organic fertilisers. Kenya prioritises sustainable practices through its Vision 2030 agenda, implementing climate-smart agriculture, agroecology, and integrated pest management (Faling, 2020; Newell et al., 2019). This includes circular practices, such as tea waste composting, reducing chemical fertiliser usage and enhancing soil health.

Multiple factors drive the shift towards circular agriculture in Sub-Saharan Africa. Firstly, the region is highly vulnerable to climate change impacts, including droughts and floods, which impact food security and livelihoods. According to Reed et al. (2022), about 12% of the African population experience food insecurity because of flooding. Circular practices like agroforestry and water conservation techniques build climate resilience, retaining soil moisture and reducing erosion. Secondly, traditional farming methods rely heavily on chemical inputs, causing soil degradation, water pollution, and health risks (Christiaensen, 2017; Sheahan & Barrett, 2017). Circular agriculture promotes organic and natural practices that reduce chemical usage, preserve soil fertility, and protect human health (Rosemarin et al., 2020). Thirdly, circular agriculture offers economic opportunities for smallholder farmers (Boon & Anuga, 2020). Sustainable practices increase

productivity, reduce costs, and access premium markets valuing environmentally friendly products. The demand for organic and fair-trade certified products is growing globally, incentivising farmers to adopt circular practices.

Circular agriculture practices have gained momentum in Ghana as a sustainable solution to climate change, soil degradation, and food security. The country has embraced organic farming, with governmental initiatives and programs supporting farmers in implementing this practice (Prah, 2023). Agroforestry, which integrates trees with crops or livestock, is another crucial aspect of circular agriculture in Ghana (Critchley et al., 2022). The successful Cocoa-Agroforestry Systems for Ecosystem Services (CAFES) project promotes agroforestry among cocoa farmers (Boon & Anuga, 2020). Recycling and reusing agricultural waste, such as livestock waste for biogas production, is also part of circular agriculture in Ghana. Innovative technologies like precision agriculture and aquaponics are being explored to optimise resource efficiency. However, limited finance, technical knowledge, and infrastructure access hinder wider adoption. Strengthening support systems through financial incentives, training, and market linkages is essential to overcome these barriers (Forkuor, Amponsah, Oteng-Darko & Osei, 2022). Ghana's progress in embracing circular agriculture demonstrates its commitment to sustainability and sets the stage for a resilient agricultural sector.

In the Yilo-Krobo Municipality, circular agriculture practices have gained considerable traction due to the community's recognition of the importance of sustainable farming methods. The municipality in the Eastern

Region of Ghana has a predominantly agricultural landscape, making it an ideal setting to implement circular agriculture. The adoption of circular agriculture practices in Yilo-Krobo is driven by the need to ensure food security for the local population. Farmers aim to improve yields while minimising synthetic fertilisers and pesticides and reducing environmental degradation by implementing sustainable farming techniques, such as organic farming and crop rotation. This not only enhances the nutritional quality of the product but also reduces the environmental impact associated with conventional farming practices.

Despite their adoption of circular agriculture practices, notable gaps remain to address. Limited access to appropriate technology, especially in rural areas, hinders the adoption of modern and efficient farming tools (Asare-Nuamah, Botchway & Onumah, 2019). Improved knowledge transfer mechanisms are necessary to provide farmers with up-to-date information and training on circular agriculture practices. Financial constraints pose challenges for farmers who lack the capital to invest in sustainable farming techniques (Jellason, Robinson & Ogbaga, 2021).

To promote wider adoption, policy and institutional support are essential. The government should develop and implement supportive policies that incentivise farmers, such as subsidies for renewable energy systems and organic farming certifications. Effective institutions can provide technical support, training, and access to resources. The Yilo-Krobo Municipality is a relevant case study, offering valuable insights and solutions to address local challenges. However, bridging gaps in knowledge transfer, technology access,

and financial resources is crucial for the widespread adoption of circular agriculture practices throughout Ghana.

Evolution of Circular Agriculture: A Historical Perspective

Circular agriculture, also known as regenerative agriculture or closed-loop farming, is a holistic approach to farming that aims to mimic the natural ecosystems and cycles to create a sustainable and self-sufficient agricultural system (Liaros, 2021). This practice is rooted in ancient agricultural traditions but has evolved in response to various challenges and advancements in science and technology. The foundations of circular agriculture can be traced back to ancient civilisations that understood the importance of balancing agricultural practices with the natural environment: the Mesopotamians, Egyptians, and Mayans practised crop rotation, terracing, and water management (Trigger, 1993; Angelakıs et al., 2020). These techniques promoted soil fertility and efficient resource utilisation. These early practices formed the basis for sustainable agricultural systems by acknowledging the interconnections between soil health, water management, and plant growth.

During the middle Ages and Renaissance, advancements in agricultural practices further contributed to the evolution of circular agriculture. The introduction of the three-field system, where one-third of the land lay fallow to allow for soil regeneration, helped maintain soil fertility and increase agricultural output (Kropp, 2022). Using manure as a fertiliser and the invention of the mouldboard plough improved soil quality and enhanced crop yields. These innovations represented a shift towards more efficient and sustainable agricultural practices.

The Industrial Revolution marked a turning point in agriculture with the advent of machinery, synthetic fertilisers, and pesticides (Watson et al., 2021; Meliala et al., 2019). The focus shifted towards maximising productivity and increasing yields to meet the growing demands of a rapidly expanding population (Hemathilake & Gunathilake, 2022). However, this period also witnessed the unintended consequences of intensive farming, such as soil erosion, loss of biodiversity, and pollution. The negative impacts of these practices prompted a renewed interest in sustainable and circular agricultural approaches.

In the mid-20th century, concerns about the environmental and health implications of conventional farming practices led to the emergence of organic farming (Pufpaff, Xu & McCann, 2021). Organic agriculture emphasises the use of natural inputs, such as compost and animal manure, and rejects the use of synthetic chemicals. This movement advocated a more holistic approach to farming, considering the ecological interdependencies between soil, plants, animals, and humans. Organic farming embraced principles of circularity by promoting biodiversity, nutrient recycling, and ecological balance (Freitas & Silva, 2022; Singh, 2021a).

In recent years, regenerative agriculture has gained prominence as a further evolution of circular agriculture (Giller, Hijbeek, Andersson & Sumberg, 2021). This approach goes beyond sustainability, aiming to restore and regenerate degraded soils, increase carbon sequestration, and enhance ecosystem health. Regenerative practices include cover cropping, rotational grazing, agroforestry, and minimal tillage, which enhance soil fertility, water retention, and biodiversity (Khangura, Ferris, Wagg & Bowyer, 2023).

Additionally, modern innovations such as precision agriculture, digital technologies, and data-driven decision-making have facilitated the implementation of circular and regenerative practices on a larger scale.

The evolution of circular agriculture has spanned centuries, drawing inspiration from ancient agricultural traditions and adapting to the challenges and advancements of each era. From the early recognition of the interdependencies in natural ecosystems to the current focus on regenerative practices, the trajectory of circular agriculture has been guided by a growing understanding of the importance of sustainable and holistic farming systems.

Problem Statement

Ghana's economy is based mainly on agriculture, substantially contributing to job creation, revenue production, food security, and economic growth. However, the country faces several challenges related to chemical fertilisers and agrochemicals. Firstly, most agro-inputs are imported, putting pressure on limited foreign exchange reserves (Ansah & Afful, 2019). Secondly, the heavy reliance on these chemicals exposes the country to external shocks and increases the risk of food insecurity (van Berkum, 2021; Raheem, Dayoub, Birech & Nakiyemba, 2021).

Additionally, the high cost of chemical fertilisers and agrochemicals makes them unaffordable for many farmers, especially with the government's inability to provide subsidies due to the balance of payment situation and the budget deficit (Adu-Amankwah & Tutu, 2019). These issues highlight the need for a shift towards promoting organic alternatives to ensure sustainability in agriculture and address the environmental degradation, soil depletion, and decreased productivity associated with conventional farming practices that

threaten the livelihoods and food supply of numerous smallholder farmers (Sumberg & Giller, 2022; Demi & Sicchia, 2021).

Adopting circular agriculture practices, which promote using natural resources, recycling waste, and sustainable land use, can contribute to sustainable agriculture and address environmental challenges (Yang et al., 2023). However, smallholder farmers in Ghana face numerous challenges in adopting circular agriculture practices, including limited access to resources and technologies, low awareness of circular agriculture practices, and inadequate policies and regulations to support their implementation (Boon & Anuga, 2020; Tulashie et al., 2023).

Smallholder farmers' limited adoption of circular agricultural techniques is troubling, as it prevents them from reducing the impact on biodiversity, minimising health risks associated with chemical usage, maintaining soil integrity through minimum or zero tillage, and avoiding the destruction of non-target species. Moreover, this low rate of adoption hampers the achievement of Sustainable Development Goals (SDGs) related to zero hunger (SDG 2) and responsible consumption and production (SDG 12) (United Nations, 2015; Murray, Skene & Haynes, 2017). Therefore, addressing these barriers and promoting the widespread adoption of circular agriculture practices among smallholder farmers in Ghana is crucial to ensure sustainable agricultural practices and meet the SDGs.

Despite some research on circular agriculture practices in Ghana, the available empirical evidence regarding the determinants of smallholder farmers' adoption of such practices is limited. Recent studies indicate that several factors, including inadequate comprehension of the concept, limited

technical assistance, insufficient credit access, and restricted market opportunities, exert a substantial influence on the implementation of agriculture practices among small-scale farmers (Bianchi et al., 2020; Boon & Anuga, 2020; Helgason et al., 2021). However, further investigation is required to comprehend the specific factors that motivate and hinder the implementation of circular agriculture among small-scale farmers in Ghana, aiming to advance food security and sustainable agricultural development. Therefore, this study aims to assess the circular agriculture practices and behaviours of smallholder farmers in the Yilo-Krobo Municipality, Ghana, to identify the factors influencing the adoption of circular agriculture practices and propose strategies to promote circular agriculture practices among smallholder farmers.

Purpose of the Study

The study aims to evaluate the circular agricultural practices and behaviors of smallholder farmers in the Yilo-Krobo municipality of Ghana. This research will enhance the understanding of how these farmers integrate resources efficiency, waste reduction and sustainable farming methods into the agricultural systems with implications for policy development and environmental sustainability in rural Ghana.

Research Objectives

a. Examine the circular agriculture practices used by smallholder farmers,
b. Analyse factors that influence the adoption of particular circular agriculture practices,

c. Identify the barriers that smallholder farmers face in adopting circular agriculture practices, and
d. Analyse the role of stakeholders in promoting circular agriculture practices among smallholder farmers in Yilo-Krobo Municipality.

Research Questions

a. What circular agriculture practices are used by smallholder farmers in the Yilo-Krobo Municipality?
b. What factors influence smallholder farmers' adoption of circular agriculture practices in Yilo-Krobo Municipality?
c. What are the barriers to adopting circular agriculture practices by smallholder farmers in Yilo-Krobo Municipality?
d. How do stakeholders contribute to promoting circular agriculture practices among smallholder farmers in Yilo-Krobo Municipality?

Significance of the Study

The significance of the study lies in its exploration of the application of circular agricultural methods by smallholder farmers in Ghana and the potential benefits it holds for rural communities and society at large. First, the study identifies the hurdles and opportunities for implementing sustainable agriculture practices among smallholder farmers in Ghana. The analysis of various circular agricultural tactics and practices provides valuable insights into the strategies that can be adopted to promote sustainable farming (Muhie, 2022). This information is crucial for policymakers and stakeholders who can develop plans and initiatives to support and incentivise the adoption of eco-friendly farming methods.

Moreover, circular agriculture minimises waste, reduces chemical inputs, and optimises resource utilisation. Smallholder farmers can reduce their environmental impact by implementing circular agricultural practices, such as crop rotation, organic fertilisers, and agroforestry (Nkansah-Dwamena, 2024). This improves soil health, reduces water pollution, and decreases greenhouse gas emissions. The study contributes to the knowledge of circular agricultural systems and provides evidence of the environmental benefits that can be achieved through their adoption.

Furthermore, by adopting sustainable farming methods, smallholder farmers can improve their yields, reduce input costs, and diversify their income streams. For example, agroforestry systems can provide additional income by selling fruits and medicinal plants (Das et al., 2022). The study highlights these economic opportunities and showcases successful examples, encouraging rural communities to embrace circular agriculture to enhance their livelihoods.

Circular agriculture promotes sustainable food production and enhances the resilience of farming systems. Smallholder farmers can enhance their productivity and ensure a more stable food supply by adopting practices that improve soil fertility, conserve water and protect against pests and diseases (Shah & Wu, 2019). This is particularly important in rural areas where food security may be vulnerable. The study's findings contribute to the knowledge base on circular agricultural systems that can help improve food security and resilience in Ghana and similar contexts.

Furthermore, the study adds to the existing body of information on circular agriculture in Ghana, providing additional perspectives and insights.

This information is valuable for scholars and researchers working in the field of sustainable agriculture and environmental management. It contributes to the knowledge exchange and supports capacity-building efforts by highlighting the successes, challenges, and factors influencing adopting circular agricultural practices. This, in turn, facilitates informed decision-making and policy development to promote sustainable agriculture on a broader scale.

The study's significance lies in its contribution to promoting sustainable farming methods among smallholder farmers in Ghana and its potential to advance sustainable agriculture practices more broadly. Identifying hurdles, opportunities, and influencing factors provides guidance for policymakers and stakeholders, supports rural community development, reduces environmental impact, enhances food security, and contributes to the knowledge base in sustainable agriculture and environmental management.

Delimitations of the Study

This study assesses smallholder farmers' circular agriculture practices and behaviours in the Yilo-Krobo Municipality of Ghana. This study attempts to evaluate the determinants that prompt smallholder farmers in Ghana to embrace circular agriculture practices. However, it is essential to note that the findings of this study are not generalisable to other regions of Ghana that may have varying socioeconomic and environmental circumstances. Additionally, this study will only focus on smallholder farmers and present the views and experiences of other stakeholders, such as agricultural extension workers and policymakers. Finally, the study will be limited to data collected from surveys and interviews, which may not capture the full complexity of smallholder farmers' experiences and perspectives.

The Organisation of the Study

The study is in five chapters. The first chapter is an introduction to the research. It includes the study's background, problem description, objectives, research questions, and the study's importance. The second chapter reviews available literature linked to and relevant to the inquiry and theoretical and conceptual issues and frameworks. The third chapter addresses the research methods. It includes the research and study designs, study area, data sources, data collection methods, data collection instruments, sample processes, data processing and analysis, and ethical issues. Chapter Four, on the other hand, contains the analysis's findings and discussions. The fifth chapter gives the conclusions and recommendations required for policy execution.

CHAPTER TWO

LITERATURE REVIEW

Introduction

The chapter reviews relevant literature on circular agricultural practices and the behaviour of smallholder farmers. The review explores existing research, studies and documented experiences related to circular agricultural Practices globally, in Africa and Ghana. The literature also contains the theoretical/conceptual framework that guides the study.

The Concept of Circular Agriculture

The concept of Circular Agriculture, also known as regenerative agriculture, is a farming approach that reduces external inputs and waste by regenerating soils, eliminating nutrient loop, and lowering environmental impacts (Dagevos & Lauwere, 2021; Marinova & Bogueva, 2022). It aims to minimise waste and environmental impacts while promoting sustainable rural development. It optimises resource use, minimises waste and pollution, and promotes ecological balance and sustainability in agricultural practices (Huajun & Changbin, 2006; Hang et al., 2021). It also helps to improve soil health and fertility, leading to higher crop yields and better food security (El Janati et al., 2021). By minimising external inputs and closing nutrient loops, circular agriculture help reduces cost for farmers and increase their profitability (Velasco-Muñoz, Mendoza, Aznar-Sánchez & Gallego-Schmid, 2021).

The concept of circular agriculture is based on the principles of circular economy, a holistic approach that seeks to reduce, reuse, recycle, and regenerate resources rather than following the traditional linear model of

"take-make-waste" (Velasco-Muñoz, Mendoza, Aznar-Sánchez & Gallego-Schmid, 2021; Aznar-Sánchez et al., 2020). Implementing circular agriculture on a large scale has the potential to decrease the resource demands and ecological impact of farming by minimizing land utilization, chemical fertilizers, and waste. This transformative approach enables a reduction in global CO2 emissions, with estimations suggesting that adopting circular methods in European food systems could lead to an impressive 80% decline in the utilization of chemical fertilizers (Helgason, Iversen & Julca, 2021).

Pre-industrial societies widely practised circular agriculture, a concept that is not new. However, modern farming, which focuses primarily on maximising profit rather than protecting the environment, has overshadowed it (Gras & Caceres, 2020). This type of farming relies on large-scale, monoculture practices that are not well suited for circular agriculture. Promoting smallholder farming, incorporating organic, mixed, and agroforestry practices is crucial to transitioning to circular agriculture. Embracing a transition towards increased product diversity has been linked to enhanced health and nutrition outcomes, in contrast to the food insecurity often exacerbated by the export-oriented production of single crops.

Furthermore, implementing circular agriculture necessitates greater labour involvement than traditional farming methods, stimulating rural economies. Embracing circular farming techniques holds significant potential in alleviating poverty and ensuring food security while generating fresh employment opportunities, particularly for women residing in rural areas. According to the FAO (2023), women constitute 43% of the agricultural workforce in low-income nations. However, they encounter more substantial

obstacles in accessing productive resources, services, technology, market information, and financial assets than their male counterparts (Patil & Babus, 2018; Onwutuebe, 2019). Unlike conventional farming, which demands significant capital for procuring expensive seeds, fertilizers, and pesticides, circular agricultural practices exhibit lower barriers to entry and offer more significant opportunities for women's involvement.

At the core of circular agriculture lies principles that guide it to minimizing waste and agricultural sustainability. These principles include regenerative agriculture, efficient use of resources and multi-purpose use and recovering value. These principles discussed below give knowledge and insights into developed and tested circular agricultural projects worldwide. These principles are not contradictory but rather complement one another in their pursuit of agricultural sustainability and the reduction of waste.

Regenerative Agriculture (Preserving and Enhancing Natural Resources)

Regenerative agriculture prioritizes using natural processes and ecosystem services while minimizing the use of non-renewable resources or those harmful to the environment (Schreefel et al., 2020). This approach avoids using chemicals, materials, and substances that are challenging to recycle, reuse, or possess toxic properties. In contrast, agricultural intensification centers on maximizing production through large-scale monocultures comprised of high-yielding crop varieties. This often involves heavy reliance on agrochemical inputs and intensive soil management practices to control weeds, pests, and diseases, which can harm the soil.

Regenerative agriculture recognises that healthy soil is the foundation for productive and sustainable agriculture. Regenerative farmers use cover cropping, crop rotation, and minimal tillage to build organic matter, improve soil structure, and enhance the soil's ability to retain water (Liu & Ramakrishna, 2021). Healthy soils sequester carbon dioxide from the atmosphere, helping to mitigate climate change. Moreover, the principle also focuses on conserving water resources by implementing efficient irrigation systems and capturing and storing rainwater. It also involves protecting biodiversity by creating habitat for beneficial insects, birds, and other wildlife on farmland. By preserving natural resources, regenerative agriculture helps maintain ecological balance and supports a more resilient agricultural ecosystem (McLennon, Dari, Jha, Sihi & Kankarla, 2021).

There is a growing awareness of the detrimental effects caused by the conventional agricultural model on the environment, biodiversity, and long-term ecological sustainability. In contrast, circular agriculture adopts a distinct perspective. It necessitates the establishment of resilient agroecosystems that possess inherent capabilities to sustain soil functions, combat pests, diseases, and weeds, and withstand unfavourable weather conditions. The circular approach is incompatible with heavy reliance on external inputs. Instead, resilient agroecosystems rely on effectively managing ecosystem services beyond mere provisioning services. Various strategies can be employed to achieve this, such as introducing beneficial species, implementing less disruptive soil management techniques, practising agroforestry, adopting rotational grazing methods, and cultivating diverse crop varieties.

Efficient Use of Natural Resources (Closing Nutrient Loops)

Efficient use of natural resources, or closing nutrient loops, is a crucial principle of circular agriculture (Bianchi, van Beek, de Winter & Lammers, 2020). It aims to close the loop by ensuring that the nutrients used in crop production are replenished and recycled within the system, minimising the need for external inputs and reducing the reliance on synthetic fertilisers. This involves using waste products from one part of the food system as inputs for another part rather than discarding them as waste (Bianchi, van Beek, de Winter & Lammers, 2020). Through such practices, circular agriculture has the potential to decrease resource demands and minimize the ecological impact of agriculture. This can be achieved by reducing land utilization, chemical fertilizers, and waste, ultimately reducing global CO2 emissions. Different key aspects and strategies are associated with closing the nutrient loop in circular agriculture. They include nutrient cycling, closed-loop system, precision agriculture, integrated livestock and crop system and renewable energy.

Nutrient cycling involves the efficient use of natural resources by implementing practices that facilitate the cycling of nutrients within the agricultural system (Yadav et al., 2021). This includes techniques such as composting, crop rotation, overcropping and livestock manure. These practices help to retain organic matter and nutrients back to the soil, improving soil health and fertility and reducing the need for synthetic inputs and chemicals. Moreover, the closed-loop system uses waste from one part of the agricultural system as resources for another. For example, in China, farmers use crop residue and food waste as input for composting or as feed for

livestock (Jia et al., 2018). This approach minimises waste and maximises resource efficiency. Furthermore, using precision agriculture technologies, such as soil sensors, remote sensing, and data analytics, can help optimise the application of nutrients and water. By providing real-time information about soil conditions and crop needs, farmers can apply fertilisers and irrigation more precisely, minimising losses and improving resource efficiency.

Nevertheless, integrating livestock and crop production systems can enhance nutrient cycling and resource efficiency (Adegbeye et al., 2020). Livestock can contribute to the system by providing manure, which can be used as a nutrient-rich crop fertiliser. Additionally, crop residues and by-products can be used as feed for livestock, closing the loop and reducing dependence on external inputs. Lastly, closing nutrient loops also involves promoting using renewable energy sources in agricultural operations. Renewable energy technologies such as solar panels or bioenergy systems can help meet the energy needs of farms while reducing reliance on fossil fuels and minimising greenhouse gas emissions.

Through these strategies, circular agriculture aims to create a regenerative and sustainable system where resources are efficiently managed, waste is minimised, and the overall environmental impact is reduced. Closing nutrient loops play a vital role in achieving these objectives by ensuring the efficient use and conservation of natural resources, reducing greenhouse gas emissions, promoting sustainable rural development and fostering a more resilient and sustainable agricultural system.

Multi-purpose Use and Recovering Value (Waste to Value)

The principle of multi-purpose use and recovering value, also known as waste to value, is a crucial aspect of circular agriculture (Bianchi, van Beek, de Winter & Lammers, 2020). It minimises food losses and transforms waste streams into valuable inputs for the food production chain. This principle aligns with the circular economy concept of reusing, recycling and reducing existing materials and products. In food systems, losses occur at various value chain stages, including production, harvesting, storage, processing, transport, and retail. Circular agriculture aims to address these losses by utilising waste streams and turning them into valuable resources. This approach involves several steps and the collaboration of multiple actors.

The first step in waste valorisation is separating the waste into streams that can and cannot be upgraded (Bianchi, van Beek, de Winter & Lammers, 2020). For example, organic waste, such as crop residues or food scraps, can be separated from non-organic waste, such as packaging materials or plastics. This allows for targeted processing and resource recovery. Once waste streams are separated, processing facilities can be set up to generate upgraded products. For instance, organic waste can be composted or subjected to anaerobic digestion to produce nutrient-rich compost or biogas. These products can then be used as inputs for agricultural production, closing the nutrient loop. Developing a market for upgraded products is crucial for waste valorisation. It requires creating awareness and demand among potential buyers, such as farmers, gardeners, or horticultural businesses. Market development efforts may involve education, promotion, and demonstrating the benefits and value of using these products (Bianchi, van Beek, de Winter &

Lammers, 2020). Efficient trade logistics are essential for the successful implementation of waste valorisation chains. It involves organising the upgraded products' collection, transportation, and distribution to the end-users. Collaboration among stakeholders, such as waste management companies, processing facilities, and distributors, is necessary to ensure smooth logistics and reduce inefficiencies.

In summary, circular agriculture creates opportunities for various actors in the agricultural value chain by implementing waste-to-value practices. Farmers can benefit from using nutrient-rich compost derived from organic waste as a natural fertiliser, reducing their reliance on synthetic fertilisers. Waste management companies can explore new revenue streams by collecting and processing organic waste into value-added products. Processing facilities specialising in composting or anaerobic digestion can be crucial in upgrading waste and producing valuable resources. Retailers and consumers can contribute by minimising food waste, properly storing and managing perishable products, and supporting using recycled and upcycled materials.

Empirical Review of Literature

This section empirically reviews smallholder farmers' circular agriculture practices and behaviours. The empirical review is based on reviewed literature related to the study objectives.

Circular Agricultural Practices of Smallholder Farmers

Circular agricultural practices refer to farming systems that prioritise the efficient use of resources, minimise waste, and promote ecological sustainability (Helgason, Iversen & Julca, 2021). These practices aim to close the nutrient and energy loops within agricultural systems, creating a circular

flow of resources and reducing reliance on external inputs. Smallholder farmers, who typically have limited resources and land, often employ circular agricultural practices to enhance productivity, reduce costs, and improve their resilience to climate change. These practices include integrating mixed crop-livestock systems, adopting organic farming methods, implementing agroforestry techniques, and employing water recycling and wastewater reuse strategies (Iordachi & Popa, 2022). Circular agriculture aims to decrease carbon dioxide emissions, optimise natural resource utilisation, and significantly reduce input dependency.

Agroforestry is a prevalent circular agricultural practice embraced by smallholder farmers. It involves integrating trees into agricultural systems, offering various advantages such as enhancing soil fertility, controlling erosion, and diversifying farm products (Helgason, Iversen & Julca, 2021; Torreiro, Pérez, Piñeiro, Pedras & Rodríguez-Abalde, 2020). Additionally, agroforestry contributes to circular agriculture by reducing reliance on chemical fertilizers and pesticides. This makes it more accessible for female farmers, who often face financial constraints and limited access to credit, thereby opening up new opportunities for women's empowerment within the rural economy. A study conducted by Altieri, Funes-Monzote, and Petersen (2012) revealed that smallholder farmers practicing agroforestry in Malawi, Tanzania, Mozambique, Zambia, and Cameroon achieved maize yield increases of up to 280% while mitigating soil erosion.

By planting trees alongside crops, farmers establish a symbiotic relationship wherein the trees provide shade, fix nitrogen in the soil, and act as windbreaks, benefiting both the crops and the environment. Combining

agroforestry with livestock farming presents further opportunities for implementing circular agriculture with reduced ecological impacts (Schneider, Rochell, Plat & Jaworski, 2021). Many smallholder farmers in India and Kenya raise livestock and utilize crop residue biomass as animal fodder, which leads to diminished soil cover (Valbuena et al., 2012; Valbuena et al., 2015). However, by incorporating trees into their farms, farmers have a more excellent biomass supply to meet the needs of their livestock and maintain adequate soil cover.

Agroforestry also reduces the necessity for plastic mulch by utilizing leaves and other plants as organic matter. Economically, agroforestry ensures a more diverse range of products and a more stable income stream for farmers. In Nigeria and Canada, farming systems integrating trees with maize crops exhibit higher average yields and returns than chemical fertilizers (Adesida, Nkomoki, Bavorova & Madaki, 2021). Similarly, in the drylands of West Africa, farmers in Burkina Faso, Ghana, Niger, and Senegal have witnessed regenerated tree growth and diversified production through agroforestry initiatives (Bayala et al., 2016).

Organic farming is another vital component of circular agriculture, aiming to eradicate reliance on chemical fertilizers, pesticides, and plastics. This approach often entails increased labour requirements, offering employment opportunities, and fostering rural development (Unay-Gailhard & Bojnec, 2019). The reduced use of pesticides and fertilizers also carries gender-related implications. In numerous regions, the handling of pesticides is traditionally perceived as a male responsibility, making pesticide-free organic farming an avenue to encourage women's involvement in agriculture

(Meemken & Qaim, 2018). An example of organic farming practice utilised by smallholder farmers is using organic fertilisers, such as compost and manure.

Organic fertilisers provide essential nutrients to the soil and improve soil structure, crop yield and water-holding capacity—a study conducted in India by Patel. (2021) showed that smallholder farmers who incorporated organic fertilisers (Nano organic materials) into their farming systems experienced a 20% increase in crop yield compared to those who relied solely on synthetic fertilisers. Smallholder farmers can reduce their dependency on costly synthetic fertilisers and contribute to nutrient cycling by recycling organic waste and livestock manure. In the past, conventional agriculture has generally achieved higher yields than organic farming, although this disparity has recently narrowed (Jouzi et al., 2017). Organic farming, under specific conditions and effective management practices, has shown promising results in terms of yields and land requirements, particularly for crop groups such as rice, soybean, corn, and grass-clover (Skinner et al., 2019; Sharma et al., 2021).

Inherently connected to the idea of mixed farming agricultural practices is circular agriculture. Mixed farming involves transitioning from monoculture to cultivating a diverse set of interdependent crops that mutually benefit each other on the same land. This approach promotes reduced input usage, improved soil fertility management, enhanced resilience, and sustainable yield increases through the combined production of different crops and legumes (Madsen, Bezner Kerr, Shumba & Dakishoni, 2021). Mixed farming offers additional opportunities for promoting circular agriculture by

fusing crop and animal husbandry. For instance, substituting locally produced feed and manure for imports and chemical fertilizers can lower CO2 emissions in agriculture, establishing a circular food system.

Despite the numerous advantages, highly specialized agricultural systems have increasingly replaced mixed-farming practices, as the Common Agricultural Policy has encouraged European farmers to scale up and specialize their agricultural production. Farms that combine crops and animals have lower costs, are less susceptible to market and price changes, and produce less nitrogen pollution. (Sneessens, Sauvée, Randrianasolo-Rakotobe & Ingrand, 2019). While the specific context plays a significant role, and there is variability within mixed-farming systems, these approaches hold the potential to foster more sustainable agricultural and rural development.

Crop rotation is an essential circular agricultural practice adopted by smallholder farmers worldwide. By alternating different crops in a sequence, farmers can break pest and disease cycles, improve soil fertility, and reduce the need for chemical inputs. A study by Corbeels et al. (2020) demonstrated that smallholder farmers in Sub-Saharan Africa, mainly those who practised crop rotation, increased crop yields compared to those who practised continuous monocropping. Crop rotation reduces pest pressure and replenishes soil nutrients, leading to sustainable and resilient farming systems (Christine, Wycliffe, Fina & Geoffrey, 2023; Adesida, Nkomoki, Bavorova & Madaki, 2021).

Water management is another critical aspect of circular agricultural practices for smallholder farmers, particularly in regions facing water scarcity. Drip irrigation systems, for example, enable farmers to deliver water directly

to plant roots, minimising evaporation and optimising water use efficiency. In a study by Assefa, Jha, Reyes, Tilahun and Worqlul (2019) in Sub-Saharan Africa, smallholder farmers who adopted drip irrigation increased their crop yields by 9% to 184% while reducing water consumption by 18% to 40%. By conserving water resources and using them judiciously, smallholder farmers can enhance their productivity while mitigating the environmental impacts of excessive water usage.

Lastly, livestock integration is another circular agricultural practice commonly employed by smallholder farmers. By integrating livestock into crop production systems, farmers can utilise animal manure for organic fertiliser, control weeds, and provide an additional source of income through the sale of livestock products. A case study in Ghana revealed that smallholder farmers practising livestock integration increased their maize yields and experienced a decrease in weed infestation (Abdul Rahman et al., 2022). Livestock integration contributes to nutrient cycling and enhances smallholder farming systems' overall resilience and sustainability.

Factors Influencing the Adoption of Circular Agricultural Practices

Circular agriculture is a sustainable farming practice that aims to reduce waste and increase resource efficiency by closing nutrient cycles and minimising external inputs. Circular agricultural practices can reduce poverty, food security, and rural development. However, adopting these practices is influenced by various factors that can vary depending on the context. These factors include farmers' attitudes, knowledge and information, technology innovations, and farm characteristics.

Environmental Concerns

Many studies have extensively supported the pivotal role of environmental concerns in propelling the adoption of circular agricultural practices (Selvan et al., 2023; Patwa et al., 2021; Silva et al., 2019). These studies shed light on the profound awareness that farmers are gaining regarding the detrimental effects associated with conventional farming practices, particularly on the fragile aspects of soil health, water quality, and biodiversity. This heightened awareness of environmental issues has paved the way for a fundamental shift in farming approaches, as farmers increasingly acknowledge the pressing need to mitigate the adverse impacts of their activities on delicate ecosystems. Climate change is one of the most pressing environmental concerns that have propelled the adoption of circular agricultural practices (Macarthur & Heading, 2019).

The urgency to combat this global phenomenon and the imperative to reduce greenhouse gas emissions have been identified as compelling drivers behind the widespread adoption of circular practices (Bherwani, Nair, Niwalkar, Balachandran & Kumar, 2022; Macarthur & Heading, 2019). The dire consequences of climate change, such as rising temperatures, extreme weather events, and changing precipitation patterns, have galvanised farmers to seek more sustainable alternatives to conventional farming methods. By embracing circular practices, farmers strive to minimise their carbon footprint, enhance carbon sequestration in soils, and contribute to the collective effort to mitigate climate change impacts.

These studies' collective body of evidence underscores the critical interplay between environmental concerns, farmer awareness, and the

increasing adoption of circular agricultural practices. This awareness serves as a catalyst, propelling farmers to take proactive steps toward sustainable farming methodologies. It reflects a growing consciousness of the negative impacts of conventional practices on essential environmental elements and highlights the responsibility and dedication farmers are demonstrating to address these challenges head-on. By embracing circular agricultural practices, farmers demonstrate their commitment to preserving and enhancing soil health, safeguarding water resources, protecting biodiversity, and contributing to a more sustainable and resilient agricultural landscape.

Economic Viability

The economic viability of circular agricultural practices is a fundamental pillar influencing adoption decisions within the agricultural sector. Recognising that farmers require tangible economic benefits to justify transitioning from conventional practices, numerous studies have focused on uncovering the potential cost savings and increased profitability associated with circular practices. For instance, the comprehensive research conducted by Tahat, Alananbeh, Othman and Leskovar (2020) underscored the financial advantages and revealed that sustainable farming practices, such as agroecology and organic farming, can substantially reduce input costs while enhancing overall farm profitability. These findings shed light on the immense potential for circular practices aligning with ecological objectives and farmers' financial aspirations.

Moreover, access to premium markets for sustainably produced goods is an additional impetus for farmers to embrace circular practices (Sultan, S., & El–Qassem, 2021). This reveals that the prospect of capturing higher prices

and entering lucrative markets incentivises farmers to transition (Zhang, Dhir & Kaur, 2022). By recognising the economic incentives tied to sustainable and circular agricultural practices, farmers are encouraged to shift their strategies, ensuring financial stability and environmental sustainability.

Policy Support

The role of policy frameworks and governmental support in promoting the adoption of circular agricultural practices cannot be overstated. Governments play a crucial role in facilitating the transition to sustainable farming through incentives, subsidies, and technical assistance (Zhu, Jia & Lin, 2019; Qiao, Martin, He, Zhen & Pan, 2019). The positive influence of policy mechanisms, such as agri-environmental schemes, incentivise and reward farmers for embracing circular practices. Such policies provide tangible support, encouraging initial adoption and ensuring long-term sustainability. Furthermore, long-term policy commitments and stability are vital in instilling in farmers the confidence to invest in sustainable practices. These policies provide farmers with a predictable regulatory environment, allowing them to plan and invest in circular agricultural practices without fear of abrupt policy changes or uncertainties. The connection between supportive policies and adopting circular practices is pivotal in fostering a favourable environment that enables the agricultural sector to transition towards sustainable and circular models.

Access to Knowledge and Information

Access to relevant information and knowledge is the bedrock for successfully adopting circular agricultural practices. Farmers must be well-informed about sustainable farming methods' potential benefits, techniques,

and success stories. In this regard, extension services, farmer field schools, and research institutions are crucial in disseminating valuable information and providing necessary training to farmers. Kansanga, Kerr, Lupafya, Dakishoni and Luginaah (2021) shed light on the significance of farmer-to-farmer knowledge exchange and learning networks in facilitating the adoption of circular practices. The adoption of circular practices can be significantly facilitated by establishing platforms for knowledge sharing and leveraging the experiences of fellow farmers.

Farmer field schools, for instance, provide practical training and demonstrations, allowing farmers to acquire hands-on experience and learn from their peers (Ingram et al., 2018). Additionally, research institutions play a vital role in conducting studies, disseminating findings, and providing evidence-based information on the benefits and techniques of circular agricultural practices. By bridging the gap between knowledge and practice, these knowledge-sharing mechanisms foster an environment that encourages and supports farmers in their transition towards circular agricultural practices.

Technological Innovation

Technological advancements can potentially revolutionise and expedite the adoption of circular agricultural practices. Precision agriculture technologies, including soil sensors and remote sensing, empower farmers to optimise resource use and minimise waste. By providing real-time data on soil moisture levels, nutrient content, and other relevant parameters, these technologies allow farmers to make informed decisions, ensuring precise and efficient resource management. The research conducted by Jurgilevich et al. (2016) highlighted the pivotal role of technological innovations in enhancing

both the economic viability and environmental performance of circular farming systems.

Furthermore, innovative waste management solutions drive circularity within the agricultural sector. Technologies such as anaerobic digestion for organic waste allow farmers to convert waste materials into valuable resources, such as renewable energy (Foster et al., 2021). Farmers can minimise waste and enhance their overall resource efficiency by utilising innovative waste management techniques. The integration of technological innovations in circular agricultural practices is instrumental in driving positive change and propelling the sector toward a more sustainable and circular future

Farm Characteristics

Farm characteristics, including farm size and the type of crops grown, play a significant role in shaping the adoption of circular agricultural practices (Atinkut et al., 2020). These factors can influence farmers' decisions to embrace sustainable and circular farming methods, often in nuanced ways influenced by available resources and unique circumstances. Due to their limited resources, smaller farms may find adopting circular practices more feasible and practical (Barros et al., 2020). With fewer resources, small-scale farmers are often compelled to maximise efficiency, reduce waste, and optimise resource utilisation. Circular agricultural practices align well with these goals, offering strategies to enhance productivity and sustainability while maximising limited resources.

The farm size can also affect farmers' degree of control and flexibility over their operations. Smaller farms typically have a more intimate and hands-on approach to managing their land, allowing for a more straightforward

implementation of circular practices (Vrolijk, Reijs & Dijkshoorn-Dekker, 202). These farms may be able to experiment with alternative techniques, diversify their production systems, and explore innovative solutions without being encumbered by complex hierarchies or bureaucratic processes. Additionally, the type of crops grown on a farm can influence the adoption of circular practices. Certain crops, such as perennial crops or those with longer growth cycles, may naturally lend themselves to circular agricultural practices. For example, agroforestry systems integrate trees with crops and provide improved soil health, enhanced biodiversity, and carbon sequestration benefits. Farmers cultivating such crops may find it more logical and advantageous to adopt circular practices that align with their crops' natural cycles and requirements.

Moreover, adopting circular practices can also be influenced by the prevailing agricultural systems and contexts in which farms operate (Sgroi, 2022; Andersson & D'Souza, 2014; Rodriguez et al., 2009). Factors such as geographical location, climate, market dynamics, and regulatory frameworks can shape the viability and feasibility of adopting circular practices. Farms operating in regions with conducive environmental conditions, supportive markets, and favourable policies may be more inclined to embrace circular agricultural practices.

Farm characteristics, including size and crop types, notably influence the adoption of circular agricultural practices (Abid, Scheffran, Schneider & Elahi, 2019; Vanlauwe et al., 2014). While resource limitations may drive smaller farms to adopt circular practices, larger farms face unique challenges but can leverage their scale to implement innovative solutions. The type of

crops grown also plays a role, with some crops aligning with circular practices. Understanding and addressing farms' specific circumstances and needs based on their characteristics is essential to effectively promote and support adopting circular agricultural practices across diverse farming systems.

In summary, the adoption of circular agricultural practices is influenced by various factors. Environmental concerns, like the adverse effects of traditional farming and the need to address climate change, motivate farmers to embrace circular practices. Circular practices also offer economic benefits, such as cost savings, increased profitability, and access to premium markets. Policy support helps farmers transition to circular practices through incentives and stable regulations. Access to knowledge and information provided by extension services and research institutions is vital for informed decision-making. Technological innovations, like precision agriculture and waste management solutions, further accelerate the adoption of circular practices. Farm characteristics, such as size and crop types, also play a role. Understanding and addressing these factors is essential for promoting the widespread adoption of circular practices, leading to a more sustainable and resilient agricultural sector.

Barriers Facing the Adoption of Circular Agricultural Practices

Circular agriculture aims to address the growing concerns about unsustainability to global food production, soil destruction, pollution of water and land resources and biodiversity losses. However, the adoption of circular agriculture faces several barriers that hinder its widespread implementation by smallholder farmers. These barriers include limited infrastructure and

innovation, social and cultural factors, uncertainty about food waste, lack of awareness and knowledge, financial constraints and market shifts.

Limited Infrastructure and Technology

Limited infrastructure and technology present a significant barrier to adopting circular agriculture practices. The successful implementation of these practices relies on having the necessary infrastructure and innovative technologies available and accessible to farmers. In many rural areas, the lack of appropriate infrastructure hinders the adoption of circular agriculture practices. For example, waste management facilities and composting systems are crucial for efficiently recycling organic waste and compost production, a critical component of regenerative farming (Liu & Ramakrishna, 2021). However, in regions lacking such infrastructure, farmers may struggle to manage and utilise organic waste effectively, limiting their ability to close nutrient cycles and reduce dependence on external inputs.

Access to advanced irrigation techniques is another critical aspect of circular agriculture. Water scarcity is a pressing issue in many agricultural regions, and adopting water-efficient irrigation systems, such as drip irrigation or precision sprinklers, can help optimise water use and minimise wastage (Nikolaou et al., 2020). However, limited access to these technologies, especially in resource-constrained areas, can impede the widespread adoption of circular agriculture practices.

Similarly, energy-efficient equipment plays a vital role in reducing the environmental impact of farming operations. Technologies such as solar-powered irrigation pumps or energy-efficient machinery can help farmers reduce their reliance on fossil fuels and decrease greenhouse gas emissions

(Guno & Agaton, 2022). However, the high upfront costs and limited availability of such equipment can be prohibitive for many farmers, preventing them from adopting circular agriculture practices. The absence of these advanced technologies and innovative solutions may hinder smallholder farmers' adoption of circular agriculture practices.

Social and Cultural Factors

Social and cultural factors can significantly impact farmers' adoption of circular agriculture practices. These factors encompass the beliefs, values, attitudes, and norms in a society or farming community. Farming communities often have ingrained cultural practices and knowledge passed down through generations. These traditions and customs may be valued for their cultural significance and perceived effectiveness, leading farmers to resist adopting new practices, including circular agriculture (Serebrennikov, Thorne, Kallas & McCarthy, 2020; Salite, 2019). The fear of deviating from established practices and the uncertainty of the outcomes associated with change can create resistance among farmers.

Moreover, cultural perceptions of success and prestige can influence farmers' adoption of circular agriculture practices. In some societies, conventional agriculture methods may be associated with progress, modernity, and higher economic status. Alternative practices like regenerative farming techniques may be seen as a step backwards or a sign of lower status. This cultural bias can discourage farmers from embracing circular agriculture, which may be perceived as less prestigious or profitable (Helgason, Iversen & Julca, 2021).

Another social factor that can impede the adoption of circular agriculture is the lack of social networks and support systems. Farmers often rely on informal networks and peer interactions to share knowledge, experiences, and innovations. If these networks are primarily composed of farmers practising conventional agriculture, it can create social pressure to conform to the prevailing practices and resist change (Skaalsveen, Ingram & Urquhart, 2020). The absence of supportive communities or networks that promote circular agriculture can hinder farmers from accessing relevant information, resources, and support needed for successful adoption.

Cultural beliefs and attitudes towards risk can also affect adopting circular agriculture practices. Some farmers may perceive new practices as risky or uncertain, mainly if they involve changes in familiar routines or a departure from conventional methods (Dessart, Barreiro-Hurlé & Van Bavel, 2019). Farmers may be concerned about potential yield losses, financial risks, or market uncertainties associated with transitioning to circular agriculture. Overcoming this barrier requires providing farmers with evidence-based information, case studies, and demonstrations of successful implementation of circular agriculture practices to address their risk perceptions and build confidence in the new approaches.

Lack of Awareness and Knowledge

Lack of awareness and knowledge among farmers, policymakers and consumers is a significant barrier to adopting circular agricultural practices (Cao & Solangi, 2023; Gedam et al., 2021). The principles and benefits of circular agriculture are often unfamiliar to many stakeholders, impeding its widespread implementation. This limited awareness hampers the ability of

farmers to make informed decisions regarding sustainable farming practices and inhibits policymakers from enacting supportive policies. Insufficient education and outreach programs focused on regenerative practices and their potential impact exacerbate circular agriculture's lack of awareness (Grelet et al., 2021; Boon & Anuga, 2020). Farmers may not have access to comprehensive training and information regarding circular agriculture's practical implementation and benefits.

Similarly, policymakers may lack the necessary knowledge to develop effective policies that promote and incentivise adopting circular agriculture practices. Furthermore, consumers are pivotal in driving demand for sustainable agricultural products. However, their limited awareness and understanding of circular agriculture may prevent them from actively supporting and demanding such products (Borsellino, Schimmenti & El Bilali, 2020). Without a well-informed consumer base, there is reduced market motivation for farmers to transition to circular agriculture practices.

Financial Constraints

Transitioning to circular agriculture practices often requires significant financial investments in infrastructure, technology, and training. Piñeiro et al. (2020) highlight that this shift towards sustainable farming requires substantial financial commitments. However, small-scale farmers, in particular, face numerous challenges in accessing adequate capital or affordable credit, which poses a significant obstacle to affording the initial costs associated with implementing circular agriculture practices (Mgbenka, Mbah & Ezeano, 2016). The financial constraints experienced by small-scale farmers often

discourage them from switching to circular agriculture, even if they recognise its long-term benefits (Helming et al., 2023).

These farmers may understand the advantages of sustainable farming methods, such as improved soil health, reduced environmental impact, and increased resilience to climate change. However, without the necessary financial support, they may struggle to invest in the required equipment, including precision farming tools or renewable energy systems. The lack of access to funds hinders their ability to adopt circular agriculture practices effectively.

In addition, the perceived lack of immediate economic benefits from sustainable practices further discourages farmers from allocating funds towards the transition (Dessart, Barreiro-Hurlé & Van Bavel, 2019; Jambo et al., 2019). Farmers often prioritise short-term gains and may hesitate to invest in circular agriculture if they do not see immediate investment returns. This mindset can impede the adoption of sustainable practices and prolong reliance on conventional farming methods, which may have negative long-term consequences for both the environment and the farmers themselves

Market Shifts

Market demand and consumer preferences changes can create barriers to farmers' adoption of circular agricultural practices. The agricultural sector operates within the larger market context, and market shifts can significantly impact farmers' decisions to adopt circular agriculture practices. These shifts refer to changes in market demands, consumer preferences, and the availability of markets for sustainable and circular products.

One barrier related to market shifts is the limited market demand for sustainably produced goods. Despite growing awareness and interest in sustainable practices, the demand for circular agricultural products may not be widespread or well-established. This can be attributed to various factors, including consumer preferences, price sensitivity, and the availability of competing products (Kiss, Ruszkai & Takács-György, 2019; Muhie, 2022). If farmers perceive a lack of market opportunities or face challenges in accessing markets that value circular products, they may hesitate to invest in the necessary changes to their farming practices.

Another barrier arises from uncertainties and fluctuations in market conditions. Markets can be volatile, and farmers may be concerned about the stability and profitability of producing circular agricultural products. Fluctuating prices, uncertain consumer demand, and limited market access can create risks and financial uncertainties for farmers considering transitioning to circular practices (Borsellino, Schimmenti & El Bilali, 2020). Farmers may be reluctant to invest in the necessary infrastructure, training, and changes to their production systems without stable market conditions and fair prices for their products.

Furthermore, the lack of clear market signals and supportive policies can hinder the adoption of circular agricultural practices. Farmers need reliable information and signals from the market to make informed decisions about adopting new practices. Clear labelling, certification schemes, and robust market standards can help farmers identify market opportunities for circular products and differentiate their offerings (Boyer et al., 2021). Farmers

may find it challenging to justify the investment required for transitioning to circular agriculture without such signals and supportive policies.

Promoting and adopting circular agricultural practices require stakeholders' active involvement and collaboration. Stakeholders such as farmers, government, NGOs and Civil Societies, Private sector entities, research institutes and consumers all play a role in adopting circular agriculture.

Resistance to Change

Resistance to change is a significant barrier that hinders the adoption of circular agriculture practices. Farmers often develop deep-rooted attachments to traditional farming methods passed down through generations (Conway, McDonagh, Farrell & Kinsella, 2021). These practices are familiar and comfortable and have historically provided livelihoods. Therefore, deviating from these established methods can be met with scepticism and resistance. Implementing regenerative agriculture requires a shift in mindset and practices, which can evoke fear of the unknown among farmers (Gosnell, Gill & Voyer, 2019). They may worry about the potential risks and uncertainties associated with adopting new techniques, such as changes in crop yields, pest management, or overall farm productivity. A lack of concrete evidence or tangible examples of successful implementations of circular agriculture practices can exacerbate these concerns.

Additionally, farmers may hesitate to embrace circular agriculture due to concerns about potential disruptions in production. Transitioning to new practices requires adjustments in farming techniques, crop rotations, and soil management, which can pose temporary challenges and uncertainties. Farmers

may worry about potential income losses during the transition period or the potential for decreased market demand for sustainable products (Rauw et al., 2020; Ostapenko et al., 2020).

Policy and Regulatory Barriers

The lack of government support, incentives and policy can significantly hinder the adoption of circular agriculture practices. Existing regulations often favour conventional agricultural methods, creating a disincentive for farmers to transition to more sustainable alternatives (Abdulai et al., 2024). Outdated policies fail to recognise the potential benefits of circular agriculture and may not provide the necessary support for its implementation.

Lack of policy coherence is another challenge. In many countries like Rwanda and Norway, different policies and regulations governing agriculture and the environment may be inconsistent or contradictory, making it difficult for farmers to navigate the regulatory landscape (Vik, 2020; van Oosten, C., Uzamukunda, A., & Runhaarm 2018). This lack of coherence can create confusion and uncertainty, discouraging farmers from embracing circular agriculture practices. Complex administrative procedures also pose barriers to the widespread implementation of circular agriculture. Cumbersome paperwork, lengthy approval processes, and administrative burdens can overwhelm farmers already managing multiple responsibilities. These complexities can hinder the efficient adoption of circular agriculture practices and deter farmers from taking the necessary steps to transition.

Farmers

Farmers are critical stakeholders in promoting circular agricultural practices, as they are the primary food producers and play a critical role in managing natural resources. Farmers can embrace circular agricultural practices by adopting strategies such as minimizing external inputs, closing nutrient loops, regenerating soils, and reducing environmental impact (Helgason, Iversen & Julca, 2021). By utilizing by-products effectively, farmers can increase yields, sequester carbon, and produce abundant and diverse food on a one-acre farm while reducing inputs and increasing profits through the circular management of resources. Prioritizing the health of soils and leveraging appropriate technology play crucial roles in this approach. Furthermore, farmers can benefit from financial support, training, and educational programs offered by governments, non-governmental organizations (NGOs), and the private sector. These initiatives are designed to assist farmers in adopting circular agricultural practices and contribute to their successful implementation.

Non-Governmental Organisations (NGOs) and Civil Societies

NGOs and civil society organisations play a vital role in raising awareness about the importance of circular agriculture and advocating for sustainable farming practices (Isgren, 2018). These organisations actively engage with farmers and communities, providing them with training, capacity building, and extension services to promote adopting circular agricultural practices (Afrad, Wadud & Babu, 2019). NGOs empower farmers with the knowledge and skills to implement sustainable techniques by organising workshops, field demonstrations, and educational campaigns (Zikargae,

Woldearegay & Skjerdal, 2322). NGOs facilitate knowledge-sharing platforms, such as conferences, seminars, and online forums, where farmers can learn from experts and exchange experiences with their peers. These platforms create opportunities for collaboration and networking, allowing farmers to access valuable information, best practices, and innovative solutions for circular agriculture.

In addition to knowledge dissemination, NGOs also mobilise resources to support the transition to circular agriculture. They seek funding from various sources, including governments, philanthropic organisations, and private donors, to implement projects and initiatives focused on sustainable farming. These resources can be used to provide financial assistance, grants, or loans to farmers for investing in infrastructure, technology, and training required for circular agriculture practices. NGOs often collaborate with other stakeholders, including farmers, government agencies, research institutions, and private sector entities, to implement pilot projects demonstrating circular agriculture's feasibility and benefits (Mungate, 2023). These projects are practical examples, showcasing the positive environmental, social, and economic impacts of adopting circular practices. They also provide valuable data and evidence that can be used to influence policy discussions and shape supportive regulations.

Through their advocacy efforts, NGOs raise public awareness about the importance of sustainable farming practices and the benefits of circular agriculture (Chitiyo & Duram, 2019). They engage in public campaigns, media outreach, and lobbying activities to promote policy changes that support the transition towards circular agriculture. By amplifying the voices of farmers

and highlighting the environmental and social benefits of circular practices, NGOs contribute to creating an enabling environment for sustainable agriculture.

In summary, NGOs and civil society organisations play a multifaceted role in promoting circular agriculture. They provide training, capacity building, and extension services to farmers, facilitate knowledge-sharing platforms, mobilise resources, collaborate with stakeholders, implement pilot projects, and advocate for supportive policies. Their contributions are crucial in raising awareness, empowering farmers, and driving the transition towards a more sustainable and circular agricultural system.

Private Sector

The private sector entities, such as agribusinesses, food companies and agricultural input suppliers, play a crucial role in promoting circular agricultural practices by leveraging their resources, expertise, and innovation capabilities. The private sector can contribute to sustainable agriculture and circularity within the food system by developing and implementing innovative solutions, technologies, and business models (Zucchella, A., & Previtali, 2019). Investing in research and development is one way the private sector can drive the adoption of circular agricultural practices. By allocating resources to develop new products and services, companies can reduce waste, increase efficiency, and promote circularity in the agricultural sector. This can involve the creation of precision farming tools, advanced monitoring systems, and data analytics platforms that optimise resource allocation and minimise environmental impacts.

Government and Policy Makers

Government and policymakers are crucial in promoting circular agricultural practices through various means. They can create an enabling environment by implementing supportive policies and regulations (Carlisle et al., 2019). This includes establishing guidelines for soil management, water usage, waste management, and other aspects of sustainable farming. By setting standards and requirements, governments ensure farmers adopt practices that minimize environmental impact, conserve natural resources, and promote ecosystem health. Financial incentives and subsidies are another way government can encourage circular agriculture (Tian, Zheng, Sun & Zheng, 2022). They can support farmers who implement sustainable farming methods by providing grants, low-interest loans, or tax incentives. These financial benefits help offset the initial costs of transitioning to circular agriculture, making it more economically viable for farmers.

Furthermore, governments can contribute to advancing circular agriculture through research and development initiatives. By investing in scientific research, governments can facilitate the development of innovative technologies, practices, and knowledge that support sustainable farming (Adenle, Wedig & Azadi, 2019). They can fund research projects, establish research centres, and collaborate with academic institutions to generate evidence-based information that informs policy decisions and best practices. In addition to regulations and financial incentives, governments can create awareness and provide education and training programs on circular agriculture (Visser et al., 2019). By allocating resources to extension services, they ensure that farmers have access to technical support and guidance. This empowers

farmers with the knowledge and skills needed to adopt sustainable farming practices

Consumers and Buyers Associations

Consumers' and buyers' associations significantly impact promoting circular agricultural practices. Consumers can incentivise farmers and businesses to adopt sustainable practices through conscious choices and selecting products produced using circular methods (Abuabara, Paucar-Caceres & Burrowes-Cromwell, 2019). Consumer preferences shape market dynamics and signal to farmers the demand for environmentally friendly and socially responsible products. Buyers' associations play a crucial role in educating the public about the benefits of circular agriculture and advocating for sustainable food choices. They raise awareness through campaigns and disseminate information to empower consumers to support sustainable farming. The support and demand from consumers drive farmers and businesses to invest in infrastructure and practices that meet sustainability requirements.

Moreover, consumer demand incentivizes businesses to implement sustainable supply chains and support farmers in transitioning to circular practices (Benitez-Altuna et al., 2023; Konefal et al., 2022). Through sustainable products and supporting businesses that embrace circularity, consumers and buyers' associations create market demand that encourages adopting circular agricultural practices. Their actions contribute to developing a more sustainable and circular food system.

Theoretical/Conceptual Framework of the Study

Scholars and professionals have used different theories and frameworks in analysing smallholder farmers" circular agricultural practices and behaviour. These theories provide an understanding of the adoption, diffusion, and factors that influence circular agricultural practices among farmers. These theories include the Theory of Planned Behaviour (TPB), Innovation Diffusion Theory (IDT), Social Network Theory, and the Sustainable Agricultural Transition Theory (Quatman & Chelladurai, 2008; Abbasi et al., 2021; Jaroenwanit et al., 2023). The study uses the Social Network Theory. This theory was chosen because it assesses how information, knowledge, and innovations related to circular agriculture flow through farmers' social networks. The theory helps to identify critical actors and opinion leaders who play a crucial role in influencing adoption behaviours and promoting circular agriculture practices.

The Social Network Theory

The Social Network Theory is a sociological perspective that examines the relationships and interactions between individuals and groups within a social context (Liu et al., 2017). It explores how these relationships influence individual behaviours, practices, attitudes, and resource access. It emphasizes that social structure and connections are crucial in shaping individuals' actions and outcomes (Liu et al., 2017). Several key researchers have contributed to the development of the social network theory. However, the theoretical underpinnings of the theory have been around for a long time. For example, the network approach's conceptual roots stem from several structural ideas from well-known sociological thinkers such as Emile Durkheim, George

Simmel, and anthropologist Radcliffe-Brown (Quatman & Chelladurai, 2008). At its core, social network theory views social relationships as a set of nodes (individuals or groups) and the connections between them as links or ties. These ties focus on social factors, cultural and demographic factors, work relations, communication channels, and shared interests.

The fundamental concepts in the social network theory include Nodes, Ties, Density, Centrality, Clustering, and Structural Holes (Lin et al., 2021). Nodes represent individuals or groups within a social network (Bhagat et al., 2011). They can be people, organizations, communities, or any other unit of analysis. Ties represent the connections or relationships between nodes. These ties can be classified based on strength, frequency, or nature. For example, a tie can be a strong friendship, a weak acquaintance, a formal organizational link, or a communication channel. Density refers to the degree of interconnectedness within a social network (Himelboim, 2017). It measures the proportion of actual ties to the total number of possible ties. High density indicates a tightly connected network, while low density indicates a more fragmented or loosely connected network.

Centrality measures the importance or prominence of a node within a network. It identifies individuals or groups that have more connections or exert more influence over others. Centrality metrics include degree centrality (number of ties), betweenness centrality (position as a bridge between other nodes), and closeness centrality (degree of proximity to other nodes) (Bloch et al., 2023). Clustering refers to the tendency of nodes in a network to form groups or communities (Leskovec et al., 2009). It identifies subgroups of nodes that are more densely connected than nodes outside the group.

Clustering helps understand the formation of social cliques, communities, or specialized groups within a more extensive network. Lastly, Structural holes represent gaps or opportunities in a network with missing ties between nodes (Goyal & Vega-Redondo, 2007). Nodes that bridge these structural holes can access diverse information or resources and occupy advantageous positions in the network.

Social network theory has been applied to various fields, including sociology, anthropology, agriculture, psychology, organizational studies, communication, and marketing (Merchant, 2012). It provides insights into how social networks influence the spread of information, diffusion of innovations, practices, social support, social capital, collaboration, and overall social dynamics. Through analyzing the structure and dynamics of social networks, researchers can understand how individuals and groups interact and how social systems function.

The Application of the Social Network Theory

Applying social network theory in studying agriculture practices and sustainability offers valuable insight into knowledge dissemination, social influences, and collaboration within farming communities. Scholars have extensively applied the social network theory in their studies to understand the knowledge flow. Identify social factors and actors and identify barriers and facilitators of agricultural practices. For instance, Munasib and Jordan (2011) investigated the effects of social capital on the choice to use sustainable agriculture practices. They discovered that community involvement influences the decision and the extent to which farmers adopt sustainable agricultural practices. Abid, Ngaruiya, Scheffran, and Zulfiqar (2017) also assessed the

role of social networks in agriculture adaptation to climate change in Pakistan. They discovered that factors such as lack of information, finances, and resources are crucial barriers affecting farmers from adapting climate adaptation agricultural practices such as changing crop varieties and other measures.

In investigating the impact of environmental awareness, technology spillover, and social networks impact of green innovation in agriculture development, Hien and Chi (2023) discovered that environmental awareness and technology spillover impact green innovation. Moreover, the social network mediates in enhancing innovation toward green agricultural production. Skaalsveen, Ingram & Urquhart (2020) also studied the role of farmers' social networks in implementing no-till farming practices using the social network theory. They discovered that knowledge and interpersonal sources of information of farmers influence farmers in adopting no-till practices.

Albizua, Bennett, Larocque, Krause, and Pascual (2021) conducted a study on the influence of social networks on farming practices and agrarian sustainability. Their findings revealed that farmers who adopt modern technology are often aware of the negative social-ecological implications of their management practices. In contrast, traditional farmers tend to recognize the positive impacts of their practices on non-material benefits, such as traditions, traditional knowledge, and climate regulation. The researchers also observed that farmers' awareness of nature's contributions to people and their decision-making regarding land management play a role in shaping the social networks within the farming community. This implies that traditional farmers,

who are more aware of their environmental impacts, rely on information controlled by more intensive modern farmers. This dynamic potentially puts sustainable practices at risk in the Navarre region of Spain.

In a comparative analysis by Adolwa, Schwarze, Bellwood-Howard, Schareika, and Buerkert (2017) on "agricultural knowledge and innovation systems in Kenya and Ghana, the focus was on sustainable agricultural intensification in the rural-urban interface". The study revealed that farmers' adoption of integrated soil fertility management practices to improve soil fertility is limited due to a low level of knowledge and awareness of the principles of the system innovation in both countries. This lack of understanding was attributed to a communication gap between farmers and stakeholders, including agricultural actors in the agricultural knowledge and innovation systems.

These studies highlight the relevance and effectiveness of social network theories in understanding the dynamics of sustainable agriculture adoption. They demonstrate that social networks play a vital role in the diffusion of sustainable practices, providing avenues for information exchange, social learning, social support, and social influence. By considering the social networks within farming communities, policymakers and practitioners can design targeted interventions to leverage existing relationships, enhance knowledge transfer, and promote the widespread adoption of sustainable agriculture practices.

Criticisms of the Social Network Theory

While social network theory has proven to be a valuable framework for understanding social relationships and their effects, it is not without its

criticisms. These criticisms include overemphasizing structural aspects, simplifying social relations, and others. Critics of the Network Analysis approach have raised concerns about its "structural determinism" (Emirbayer & Goodwin, 1994). These critics argue that studies often focus solely on the structural effects on individuals, overlooking how individuals establish and disrupt ties to attain advantageous positions (Borgatti & Halgin, 2011). Another aspect of this criticism is the lack of a “theory of change” within network studies, particularly in exploring how social actors establish and disrupt ties over time. It is important to note that these two criticisms should not be conflated. A theory of change could focus on how individual actions (micro) contribute to network evolution (micro-macro link). However, individual predispositions for action may be influenced by their network position.

Another ideology critique of some contemporary ideas about networks suggests that social network theory ignores the power relations that shape social networks and how networks can be used to reinforce existing power structures (Joseph, 2010). This criticism argues that social network theory needs to pay more attention to how social networks can reinforce existing power structures and how power relations shape social networks. Power is fundamentally relational, according to social network theory (Kent, Sommerfeld & Saffer, 2016). People do not have power generally; they have power because they can rule over others. Because patterns of relations impact power, social systems can have different levels of power. However, some scholars argue that social network theory needs to pay more attention to how power relations are shaped by broader social structures and institutions

(Lounsbury, M., & Ventresca, 2002; Wiseman, Cuevas-Rodríguez & Gomez-Mejia, 2012; Kilduff, & Tsai, 2003)

Lastly, Social network theory often treats networks as independent entities and may not adequately consider the broader social, cultural, and economic contexts in which they are embedded (Erikson, 2013). Neglecting contextual factors can hinder understanding how larger social structures, institutions, and cultural norms influence network formation, behaviour, and outcomes.

Relevance of the Theory to the Study

The social network theory is highly relevant to studying smallholder farmers' circular agriculture practices and behaviours in the Yilo-Krobo Municipality, Ghana. The theory provides a valuable framework for understanding the interactions, relationships, and influence within a social system, including smallholder farmers and other stakeholders (Hermans et al., 2017). Adopting the theory helps to gain insights into the network structure, identify influential actors, understand the factors influencing adoption, identify barriers, and analyse the role of stakeholders in promoting circular agriculture practices. Such understanding is crucial for developing effective interventions and policies to enhance the adoption and diffusion of circular agriculture practices among smallholder farmers in the Yilo-Krobo Municipality, Ghana.

Conceptual Framework

The social network theory provides valuable insights into the variables of the conceptual model and helps achieve the study's objectives. The conceptual model consists of four primary variables: circular agricultural practices, socio-demographic characteristics, barriers and stakeholders. These

variables are interconnected in a circular form, indicating that they influence and are influenced by each other. The knowledge and awareness of circular agriculture are positioned in the middle, acting as a moderating variable that affects all four variables.

The Circular Agriculture Practices variable represents the specific agricultural practices employed by smallholder farmers that align with the principles of circular agriculture. It includes organic farming, crop rotation, agroforestry, water conservation, and waste recycling. The socio-demographic variable encompasses the individual characteristics of smallholder farmers, including age, gender, education, farming experience, and social networks. Socio-demographic characteristics can influence the adoption and implementation of circular agriculture practices. For example, farmers with higher levels of education may be more aware of circular agriculture concepts and more likely to engage in such practices (Marthinson & Ramsö, 2021). The social network theory assists in understanding how the socio-demographic characteristics of smallholder farmers, such as age, education, and farming experience, shape their connections and interactions within the social network. Additionally, social networks and interactions among farmers can play a role in disseminating knowledge and promoting circular agriculture practices.

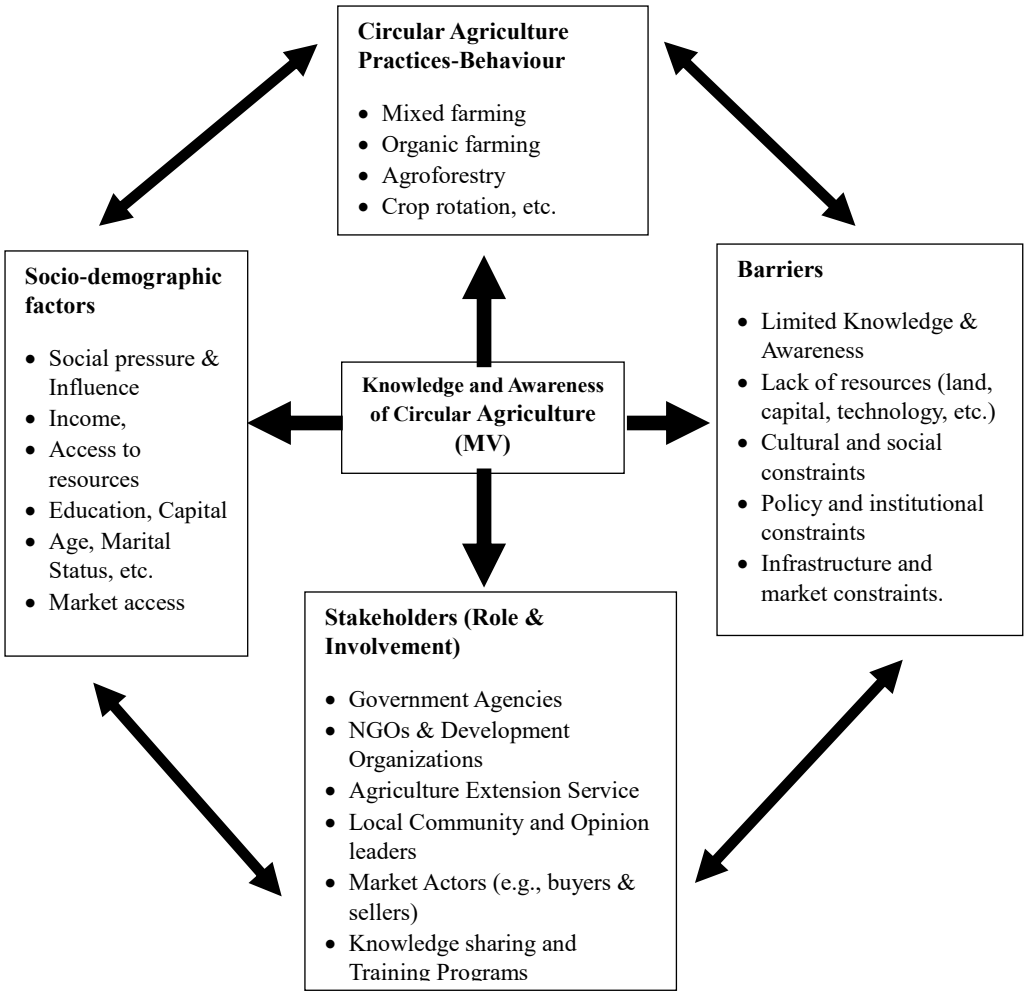

Figure 1: Conceptual Framework of the Study

Sources: Quatman and Chelladurai, 2008; Adolwa et al., 2017; Munasib and Jordan, 2011

Barriers refer to smallholder farmers' challenges and obstacles in adopting circular agriculture practices. These barriers can be external and internal, such as limited access to resources, lack of technical knowledge, financial constraints, market limitations, or cultural beliefs (Campuzano et al., 2023). Barriers can affect the adoption of circular agriculture practices and influence the knowledge and awareness of farmers (de Lauwere et al., 2022). The theory of social networks provides insights into how social relationships and network structures impact the barriers faced by smallholder farmers in adopting circular agriculture practices. It can identify whether specific

network configurations hinder the spread of information, collaboration, or the acceptance of new practices. By mapping the social network, the study can identify influential individuals or organizations that can help overcome barriers by providing support, resources, or knowledge dissemination.

Stakeholders include individuals, organizations, and institutions that have an interest or influence in adopting and promoting circular agriculture practices. They can include government agencies, NGOs, agricultural extension services, researchers, and local community organizations. Stakeholders play a vital role in providing support, knowledge, resources, and policy frameworks to facilitate the adoption of circular agriculture practices among smallholder farmers (Nkansah-Dwamena, 2024). The social network theory helps analyse stakeholders' roles and relationships in promoting circular agriculture practices. It can identify the stakeholders involved in the social network of smallholder farmers and examine their connections, collaborations, and information exchange patterns.

By incorporating the social network theory, the study gains a comprehensive understanding of the relationships, interactions, and influences within the social network of smallholder farmers in Yilo-Krobo Municipality. It also explores how knowledge and awareness of circular agriculture, as a moderating variable, affect the adoption of circular agriculture practices, the barriers faced, and the roles of stakeholders. This approach allows for a more nuanced analysis of the social dynamics surrounding circular agriculture practices and can inform strategies for promoting and improving circular agriculture behaviours among smallholder farmers in the specific context of Yilo-Krobo Municipality, Ghana.

In summary, the conceptual model depicts the interconnectedness of circular agriculture practices, socio-demographic characteristics, barriers, and stakeholders, with knowledge and awareness of circular agriculture acting as a moderating variable. The social network theory provides a lens through which to analyse the social interactions and relationships among smallholder farmers, exploring their influence on the adoption, dissemination, and promotion of circular agriculture practices.

Chapter Summary

This chapter has provided a comprehensive overview of circular agricultural practices among smallholder farmers, highlighting their significance and the need for their adoption to ensure sustainability in agriculture. The literature review defined the concept of circular agriculture and discussed its economic, environmental, and social implications, emphasizing its potential benefits for farmers and the broader society. Theoretical frameworks, such as the social network theory, were explored to understand the social dynamics and influences that play a role in farmers adopting circular agriculture practices. This analysis shed light on the importance of social interactions, relationships, and support systems in facilitating farmers' adoption of circular practices and behaviours.

The empirical review delved into farmers' actual implementation of circular agriculture practices, examining the factors influencing their adoption and the barriers they face. By identifying these factors and barriers, this review provides valuable insights that can inform the development of strategies to improve the adoption of circular agriculture practices among farmers. Furthermore, the review acknowledged the issue's complexity, involving

multiple stakeholders and challenges. It highlighted the importance of considering the role of various stakeholders, such as policymakers, researchers, agricultural extension services, and local communities, in promoting and supporting circular agricultural practices. Collaboration and coordination among these stakeholders are crucial for creating an enabling environment and effectively addressing the barriers to adoption.

In summary, this literature review reinforces the urgent need for farmers to adopt circular agriculture practices to achieve sustainability in agriculture. This review provides a foundation for future research and policy development in circular agriculture by synthesising existing knowledge and identifying gaps in understanding. By addressing the barriers and challenges and leveraging the insights gained from this review, stakeholders can work together to promote and improve the adoption of circular agriculture practices among smallholder farmers, leading to a more sustainable and resilient agricultural system.

CHAPTER THREE

RESEARCH METHODOLOGY

Introduction

This chapter presents the research methodology used in the study. It contains the research philosophy and design, study area, target population, and other aspects of the methodology, such as data analysis and ethical considerations.

Study Area

The Yilo-Krobo Municipal Assembly is part of Ghana's Metropolitan, Municipal, and District Assemblies in the Eastern Region. It shares borders with Lower and Upper Manya Krobo Districts to the North and East, respectively, while Dangme West and Akwapim North Districts are located to the South. The Municipality also shares boundaries with New Juaben and East Akim in the southwest and Fanteakwa District in the west. The Municipality covers an estimated area of approximately 805 square kilometres, accounting for 4.2% of the total area of the Eastern Region. The capital of the Municipality is Somanya.

The Yilo-Krobo District falls within the dry equatorial climatic zone and experiences significant rainfall. It has a bi-modal rainy season, with peak periods occurring in May-June and September-October. The annual rainfall ranges from 750mm in the Lower Yilo to 1600mm on the slopes of the ranges in the Upper Yilo. The district's temperature varies between a minimum of 24.9°C and a maximum of 29.9°C, with a relative humidity of 60-93%. The vegetation in the district consists of a semi-deciduous rainforest and savanna grassland. The rainforest covers a more significant portion of the district,

approximately 85% of the estimated area in Upper Yilo, while the savanna grassland occupies around 15% of the estimated area in Lower Yilo. The district is predominantly mountainous, with the Akwapim Range running from southwest to northeast, contributing to an undulating landscape. The lowlands are located in the south-eastern part of the district, known as Lower Yilo.

The rocks in the district belong to the Togo series, including quartzites, phyllites, sandstones, and sandy shades. The highlands in the district range between 300 and 500 meters above sea level on average, with a scarp rising to 600 meters forming the New Juaben District boundary. The district has two main watersheds and three river basins. One watershed is the Akwapim Range, where streams flow eastward on the lowlands of Lower Yilo into the Volta River, while streams on the west of the range flow into the Ponpong River, which eventually empties into the Volta Lake. The district's predominant soil types fall into three major groups: soils developed over sandstone, soils developed over Buem, and soils developed over Togo rocks.

As of the 2021 population and housing census, the population of the Yilo-Krobo Municipality is 122,705, with 59,656 males and 63,049 females. The primary economic activities in the Municipality are agriculture, services, trading, and small-scale industrial activities. Agricultural activities, mainly on staple food production such as maize, cassava, plantain, and cocoyam, engage 58% of the working population. The dominant language spoken in the Municipality is Dangme.

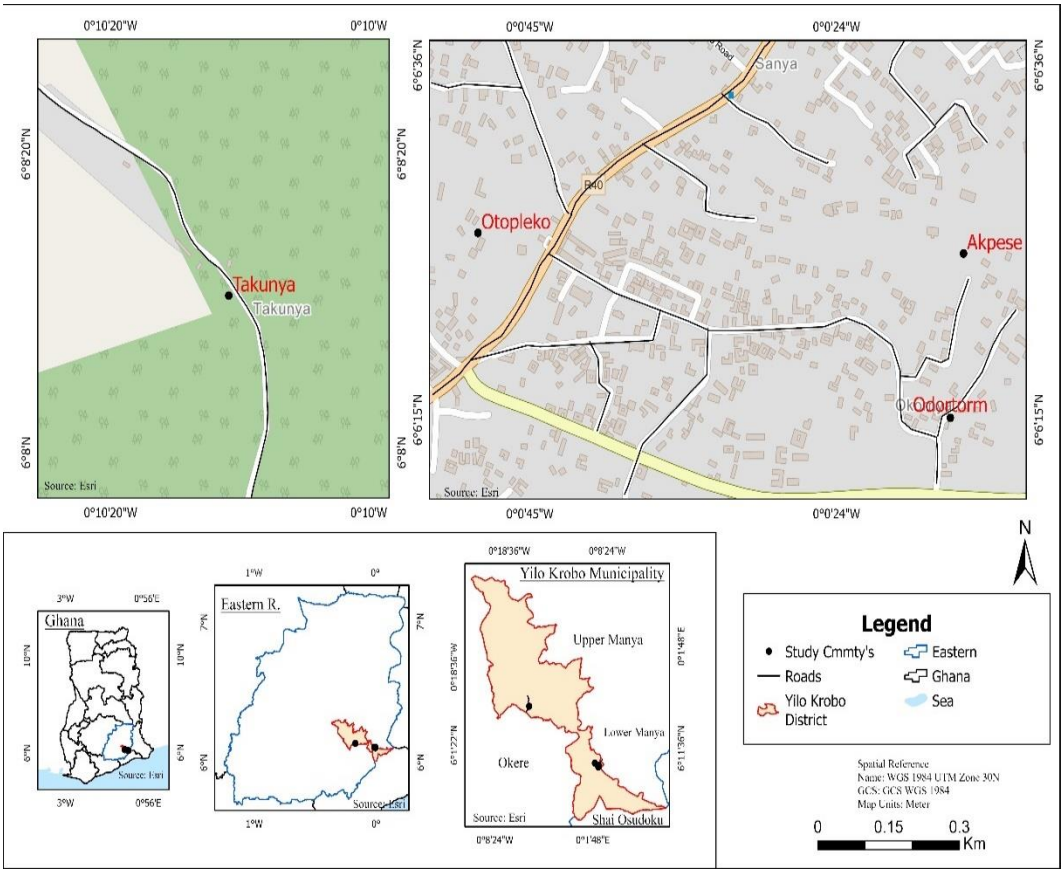

Figure 2: Study Area Map

Source: Authors Construct (2023)

The study communities selected within the Yilo-Krobo Municipality (Takunya, Oterkpolu, Akpese, and Odortorm) were chosen due to the concentration of agricultural activities in those areas. According to the GSS housing and population census of 2010, 57.3% of households in the district are involved in agriculture. In rural areas, seven out of ten households (72.2%) are engaged in agriculture; in urban areas, 29.7% are involved in agricultural activities. Crop farming is the primary agricultural occupation, with 93.9% of households engaged in it. Poultry (chicken) rearing is the dominant form of animal husbandry in the Municipality.

Research Philosophy

The Pragmatism philosophy guides the study. Pragmatists understand that different perspectives exist to interpret the world and conduct research (Moon, K., & Blackman, 2014). Pragmatism is a research philosophy emphasising practicality and problem-solving (Kelly & Cordeiro, 2020). It focuses on the practical implications of research findings and aims to provide actionable recommendations to address real-world problems. Pragmatism is suitable in this study context because it aligns to understand and address real-world issues smallholder farmers face. The study also analyses stakeholders' role in promoting circular agriculture practices, which can inform practical strategies and recommendations for improving adoption rates. The pragmatism research philosophy is appropriate for this study as it emphasises practical implications and can provide valuable insights for addressing the challenges and promoting circular agriculture practices among smallholder farmers in the Yilo-Krobo Municipality of Ghana.

Research Design

The descriptive research design was used in the study. The descriptive research design involves analysing and describing a particular phenomenon to generate insights, understanding and information on the current state of the phenomenon (Rahi, 2017). The descriptive research design was chosen because it allows for a comprehensive exploration and documentation of smallholder farmers' circular agriculture practices and behaviours in the Yilo-Krobo Municipality in their natural setting. This is because the descriptive research design helps to describe the current state of circular agriculture practices and behaviours among smallholder farmers. By observing and

documenting smallholder farmers' circular agriculture practices and behaviours, this study provides insights into the unique challenges, opportunities, and cultural factors that influence these practices. This understanding can inform the development of targeted interventions or policies to promote sustainable agriculture practices.

Research Approach

A mixed-method approach was used in the study. This approach combines qualitative and quantitative methods to provide a comprehensive understanding of smallholder farmers' circular agricultural practices and behaviours and the factors influencing the adoption of circular agriculture practices (Malina, Nørreklit, & Selto, 2011). It allows for a deeper exploration of the social, economic, and political aspects of circular agriculture, in addition to assessing the current state of adoption and identifying potential strategies for promotion.

The qualitative component of the study collected information using an interview guide (Halcomb & Hickman, 2015). The quantitative component of the study used questionnaires to collect data on the circular agriculture practices among smallholder farmers in the Yilo-Krobo Municipality (Schensul & LeCompte, 2012). These tools helped identify the extent to which circular agriculture practices are being adopted, the benefits and challenges of adopting these practices, and the role of stakeholders that influence adopting these practices in the Yilo-Krobo Municipality of Ghana.

Target Population

The target population for the study are smallholder farmers in the Takunya, Oterkpolu (Otopleko), Akpese, and Odortorm communities in the

Yilo-Krobo Municipality. Moreover, the target population includes key informants such as Community and Opinion leaders, Agricultural Officers, and Extension Officers in the Yilo-Krobo Municipality.

House

Housing is defined as all the elements that go into creating a home that satisfies all the requirements for being a suitable and acceptable place to live. It consists of the actual housing, the neighborhood's and the house's services and infrastructure, and the input markets for labor, materials, land, and money needed to produce and sustain it. The idea of housing, in its simplest form, refers to the solutions intended to enhance both the environment and the place of residence. Dwellings typically lack consideration for the environment and services required to sustain its occupants when housing is limited to shelter or living space alone (GoG/MLGRD 2012).

Household

A household was defined as an individual or a collection of individuals who shared the same housekeeping arrangements and resided in the same home or complex (Klocker et al., 2012). A household typically consisted of a man, his wife, his kids, and any additional family members or housekeepers who might be residing with them. It's crucial to keep in mind, though, that household members aren't always connected either through blood or marriage as housekeepers and other non-family members can also be a part of a home.

Household Head

A male or female household member who is acknowledged as such by the other members of the home is considered the head of the household. Typically, the individual with the most financial and social responsibilities for

the household is the head of the household. Every relationship is described in terms of the head (Lambrecht, 2016).

Compound house

According to Afram (2009), a compound house is referred to as "Ghana's traditional house." Typically, it consists of small rooms with shared restrooms, kitchens, and an open courtyard that accommodates multiple homes (ISSER 2013). Low-income groups are big fans of this kind of housing since it's reasonably priced and makes it possible to share amenities with other individuals and organizations for a much lower price.

Sample and Sampling Technique

Sample Size and sampling technique for Smallholder Farmers

Based on the GSS (2010) census report, the total number of household heads in Yilo-Krobo Municipality was 3785. The total household heads population was input in the Yamane Sample size formula to estimate the sample.

The Yamane sample size calculation formula (Yamane, 1967);

$$n = \frac{N}{(1 + Ne^2)}$$

Where:

n = number of samples

N = Total population of household heads in the Yilo-Krobo

Municipality = 3785

e= Confidence interval = 0.05

$$n = \frac{3785}{\left(1 + 3785(0.05^2)\right)}$$

$$n = 362$$

The sample of respondents for the survey is 362. Therefore 362 respondents were to be selected for the study. However, 358 respondents were interviewed for the study based on the participants availability at the study locations.

Therefore, to determine the sample size of the four communities, the proportion of the total sample was taken based on the total number of houses in the four communities, presented in Table 1. Therefore, the sample size for the smallholder farmers selected and interviewed in Oterkpolu was 129, Akpese was 71, Odortorm was 79, and Takunya was 79.

Table 1: Sample of Study Communities

Study Communities	Houses	Percentage	Samplesize(HH)
Oterkpolu	167	31.9	114
Akpese	137	26.1	94
Odortorm	115	21.9	78
Takunya	105	20.1	72
Total	**524**	**100**	**358**

Sampling Technique for the Selecting of Smallholder Farmers (Household Heads)

First, a simple random sampling technique was used in selecting the total sample of smallholder farmers from the communities. Simple random sampling involves randomly selecting a subset of participants from a population, with each member having an equal chance of being selected (Sharma, 2017). According to GSS (2010), the total number of houses in Oterkpolu, Akpese, Odortorm and Takunya was 167, 137, 115 and 105, respectively. The total list of all the 524 houses in the four communities was

used to select the samples from the respective communities based on the number of houses in each community. Each house was assigned a unique number based on the house number in the four communities. Then, the simple random thus the lottery method was used to select the 358 houses from the four communities.

From these houses, one household head who is a smallholder farmer above the age of 18 was purposively selected based on their experience (10years) and who is into crop farming, availability to represent the entire house and all the households in the house. In total 358 household heads were selected from the 524 houses to represent the sample for the interviews.

Sample size and sampling technique for Key-Informants

The purposive Sampling technique was used in selecting the key informants. Purposive sampling is a non-probability sampling technique in which units are selected based on their characteristics or relation to the research issues (Vehovar et al.,2016). The respondents were selected based on the following criteria.

a. Knowledge and Experience in Agriculture practices
b. Position in the communities
c. Willingness to partake in the study

Nine (9) respondents were selected as key informants for the study. The identification of the key informants was.

a. One Assemblyman each from Oterkpolu, Akpese, Odortorm and Takunya.
b. The Municipal Director for the Ministry of Food and Agriculture for the Yilo-Krobo Municipality

c. Four Agric Extension Officers (one from each of the four communities)

Data Sources

Primary and Secondary sources of data were used in the study. The primary data was collected using an interview guide and questionnaire. The secondary data was from published works, reports, and other documents.

Data Collection Instrument

A questionnaire and interview guide were used in the study. These instruments were chosen because they are the most appropriate for collecting data for the study in consonance with the research approach, philosophy and design. The questionnaire was structured into several sections to capture different aspects of smallholder farmers' circular practices and behaviour in the Yilo-Krobo Municipality. The questionnaire contains both closed and open-ended questions. The questionnaire is in 5 sections. Section 1 collects information about the demographic profile of smallholder farmers.

Section 2 focuses on the specific circular agriculture practices adopted by smallholder farmers. Section 3 explores the factors that influence the adoption of circular agriculture practices. Section 4 addresses the barriers smallholder farmers face in adopting circular agriculture practices. Moreover, section 5 examines the role of various stakeholders in promoting circular agriculture practices. The questionnaire collected quantitative data from smallholder farmers during the study.

The interview guide collected qualitative information from key informants about their perspectives, experiences and insights regarding adopting circular agriculture practices. The information gathered using the

interview guide focuses on the current adoption of circular agriculture practices, influencing factors, barriers and the role of stakeholders.

Recruitment and Training of Field Assistants

Four field assistants were recruited from the University of Cape Coast, Department of Geography and Regional Planning, to assist with the data collection. They were selected based on their ability to speak and translate "Krobo" into English. A two-day intensive training program was organised for the field assistants to ensure they were well informed about the data collection procedures, including conducting interviews and collecting data.

Pretesting of Instrument

The interview guide and questionnaires were pretested in Obenyemi-Guata and Azza farming communities in Yilo-Krobo Municipality to ensure the validity and effectiveness of the instruments before conducting the study in the selected study Areas. The pretesting helped gather valuable insights and make necessary adjustments, ensuring that the instruments effectively captured the required data before the data collection.

Data Collection Procedure

The instruments (questionnaire and interview guides) collected data concerning circular agriculture practices from smallholder farmers and stakeholders in the Yilo-Krobo Municipality. Several approaches were employed to gain access to the participants. These included obtaining permission from the respondents, community leaders and municipal officials, explaining the purpose and significance of the study, and assuring them of confidentiality and anonymity. Also, building rapport and trust with the respondents was essential for securing access and cooperation.

Furthermore, the interviews were conducted with key informants involved in circular agriculture practices. The interview guide provided a structure for the interviews while allowing flexibility for open-ended discussions. The interviews took place in a mutually convenient location. The interviews lasted between 30-40 minutes. All ethical issues that protected the respondents were applied.

Moreover, regarding the quantitative data, the questionnaire was used to gather data from the smallholder farmers in Oterkpolu, Akpese, Odortorm and Takunya. Simple random sampling was used to select respondents using community household enumerations. The questionnaire offers more information about the circular agriculture practices and behaviours of smallholder farmers in the Municipality. The survey lasted between 30 to 45 minutes. Data was collected with the help of field assistance to ensure quick data collection and to overcome the language barriers. All ethical issues that protected the respondents were applied.

While collecting data, comprehensive and detailed field notes were meticulously recorded to capture significant observations, interview answers, non-verbal signals, and contextual details. These field notes played a crucial role in the subsequent analysis and interpretation of the data. Moreover, supplementary materials, including photographs or videos (obtained with appropriate consent), were gathered to provide additional documentation and contextual information that supported the finding.

Data Processing and Analysis

The data gathered from the questionnaires were analysed using descriptive and inferential statistics to assess the smallholder farmers' circular

agriculture practices and behaviours. The analysis was presented in tables and charts. The IBM SPSS (SPSS (Statistical Package for the Social Sciences)) version 26 was used for the analysis.

Qualitative data from interviews were transcribed, coded, and analysed using thematic analysis to identify key themes. First, the interview recordings and observational notes were transcribed into written text. This ensured that the data was easily accessible for analysis and allowed for a thorough examination of participants' responses. Afterwards, the coding process categorised and labelled segments of data based on their content, meaning or relevance to the research objectives. It helped organise and structure the data to identify patterns, themes, and connections. Lastly, thematic analysis was employed to extract critical themes related to the study's objectives. The coded segments were systematically reviewed, identifying recurring patterns and grouping them into meaningful themes that captured the essence of the data. The Maxqda software, a popular qualitative data analysis software, was used.

The Descriptive and inferential statistics are particularly suited for examining the distribution and relationships within questionnaire responses, enabling clear identification of trends and statistically significant differences in smallholder farmers' circular agriculture practices (Clark et al., 2021). Presenting these findings in tables and charts further enhances interpretability. Meanwhile, thematic analysis is valued for its flexibility and systematic approach, allowing the researcher to delve deeply into interview data and uncover nuanced themes that reflect participants' lived experiences and perspectives (Braun & Clarke, 2006). By employing this combination of quantitative and qualitative techniques, a more comprehensive understanding

of both the scope and depth of farmers' behaviours is achieved, thereby strengthening the overall rigour of the study (Creswell, 2014).

Statistical Analysis

The study employed various statistical analysis. These statistical tests help to make meaning out of the analysis that was made on the data that was collected. Notable among them are the Likert scale, Cronbach alpha, Kendall Coefficient of Concordance, Mean, Median, Mode, Frequencies and Percentages.

Likert Scale

A Likert scale is a commonly used psychological measurement tool that assess people's attitudes, opinions, beliefs, and other subjective feelings or perceptions. Named after its creator, psychologist Rensis Likert, this scale typically consists of a series of statements or questions related to a specific topic, issue, or concept (Banerjee et al., 1999a; Donner et al., 2000). Respondents are asked to indicate their level of agreement or disagreement with each statement by selecting a response from a predetermined set of options, usually ranging from "Strongly Disagree" to "Strongly Agree." The Likert scale is designed to quantify subjective data, making it easier to analyse and interpret. It provides a numeric value for each response option, which can be used for statistical analysis, making it a valuable tool in various fields, including psychology, sociology, market research, and social sciences (Lee & Oh, 2018; Olawumi, 2018).

The Likert Scale options were assigned the following numbers: Strongly Disagree =1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree =5.

Survey designers can customize Likert scales to suit their specific research needs by adjusting the number of response options, the wording of statements, and the direction of the scale (e.g., from "Positive" to "Negative" or vice versa). Once the responses are collected, researchers can calculate measures like the mean (average) or median to summarize the data and gain insights into the attitudes or opinions of the respondents (Kraemer et al., 2002; Livadiotis, 2015). Analysing Likert scale data can help researchers understand trends, differences between groups, and the overall sentiment towards a particular topic or concept.

Cronbach Alpha

Cronbach's alpha is a measure used to assess the reliability or consistency of a set of items in a questionnaire or scale. It is named after its developer, Lee Cronbach. Cronbach's alpha is a coefficient that ranges between 0 and 1, with higher values indicating greater internal consistency. It is based on the average inter-item correlation among the items in the scale (Alavi et al., 2020; Millstein & Levinson, 2018). The formula for calculating Cronbach's alpha is:

$$\alpha = \frac{k}{k-1} \times \left(1 - \frac{\sum \sigma_i^2}{\sigma_t^2}\right)$$

Where:

- α is Cronbach's alpha coefficient
- k is the number of items in the scale
- σ_i^2 is the variance of the i^{th} item
- σ_t^2 is the variance of the total score of all items

Cronbach's alpha can be interpreted as follows:

- Values closer to 1 indicate high internal consistency, suggesting that the items in the scale are measuring the same underlying construct.
- Values closer to 0 indicate low internal consistency, implying that the items in the scale are not correlated with each other and may be measuring different constructs.

Researchers commonly use a threshold of 0.7 or higher as an acceptable level of internal consistency for most purposes (Barceló, 2018; Green et al., 2009). However, the appropriate threshold may vary depending on the context and the field of study. Cronbach's alpha is widely used in social sciences, psychology, education, and other fields to evaluate the reliability of questionnaires, scales, or tests. It helps researchers determine whether the items in a measure are consistent and reliable in measuring a specific construct. One of the advantages of Cronbach's alpha is that it provides a single numerical value that represents the internal consistency of a scale. This makes it a convenient and straightforward measure to use when assessing reliability. Additionally, it allows researchers to compare the internal consistency of different scales or versions of a scale.

Some limitations of Cronbach's alpha could be; it is sensitive to the number of items in the scale, and shorter scales tend to have lower alpha values. Additionally, Cronbach's alpha can be influenced by the homogeneity or heterogeneity of the items in the scale, as well as the sample size. Therefore, it is recommended to interpret Cronbach's alpha in conjunction with other reliability analyses and consider the context and purpose of the measurement.

To conclude, cronbach's alpha is a valuable tool for assessing the internal consistency reliability of scales and questionnaires. It provides a numerical value that indicates how well the items in a measure are correlated with each other (Bonett et al., 2014; Trizano-Hermosilla & Alvarado, 2016). However, it is important to consider its assumptions, limitations, and interpret the results in the specific context of the research study.

Kendall's Coefficient of Concordance

Kendall's Coefficient of Concordance, often denoted as W, is a measure of agreement among multiple observers or raters on the ranking of a set of items. It quantifies the degree of similarity or concordance between the rankings provided by different observers (Gearhart et al., 2013; Ordóñez et al., 2020). The formula for Kendall's Coefficient of Concordance is as follows:

$$W = \frac{12 \cdot \sum_{j=1}^{k} R_{\cdot j}^2 - 3 \cdot n \cdot (k+1)^2}{n \cdot k \cdot (k^2 - 1)}$$

where:

- W is Kendall's Coefficient of Concordance.
- k is the number of observers or raters.
- n is the number of items being ranked.
- $R_{\cdot j}$ is the sum of ranks assigned by the j-th observer.

The formula calculates the ratio of the observed agreement among the raters (the sum of squared ranks) to the maximum possible agreement (which depends on the number of items and raters). Kendall's Coefficient of Concordance is only applicable when dealing with ranked data, and it is commonly used in fields such as psychology, sociology, and market research to assess inter-rater agreement (Gearhart et al., 2013). Kendall's W is sensitive to tied ranks. If there are many tied ranks in the data, it can affect the accuracy

of the coefficient. Like many statistical methods, Kendall's W assumes independence of observations. If there is dependence among the observations (e.g., if the rankings are influenced by a common factor), the validity of the results may be compromised (Lee & Oh, 2018). Assumptions of continuity and limited ranked data are all problems of Kendall's Coefficient of concordance (Baumgartner et al., 1999; Betensky et al., 1999).

Tobit Regression

Tobit regression model was used to analysis the factors influencing adoption of circular agriculture practices.

Tobit regression, also known as a censored regression model, is a statistical technique used to estimate relationships between variables when the dependent variable is censored (Pertiwi. et al., 2016). This means that the observed values of the dependent variable are limited to a certain range. In this particular instance, the highest score of the dependent variable is one (1) and the lowest is zero (0). A set of 20 questions were used to elicit information from the farmers or respondents on circle agriculture practices. The questions were based on five-point Likert estimation, with the highest score per question being five (5) and lowest zero (0). Thus, the total score for the twenty (20) questions is 10 and the lowest zero. The total score was transformed in to an index, that is 100/100 = 1 and the lowest as zero for the dependent variable. Hence, the stochastic model of adoption within Tobit modelling framework was specified as follows:

$$Y_t^* = \beta X_t + u_t \qquad (t = 1, 2....., N) \qquad \textbf{(1)}$$

Where Y_t represent the latent unobserved component of the adoption of circular agriculture practices, β is a $(k \times 1)$ vector of unknown parameters, N is the number of observations which represent individual farmers who participated in the enumeration, X_t is a vector of the type $(k \times 1)$ denoting independent variable (Baffoe-Asare et al., 2013) which capture factors that influence the adoption of circular agriculture practices and μ_i is independent nominal destruction error term with mean zero and constant variance. The conditional terms or probability of adoption are described as follows (Baffoe-Asare et al., 2013; Gould et al.,1989):

$$Y_t = \begin{cases} 0 & if \quad Y^* \quad \leq 0 \\ Y^* & if \quad 0 \quad 0 < Y^* < 1 \\ 1 & if \quad Y^* \quad \geq 1 \end{cases} \qquad (t = 1.....N) \quad \textbf{(2)}$$

Adoption occurs when Y_t falls within $0 < Y^* < 1$ and $Y^* \leq 0$, nom-adoption occurs when $Y^* \leq 0$

The highest value or the upper limit of Y_t is 1 and the lower limit is 0. The final empirical model of multivariate Tobit regression analysis of factors affecting the adoption of circular agriculture practices is specified as:

$$Y_t = \beta_0 + \beta_1 X_1 + \beta_2 X_2 .....\beta_n X_n \qquad \textbf{(3)}$$

Where X(s) are independent socioeconomic variables affecting CAP and β(s) denote parameter estimates.

$$Adoption = \beta_0 + B_1 Gender + \beta_2 Age + \beta_3 Education + \beta_4 MaritalStatus + \beta_5 HouseholdSize + \beta_6 Age\_18 + \beta_7 Tenure + \beta_8 Experience + \beta_9 LandAccess + \beta_{10} LandHolding + \beta_{11} AreaCultivated + \beta_{12} AccesstoInput + \beta_{13} ExtensionServices + \beta_{14} FarmTypes + \beta_{15} NumberofCrops + \beta_{16} ActualAnnualIncome + \varepsilon$$

Mean

The mean, often referred to as the average, is a fundamental concept in statistics and mathematics. It is a measure of central tendency used to describe the "typical" value or the arithmetic centre of a set of numerical data points (Bickel et al., 2015). To calculate the mean, you sum up all the data points and then divide that sum by the total number of data points. The formula for the mean is:

Mean = (Sum of all data points) / (Total number of data points)

The mean is a useful summary statistic because it provides a single value that represents the centre of the data. However, it's important to note that the mean can be influenced by extreme values, known as outliers (Osborne et al., 2019). In cases where there are outliers, or the data is not normally distributed, other measures of central tendency like the median or mode may be more appropriate.

Chi Square

The chi-square (χ^2) test is a statistical test used to determine whether there is a significant association or independence between two categorical variables in a contingency table. It is a non-parametric test, which means it doesn't make any assumptions about the distribution of the data. The chi-

squared test is widely used in various fields, including statistics, biology, social sciences, and market research (Nasution et al., 2024)

Ethical Consideration

Ethical clearance (UCCIRB/CHLS/2023/114) was sought from the Institutional Review Board of the University of Cape Coast and Department of Geography and Regional Planning. This section pertains to the ethical standards that researchers must adhere to throughout all stages of the research process. Once the clearance was obtained, the research was conducted with strict adherence to ethical considerations, including the right to participation, informed consent, confidentiality, data privacy, and anonymity.

Participants' consent was obtained before their involvement in the study. Participants were informed that their participation was voluntary and free to decline participation at any time without obligation. Their consent was documented through their signature or thumbprint on the consent form. Participants were also encouraged to ask questions about the study, and the investigator and research assistants responded satisfactorily.

Participants were assigned unique serial numbers to safeguard their identities to ensure anonymity and confidentiality. This measure ensured that any information provided by participants on circular agriculture practices could not be linked back to them, and unauthorized access to the data was prevented. Participants were assured that their data would be stored securely in a personal password-protected drive by the researcher and that it would not be used for any purposes other than the study itself, protecting their privacy.

By adhering to these ethical considerations, the study upheld the principles of research ethics, safeguarding the rights and well-being of the

participants. These ethical practices ensure the integrity and validity of the research findings and maintain trust between the researcher and the participants.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

The chapter presents the results and discusses the data collected for the study. The study comprised 358 smallholder farmers and nine key informants who were selected and interviewed based on their practice, knowledge, and experiences in agricultural practices in the Yilo-Krobo Municipality. This chapter analyzed and presented the data and findings collected from these respondents through surveys and interviews. The chapter is grouped into five subsections: the socio-demographic characteristics of the respondents and four sections that address the study's objectives.

Socio-Demographic Characteristics of the Smallholder Farmers

This section provides information on the results and discussion on the socio-demographic factors of the smallholder farmers who practice circular agriculture in Yilo-Krobo Municipality. These factors are essential as they help to understand the smallholder farmers and enable them to conceptualize findings within broader societal trends and disparities. Three hundred fifty-eight smallholder farmers in Yilo-Krobo Municipality were surveyed for the study, and their socio-demographic characteristics are presented in this section. It includes their age, income, education level, and other factors. Table 2 presents the findings on the gender distribution of the smallholder farmers engaged in circular agricultural practices in the Yilo-Krobo Municipality. The data reveals that most farmers (80.7%) are males compared to females (19.3%). The stark gender imbalance indicates that women are underrepresented in agriculture in the Municipality. This is often due to

various socio-cultural barriers, such as traditional gender roles that limit women's access to land, resources, and decision-making power in agriculture in Ghana (Bissah et al., 2022; Asante et al., 2023).

Gender of the Farmers

Table 2: Gender Distribution of Respondents from Four Communities within the Yilo-Krobo Municipality

Gender	Frequency	Percentage
Male	289	80.7
Female	69	19.3
Total	**358**	**100.00**

Source: Field Data (2024)

Age Distribution of the Farmers

Table 3: Age of Farmers

Age Group	Frequency	Percentage
20 – 29	13	3.6
30 – 39	71	19.8
40 – 49	86	24.0
50 – 59	96	26.8
60 – 69	73	20.4
70 – 79	19	5.3
Total	**358**	**100.00**

Source: Field Data (2024)

The age distribution of smallholder farmers engaged in circular agriculture in the Yilo-Krobo Municipality, as shown in Table 3, reveals a diverse range of ages with significant implications for agricultural practices and policy-making. The largest group of farmers falls within the 50-59 age bracket, accounting for 26.8% of the total, followed closely by those aged 40-49 (24%) and 60-69 (20.4%). However, 5.3% of farmers also fell within the 70 – 79 age brackets. This indicates that most farmers are middle-aged to older

adults, with younger farmers (20-29) comprising only 3.6% and those in their thirties (30-39) making up 19.8%. The relatively low percentage of younger farmers suggests a potential generational gap in the agricultural sector, which could impact the long-term sustainability and innovation in farming practices in the Municipality.

This age distribution aligns with findings in other studies, such as those by Yeboah and Jayne (2020), highlighting the ageing farming population in many African countries and the need for strategies to attract and retain younger individuals in agriculture. The overrepresentation of older farmers could imply a wealth of experience in traditional farming practices but may also suggest resistance to adopting new technologies and circular agricultural methods (Conway et al., 2021: 2022).

Education Level of Farmers

Table 4: Educational Level of Farmers

	Gender		
	Female	**Male**	**Total**
No Formal Education	35 (9.77)	98 (27.37)	**133 (37.15)**
Basic/JHS	23 (6.42)	124 (34.63)	**147 (41.06)**
Secondary	11 (3.07)	50 (13.96)	**61 (17.03)**
Tertiary	0	17 (4.74)	**17 (4.74)**
Total	**69 (19.27)**	**289 (80.72)**	**358 (100)**

Source: Field Data (2024) $(\chi^2 = 9.56\,; P = 0.023)$

Table 4 presents the education levels of smallholder farmers in the Yilo-Krobo Municipality. The results indicate a significant disparity in educational attainment among the farmers. Most farmers possess basic education (JHS) at 41.1%, followed by those without formal education at 37.2%. Fewer farmers have secondary education (17%), and only 4.7% have

attained tertiary education. The gender breakdown shows that more male farmers (191) have access to education than females (34). This distribution suggests that many farmers lack the advanced educational background that could facilitate the adoption of innovative agricultural practices, such as those required for practical circular agriculture. The chi-square value of 9.56 and a p-value of 0.023 indicate that this difference in educational attainment between genders is statistically significant, highlighting a notable gap in educational opportunities or attainment between male and female farmers.

The dominance of basic and no formal education aligns with findings from previous studies that highlight the challenges faced by farmers with lower educational backgrounds in accessing and utilising agricultural technologies and knowledge (Grelet et al., 2021; Boon & Anuga, 2020). The low level of tertiary education, particularly with no female representation, shows the need for targeted educational programs and training to empower farmers with the necessary skills and knowledge for sustainable farming practices.

Religion of Farmers

Table 5: Religion of Farmers

GENDER	RELIGION			TOTAL
	Tradition	**Christian**	**Muslim**	
Male	0	70(19.5)	0	70 (19.5)
Female	2(0.56)	283(79.1)	3(0.84)	288(80.5)
TOTAL	2(0.56)	353(98.60)	3(0.84)	358(100)

Numbers in parenthesis are in percentages $(\chi^2 = 1.232; P = 0.540)$

Source: Field Data (2024)

Table 5 reveals that the majority of smallholder farmers in the Yilo-Krobo Municipality are predominantly Christian, comprising 98.6% of the

population, while 0.8% follow Islam and 0.6% practice traditional African religions. This high level of religious homogeneity could influence community norms and values related to agricultural practices, including circular agriculture, which emphasizes sustainability and resource efficiency. The chi-square value of 1.232 with a p-value of 0.540 indicates that religious affiliation does not significantly impact the adoption of circular agriculture practices. Nevertheless, the strong Christian presence suggests that utilizing church networks and engaging religious leaders could be effective strategies for promoting circular agriculture and disseminating information within the community.

This pattern aligns with national trends reported by the Ghana Statistical Service (2021), which indicate a predominantly Christian population in Ghana, though the religious composition in other regions might differ, potentially affecting local agricultural dynamics. Studies such as Reyes et al. (2021) have shown that religion can significantly influence agricultural decision-making and resource management. Thus, understanding the religious composition helps tailor agricultural interventions that resonate with the community's beliefs and values, fostering greater acceptance and participation. Engaging religious institutions in promoting sustainable farming practices could enhance community cohesion and the successful implementation of circular agricultural initiatives.

Marital Status of Farmers

Table 6: Marital Status of Farmers

GENDER	MARITAL STATUS				
	Single	**Married**	**Divorced**	**Widow/Widower**	**Total**
Male	72(20.10)	189(52.79)	16(4.38)	11(3.13)	**288(80.4)**
Female	6(1.68)	54(15.08)	6(1.77)	4(1.07)	**70(19.6)**
Total	**78(21.78)**	**243(67.87)**	**22(6.15)**	**15(4.20)**	**358(100)**

Numbers in parenthesis are in percentages $(\chi^2 = 9.392\,; P = 0.025)$
Source: Field Data (2024)

Table 6 details the marital status of farmers participating in the study, showing that the majority are married, accounting for 69.0% of respondents. Single farmers are the second largest group at 20.4%, with divorced individuals representing 6.7% and widowed farmers at 3.9%. This distribution highlights the potential influence of marital status on the adoption of circular agricultural practices. The significant chi-square value of 9.392 with a p-value of 0.025 suggests that marital status significantly affects farming practices. Married farmers, benefiting from household stability and shared resources, might be better positioned to invest in and implement circular agriculture methods, which often require substantial initial effort and resources for long-term gains.

On the other hand, single and divorced farmers may face more challenges due to limited household labour and support, impacting their ability to engage in such practices fully. Widowed farmers, representing the smallest group, might encounter additional socio-economic difficulties, potentially hindering their participation in innovative agricultural techniques.

Years Spent in Farming

The findings presented in Table 7 detail the distribution of farmers based on the years spent in farming. The farmers' distribution across the years provides insight into the level of experience and potential variations in agricultural practices of the smallholder farmers in the Yilo-Krobo Municipality. Danso-Abbeam et al. (2018) state that farmers' expertise impacts agricultural productivity, technology adoption, and sustainable practices.

Table 7: Years Spent in Farming

	Gender		
Experience	**Female**	**Male**	**Total**
1 – 10	37(21.1)	138(78.9)	175(100)
11 – 20	26(29.5)	62(70.5)	88(100)
21 – 30	3(6.1)	46(93.9)	49(100)
31 – 40	0(0.0)	21(100.0)	21(100)
41 – 50	3(13.0)	20(87.7)	23(100)
51 – 60	0(0.0)	2(100.0)	2(100)
Total	**69(19.3)**	**289(80.7)**	**358(100)**

Source: Field Data (2024): Numbers in parenthesis are in percentages

Table 7 reveals significant gender and experience disparities among the smallholder farmers engaged in circular agriculture. Most farmers (175) have between 1 and 10 years of farming experience, with males comprising 78.9% and females 21.1%. For those with 11–20 years of experience, males dominate at 70.5%, compared to 29.5% of females. This trend continues and becomes more pronounced in the higher experience categories: males represent 93.9% of those with 21–30 years, 100% in the 31–40 and 51–60 years, and 87% in the 41–50 years range.

These findings highlight that male farmers outnumber females and tend to have more extensive farming experience. This finding has two

implications: first, it highlights the urgent need for initiatives to support and encourage women to stay and grow in agriculture over the long term. Second, the higher concentration of male farmers with extensive experience indicates a potential pool of expertise that could serve as a mentor and support system for less experienced female farmers. This difference between men and women in farming experience aligns with studies by Obayelu et al. (2020) and Nyasimi and Huyer (2017). These studies stress the imbalance of gender in agriculture and the need for gender-inclusive policies to make sure women have equal access to resources, training, and support.

Income and Expenditure of Farmers

Smallholder farmers' income and expenditure patterns are critical in understanding agricultural practices' economic viability and sustainability. These financial components provide insight into the profitability of farming activities, farmers' living standards, and economic challenges. Farmers' income sources typically include crop and livestock sales, government subsidies, and off-farm employment, while expenditures often cover inputs such as seeds, fertilisers, equipment, labour, and household needs. Understanding the balance between income and expenditure helps identify areas where farmers may need support to improve their profitability and financial stability. Tables 8 and 9 provide an overview of the income and expenditure of smallholder farmers in the Yilo-Krobo Municipality.

Table 8: Average Annual Expenditure of Farmers

Category	Frequency	Percentage
Less than GH₵ 2000	305	85.5
GH₵ 2001 – 4000	36	10.1
GH₵ 4001 – 6000	11	3.1
GH₵ 6001 – 8000	3	0.8
GH₵ 8001 – 10000	3	.08
Total	**358**	**100.0**

Source: Field Data (2024)

Table 8 shows that smallholder farmers' average annual expenditure patterns in the Yilo-Krobo Municipality indicate that a significant majority (85.5%) spend less than GH₵ 2000 on agricultural activities. About 10.1% spending between GH₵ 2001 and 4000, 3.1% between GH₵ 4001 and 6000, and 0.8% each between GH₵ 6001–8000 and GH₵ 8001–10000 categories. This expenditure distribution suggests that most farmers operate with limited financial resources, which could constrain their ability to invest in advanced agricultural technologies, inputs, and sustainable practices essential for circular agriculture. Such financial limitations emphasise the need for targeted support and funding programs to enable smallholder farmers to adopt more efficient and sustainable farming methods.

Adams and Jumpah (2021) posit that limited expenditure on agriculture is a common issue among smallholder farmers in Ghana, often leading to lower productivity and a limited capacity to innovate. These findings show the importance of financial interventions, such as microloans, subsidies, and training programs, to enhance farmers' capacity to engage more effectively in circular agricultural practices.

Table 9: Average Annual Income of Farmers

Income	Frequency	Percentage
Less than GH₵ 2000	73	20.4
GH₵ 2001 – 3000	96	26.8
GH₵ 3001 – 4000	106	29.6
GH₵ 4001 – 5000	83	23.2
Total	**358**	**100.0**

Source: Field Data (2024)

The average annual income distribution of smallholder farmers in the Yilo-Krobo Municipality, as shown in Table 9, clearly represents their economic condition, which has consequences for agricultural productivity and financial stability. According to the data, most farmers (29.6%) make an annual income between GH₵ 3001 and GH₵ 4000. This is followed by 26.8% of farmers who earn between GH₵ 2001 and 3000 and 23.2% who earn between GH₵ 4001 and 5000.

Significantly, 20.4% of farmers earn less than GH₵2000. The income distribution indicates that many farmers earn relatively modest earnings, which hampers their capacity to invest in sophisticated agricultural technologies and sustainable practices vital for circular agriculture. Previous studies, like Abokyi et al. (2020), confirm that income limitations pose a significant obstacle for small-scale farmers in Ghana. Financial constraints can impede the implementation of circular agricultural methods, as they typically necessitate initial investments to yield long-term benefits. Farmers can overcome economic barriers and improve their ability to adopt sustainable practices by implementing financial support programs, micro-loans, and subsidies. In addition, improving market entry and optimising value chain

operations could contribute to higher farmers' earnings, promoting a more robust agricultural industry.

Moreover, figure 3 presents the data on whether the smallholder farmers in the Municipality receive any form of remittances. Most farmers (99%) reported not receiving remittances, while only 1% did. This finding suggests that most farmers rely mainly on their agricultural activities for income and financial support, without significant external financial aid from family or other sources. The lack of remittances exposes these farmers' vulnerability and limited economic resilience, as remittances often serve as a crucial financial buffer for many rural households in Ghana. The absence of remittance inflow could hinder their ability to invest in improved agricultural practices, such as adopting circular agricultural techniques that may require initial capital outlay.

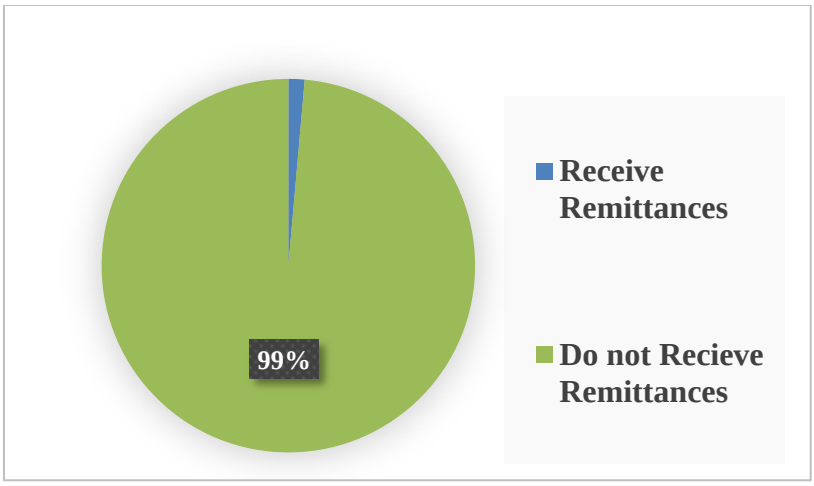

Figure 3: Proportion of Farmers receiving Remittances
Source: Field Data (2024)

Household Size of Farmers

Table 10 presents the household size of smallholder farmers engaged in circular agriculture in the Yilo-Krobo Municipality. The findings demonstrate a predominance of smaller to mid-sized households, with 51.7% of farmers

having household sizes of 1–5 members and 46.4% having 6–10 members. Only a tiny fraction (2%) has households with 11–15 members. This distribution shows that most farming households are relatively small, which may impact labour availability and resource allocation for farming activities.

Additionally, the age composition within these households reveals that 75.1% of the household members are below 18 years old, indicating a high dependency ratio and suggesting that a significant portion of the household labour force comprises young dependents who may not yet contribute significantly to agricultural labour. Only 24.9% of household members are over 18, and they are likely the primary labour force for agricultural activities.

Table 10: Household Size of Farmers and labour endowment

Characteristic	Category	Frequency	Percentage
Household Size	1 – 5	185	51.7
	6 – 10	166	46.4
	11 – 15	7	2.0
Total		**358**	**100.00**
Labour	Below 18 years	269	75.1
Endowment	Above 18 years	89	24.9
Total		**358**	**100.0**

Source: Field Data (2024)

The implications of these findings are multifaceted, as smaller household sizes with a high number of dependents could strain the capacity of households to engage in labour-intensive circular agricultural practices, which often require more hands-on involvement and innovative approaches. This dynamic also exposes the potential need for external support to enhance productivity, such as access to hired labour, mechanisation, or labour-saving technologies.

Furthermore, many young dependents suggest investing in educational programs to equip the younger generation with knowledge and skills in

sustainable and circular agricultural practices. These findings are in line with what other research has found about the problems and chances that come up with household labour dynamics in smallholder agriculture, such as labour demand, labour shortages, youth migration, dependency ratios, and economic vulnerability (Njuki et al., 2011; Jayne et al., 2010).

Land Access, Holdings and Tenure System

Land access and the land tenure system are fundamental aspects of agricultural practices and rural livelihoods. Land tenure arrangements, which define the legal and customary rights individuals or groups have to land, play a critical role in determining access to land and the security of land holdings. These arrangements can include freehold ownership, leasehold, communal land rights, and informal or customary tenure systems (Joireman, 2024). Access to land, influenced by these tenure systems, impacts the size of land holdings and the ability of farmers to engage in productive agricultural activities (Place & Otsuka, 2002).

The total land size, or holdings, refers to the aggregate area of land that a farmer or farming household controls, which directly affects the scale of agricultural operations. Within these holdings, the land area under cultivation is the portion actively used for growing crops, while the area under Fallow represents land left unplanted for periods to restore fertility. The interplay between tenure security, land access, and cultivated and fallow land management shapes agricultural systems' efficiency, sustainability, and productivity, influencing food security and economic stability in rural areas. This subsection presents the respondents' findings on the land access and tenure systems in the Yilo-Krobo Municipality.

Table 11 provides insights into land access among smallholder farmers involved in circular agriculture in the Yilo-Krobo Municipality. The data reveals that a higher proportion of male farmers (67.04%) have land access compared to female farmers (17.87%). However, a slightly greater percentage of male farmers (13.40%) lack land access compared to female farmers (8.7%). Despite these variations, the majority of farmers, 84.92%, report having land access. The chi-square value of 2.881 with 1 degree of freedom and a p-value of less than 0.090 suggests that the differences in land access between genders are not statistically significant. This pattern indicates that, although fewer women are engaged in agriculture, those who are involved have relatively better access to land compared to their male counterparts.

However, there is an overall gender disparity in land access, with males having more access to agricultural land in the Municipality. Such disparities in land ownership have implications for female farmers' ability to engage in agriculture and generate income and potentially exacerbate gender-based inequalities in the Municipality (Ntihinyurwa et al., 2019). These findings further emphasise the importance of land rights for women in improving agricultural productivity and household welfare.

Table 11: Land Access and Gender

	Gender		Total
	Female	**Male**	
No	6 (1.67)	48 (13.40)	54 (15.08)
Yes	64 (17.87)	240 (67.04)	304 (84.92)
Total	70 (19.54)	288 (80.44)	358 (100)

Chi^2 =2.881 N=358 p<0.090 df = 1 Numbers in parenthesis are in percentages

Source: Field Data (2024)

Moreover, the smallholder farmers further indicated the form of land tenure agreements in the Municipality. From Figure 4, Most farmers (42%) rent their agricultural lands. About 22% of the farmers use the sharecropping system and the title deed, giving them more security and incentive to invest in circular agricultural practices. About 13% of the farmers had a land lease, which can pose risks regarding duration and term of use. 1% of the farmers work on communal lands, which can offer stability and limit individuals' decision-making power on the land. These tenure arrangements are essential to the farmers as they determine what farming techniques can be used on the land.

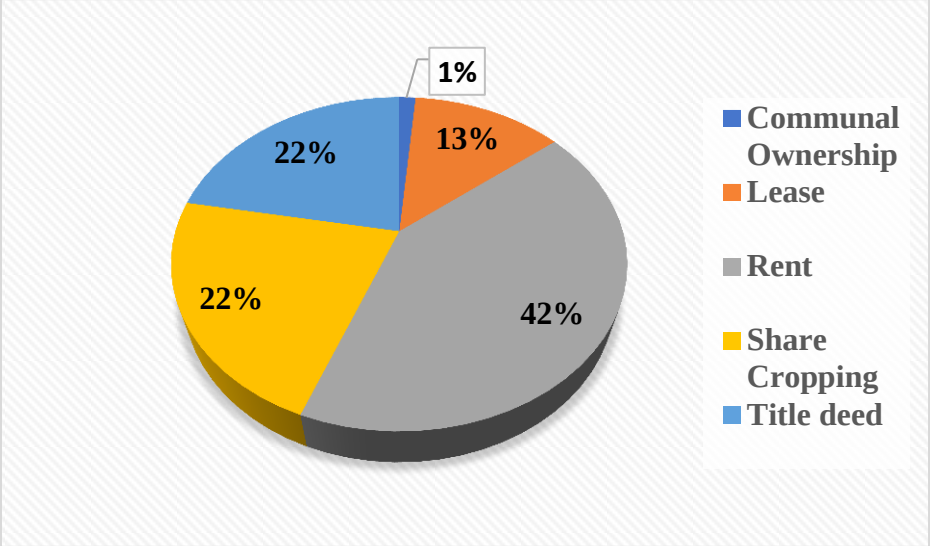

Figure 4: Land Tenure Arrangement
Source: Field Data (2024)

Table 12 further revealed the total land size or holdings of the farmers in the Municipality based on their gender. The analysis reveals a significant gender disparity in land ownership and sizes, with males owning land more than females. This situation is common in Ghana, as males are often regarded as family heads and have access to agricultural land (Bonye, 2022). From the data, most farmers, both men and women (81.2%), have small plots of land

between 1 and 5 Ha. Moreover, about 24.6% of male farmers have 6–10 Ha, while only 15.9% of female farmers do. The gender disparity becomes more pronounced with larger land sizes: only 2.9% of female farmers have 11-15 Ha, and none possess land between 16-25 acres, while small percentages of male farmers own land in these categories (2.4% for 11-15 acres and 0.7% for both 16-20 and 21-25 Ha).

These results show that it is harder for women in the Yilo-Krobo Municipality to get to larger plots of land. This can make them less productive and less able to use circular farming techniques in many situations. This trend fits what Bonye (2022) and Kuusaana et al. (2013) found, which shows structural differences between men and women regarding land ownership in Ghana.

Table 12: Land holdings of Farmers and Gender

	Gender		
Land Holding/Size (Ha)	**Female**	**Male**	**Total**
1 – 5	56 (81.2)	207 (71.6)	**263(73.5**
6 – 10	11 (15.95)	71 (24.6)	**82(22.9**
11 – 15	2 (2.9)	7 (2.4)	**9(2.5)**
16 – 20	0 (0)	2 (0.7)	**2(0.6)**
21 – 25	0 (0)	2 (0.7)	**2(0.6)**
Total	**69**	**289**	**358**

Numbers in parenthesis are in percentages

Source: Field Data (2024)

Agricultural Practices and Market Access

Smallholder farmers are essential to Ghana's agricultural production and contribute significantly to food security and rural livelihood. These farmers in the Yilo-Krobo Municipality mostly manage small plots between 1 to 5 Ha, often characterised by limited access to quality seeds, fertilisers,

irrigation, extension services, and market access. This subsection focuses on smallholder farmers' agricultural practices and market access, delving into many aspects, including type of farming, cultivation area, fertiliser usage, and market access.

Table 13 presents the findings of the farming activity in which the smallholder farmers in Yilo-Krobo are engaged. From the analysis, most farmers (85%) are engaged in crop farming, while 14.24% are engaged in mixed farming. This heavy reliance on crop farming exposes the farmers to environmental shocks that affect crop yield, such as price fluctuation and climate vulnerability.

Table 13: Farming Type

Gender	Crop Farming	Mixed Farming
Female	63 (17.59)	7 (1.95)
Male	244 (68.15)	44 (12.29)
Total	307 (85.75)	51 (14.24)

Source: Field Data (2024)

Furthermore, the farmers indicated the amount of land under cultivation and the type of crops planted. According to figure 4, most farmers (83.5%) grow crops on 1 to 5 Ha of land. About 14.8% of the smallholder farmers grow crops on 6 to 10 Ha. 1.1% and 0.6% of the farmers grow crops on 11 to 15 Ha and 16 to 20 Ha, respectively. The small-scale farming predominance in the Municipality suggests a limited economic scale, which hinders farmers' ability to achieve higher production and profitability. According to Jayne et al. (2014) and Cotula et al. (2004), other factors such as land tenure issues, financial problems, and inadequate access to agriculture may prevent farmers from cultivating large land sizes.

The farmers further stated the predominant crops that they grow on the land. The crops were beans, cassava, maize, tomatoes, cocoyam, yam, potato, pepper, okra and mangoes. The predominant crops that the farmers cultivated were cassava and maize, which were stable crops in the Municipality. The farmers who practice mixed farming indicated that they rear goats, sheep, fowls, and birds alongside the growing crops. The low level of participation in mixed farming, which can provide advantages in diversification and mitigating risks associated with relying on a single crop, suggests that targeted assistance and incentives could be implemented to improve resilience and sustainability.

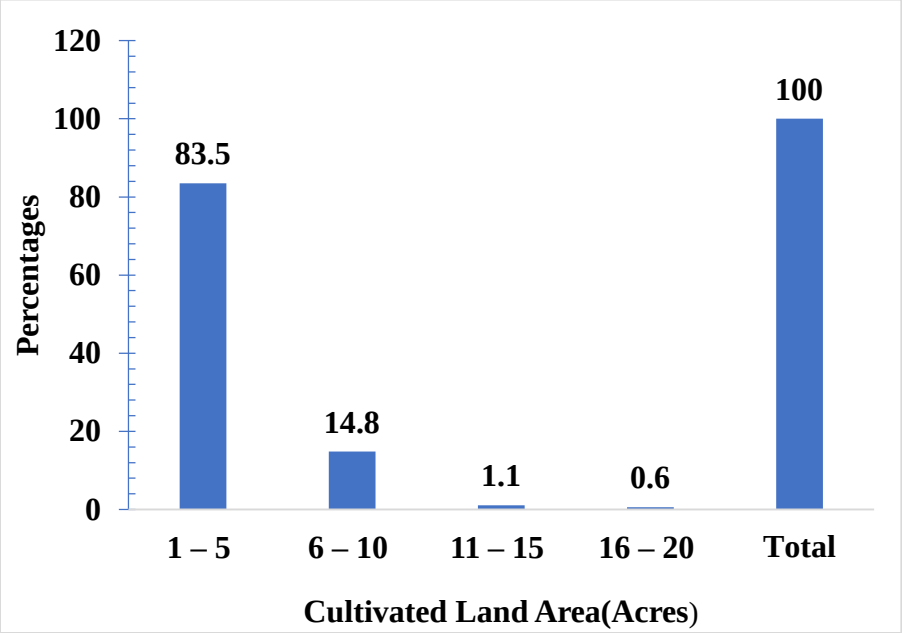

Figure 5: Cultivated Land Size

Source: Field Data (2024)

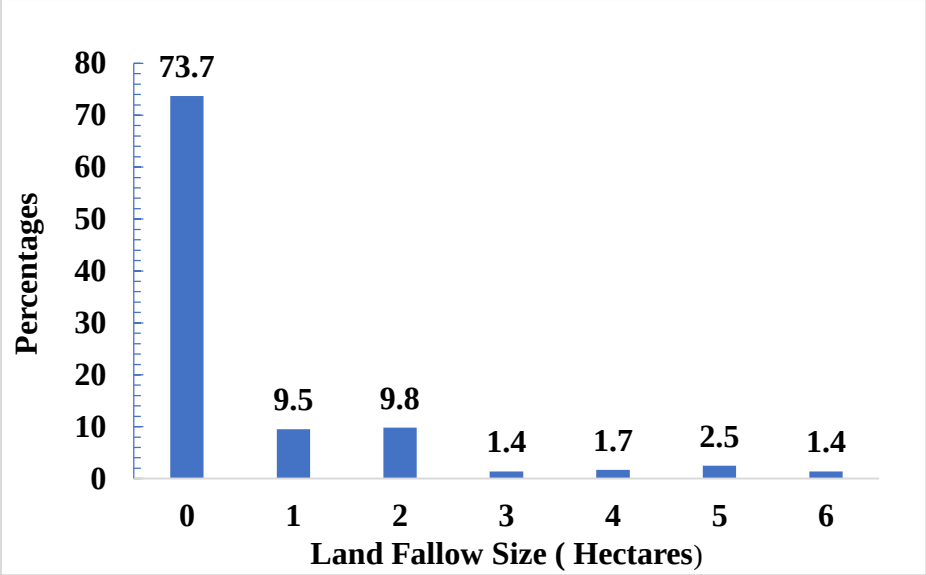

Figure 6: Total land under Fallow

Source: Field Data (2024)

The farmers further indicated the number of hectares of land under fallow. Fallow is an agricultural technique where arable land is left unseeded for one or more seasons to allow the land to recover, store organic matter, and disrupt the pest life cycle. According to Figure 6, most farmers (73.7%) do not practice land fallow; as a result, they leave no hectares of land for replenishing. However, about 26.3% of the farmers practice land fallow, ranging from land areas of 1 to 6 hectares. The analysis implies that most farmers do not leave unseeded land to replenish the soil for a season. This suggests a lack of adoption of sustainable farming practices crucial for circular agriculture, which aims to close the nutrient loop and minimise waste (Żarczyński et al., 2023).

Table 14: Access to Agriculture Input, Market and Extension Services

	Frequency	Percent
Access to Agricultural Extension Service		
No	334	93.3
Yes	24	6.7
Total	**358**	**100.0%**
Access to Agriculture Input Rating		
Sufficient	146	40.8
Limited	45	12.6
Moderate	167	46.6
Total	**358**	**100.0%**
Access to local and Regional Market		
Excellent Access	165	46.1
Moderate Access	169	47.2
Limited Access	24	6.7
Total	**358**	**100.0%**

Source: Field Data (2024)

Smallholder farmers in Sub-Saharan Africa often face significant barriers to accessing essential agricultural inputs, markets, and extension services. Limited access to inputs such as fertilisers, seeds, and tools, as well as inadequate market connections and insufficient extension support, hinder the productivity and livelihoods of these farmers (Ferris et al., 2014). Interventions that provide smallholder farmers with inputs, financing, and extension services have shown promise in improving their incomes and agricultural outcomes. However, challenges remain in ensuring the sustainability and scalability of such programs to reach the millions of smallholder farmers in need.

The findings in Table 14 demonstrate notable obstacles and discrepancies in the support systems necessary for sustainable agricultural practices, such as smallholder farmers' access to agricultural inputs, markets, and extension services in the Yilo-Krobo Municipality. About 93.3% of farmers indicated a lack of access to agricultural extension services, leaving only 6.7% with access to such assistance. The absence of access can significantly restrict farmers' capacity to embrace inventive and sustainable methods, such as circular agriculture.

The distribution of agricultural input access is somewhat equitable, with 40.8% of farmers describing it as satisfactory, 46.6% describing it as average, and 12.6% describing it as limited. The variation in the accessibility of inputs could result in varying agricultural practices and levels of output throughout the Municipality. 46.1% of farmers have access to local and regional markets, 47.2% have moderate access, and a minor proportion (6.7%) face inadequate market access. Having favourable market access is essential for farmers to sell their agricultural products and maintain their means of living (Barrett, 2010). The differences in extension services and input availability align with the findings of Jayne et al. (2021) and Mapiye et al. (2021), which show how vital extension services and easy access to inputs are for improving agricultural production and sustainability in sub-Saharan Africa.

Influence of Society and Cooperative Organisation on Farming Practices

The influence of society and cooperative organisations on farming practices is significant. Agricultural cooperatives play a crucial role in enhancing farm productivity and sustainability by promoting joint activities among farmers. These cooperative societies help farmers pool their resources,

share knowledge, and access modern farm implements, which leads to increased efficiency and productivity. From Figure 7, most smallholder farmers indicated they are not members of any cooperative society in the Yilo-Krobo Municipality. However, 4% of the smallholder farmers indicated they are part of cooperative societies.

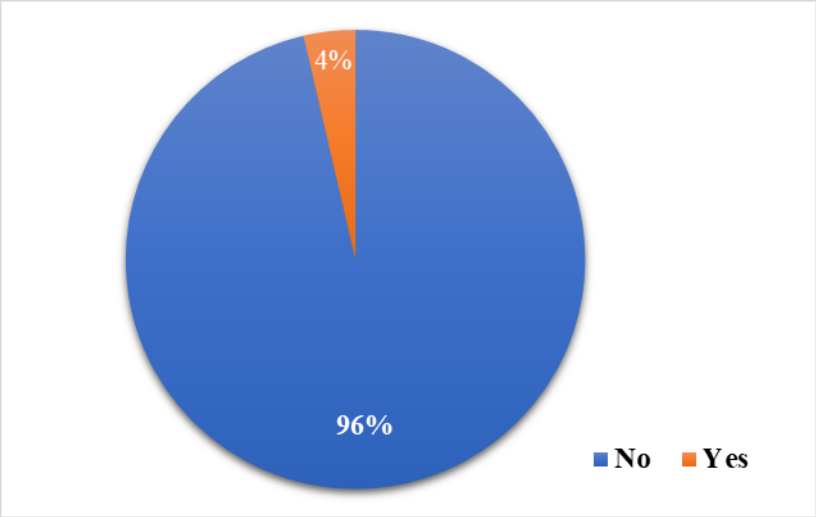

Figure 7: Membership of Cooperative Society
Source: Field Data (2024)

Furthermore, Table 15 reveals the impact of social pressure and societal expectations on smallholder farmers involved in circular agriculture in the Yilo-Krobo Municipality. The statistics suggest that social factors have a limited impact on altering agricultural practices. A Cronbach's alpha value of 0.746 suggests a good level of internal consistency in the measurement scale used to assess the influence of social pressure on farming practices. More specifically, 91.6% of farmers stated that social pressure did not impact their farming operations. Only 2% of the farmers claimed that social pressure had a significant influence, while 6.4% found it to have a moderate influence.

Table 15: Social Pressure and Expectation

	Frequency	Percent
Highly Influential	7	2.0
Moderately Influential	23	6.4
Not Influential	328	91.6
Total	**358**	**100.0%**

Cronbach Alpha = 0.746

Source: Field Data (2024)

Similarly, the influence of public expectations on agricultural practices was considered insignificant, as reported by 92.2% of the farmers in Table 16. Only 7.8% of the farmers believed that societal expectations impacted their methods. The data indicate that farmers in this area predominantly base their agricultural decisions on reasons unrelated to social influences, such as economic concerns, personal experience, or environmental conditions. Their disconnection from social influences suggests a degree of independence in their farming decisions, potentially enabling them to embrace innovative approaches like circular agriculture without societal norms limiting them.

However, it also implies a lack of community involvement and collective agricultural knowledge, which could potentially improve the effectiveness of promoting sustainable practices. The results contradict the findings of previous studies, which suggest that social networks and community influence significantly impact agricultural practices. However, in certain areas where traditional farming communities are less united, individual decision-making tends to be more influential (Rockenbauch & Sakdapolrak, 2017; Lalani et al., 2016).

Table 16: Societal Expectations on Agricultural Methods

	Frequency	Percent
Yes	28	7.8
No	330	92.2
Total	**358**	**100.0%**

Source: Field Data (2024)

Knowledge and Training on Circular Agriculture

The knowledge and training of smallholder farmers in circular agriculture are crucial for the successful adoption and implementation of sustainable agricultural practices. From Figure 8, most smallholder farmers (63%) in the Yilo-Krobo Municipality have knowledge and training on circular agriculture. The comparatively high proportion of well-informed farmers indicates a favourable inclination towards sustainable farming methods, which can result in enhanced soil health, efficient use of resources, and overall environmental sustainability. Nevertheless, 37% of farmers lack training, emphasising a crucial deficiency that must be resolved to guarantee the widespread adoption of these techniques. The existence of this gap might be attributed to factors such as restricted availability of educational resources, extension services, or financial limitations.

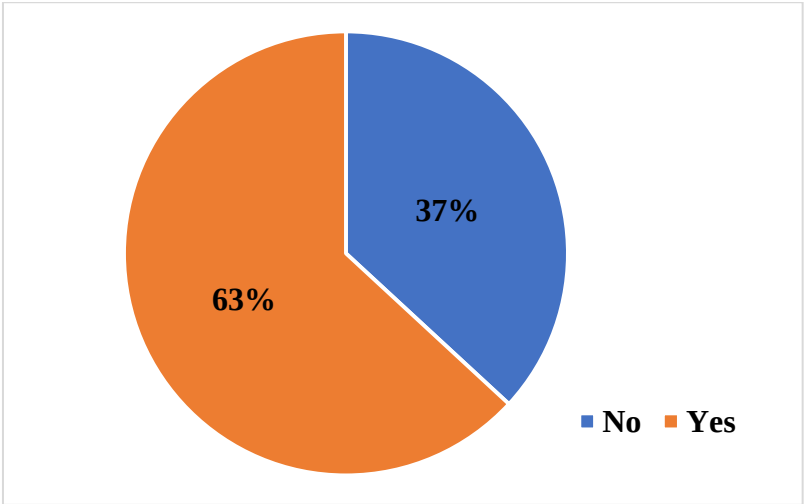

Figure 8: Knowledge/Training on Circular Agriculture

Source: Field Data (2024)

Figure 8 provides additional information about smallholder farmers' awareness of circular agriculture practices in the Yilo-Krobo Municipality. This information illuminates the dissemination of agricultural knowledge and training. Among the 226 participants who received education and training, 46% reported acquiring knowledge about circular agriculture from their peers and fellow farmers. This highlights the significant impact of informal networks and community interactions on disseminating agricultural methods.

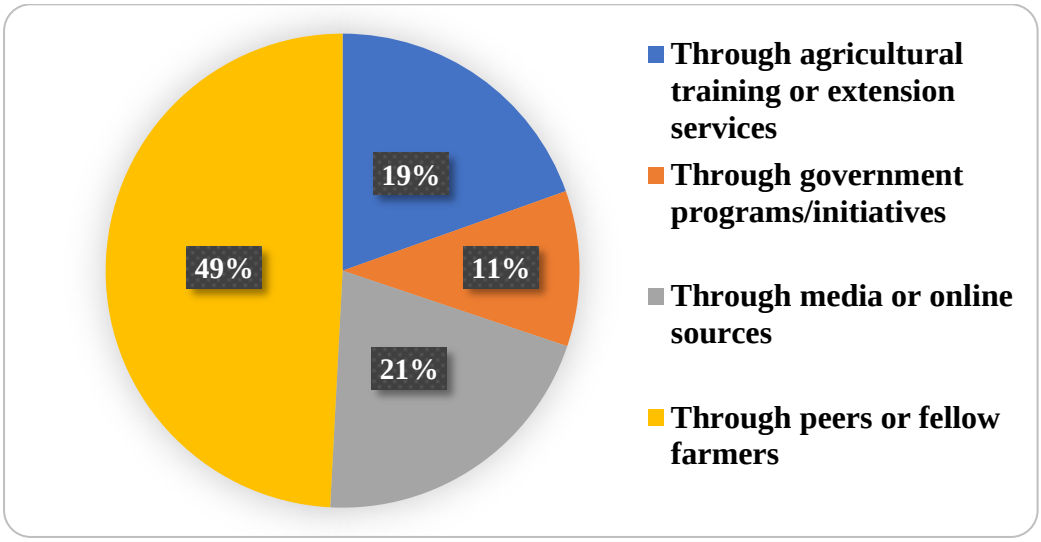

Figure 9: Awareness of Circular Agriculture Practices
Source: Field Data (2024)

In addition, a notable 21% of farmers reported acquiring knowledge through media and online sources, highlighting the increasing impact of digital and mass communication in rural regions. 19% of farmers relied on agricultural extension services as their primary source of knowledge, demonstrating these programs' enduring and crucial significance in educating farmers about sustainable practices. 11% of the respondents mentioned government programs, suggesting a comparatively modest yet notable influence on awareness. These patterns indicate that although institutional channels such as extension services and government programs are necessary,

utilising peer networks and digital media can significantly improve the extent and acceptance of circular agriculture.

Mekonnen et al., (2018) research, which emphasises the importance of social networks in disseminating agricultural innovations, aligns with these findings. The results suggest that, in order to spread circular agriculture methods effectively, a comprehensive strategy is required. This strategy should improve peer learning, increase digital communication efforts, and extend formal educational programs. This comprehensive plan can guarantee broader and more efficient implementation of sustainable agriculture practices among smallholder farmers.

Nevertheless, figure 10 presents the self-assessed knowledge of smallholder farmers in the Yilo-Krobo Municipality regarding circular agriculture practices. The analysis indicates that a considerable percentage of farmers assess their knowledge as high (35.5%), although a smaller percentage assesses it as very high (2.8%). In contrast, 24.6% of farmers evaluated their level of knowledge as low, while another 24.3% believed it to be very low.

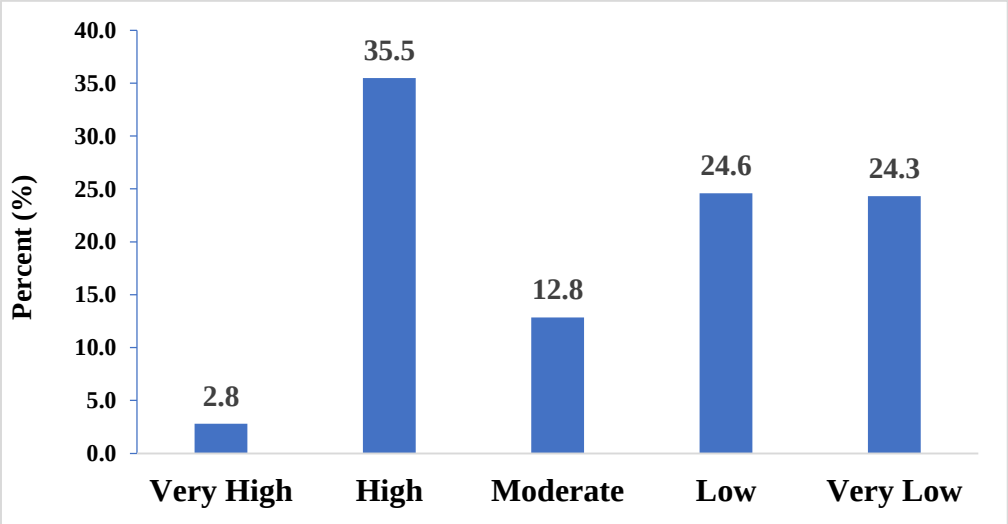

Figure 10: Circular Agriculture Knowledge Rating

Source: Field Data (2024)

Additionally, 12.8% of farmers perceive their knowledge to be moderate. The findings suggest a significant discrepancy in the knowledge levels of farmers, with the majority having a strong or very limited awareness of circular agriculture. This contrast implies that although farmers are knowledgeable and potentially applying innovative methods, a significant proportion lack sufficient understanding, which may impede the widespread acceptance and efficacy of circular agriculture techniques (Mehmood et al., 2021).

Circular Agriculture Practices of Smallholder farmers in the Yilo-Krobo Municipality

Circular agricultural practices are farming methods that aim to minimize waste, optimize resource use, and promote sustainability in agriculture. Farmers adopt different circular agricultural practices, such as crop rotation and cover cropping, designed to mimic natural cycles and reduce environmental impacts on farming activities. This section focused on the objective one of the studies, which examines the circular agricultural practices used by smallholder farmers in the Yilo-Krobo Municipality. This involves analyzing farmers' perceptions of the practices involved in circular agriculture and the actual practices the farmers use on the farms.

Table 16 reveals farmers' perceptions of the Yilo-Krobo Municipality regarding the various practices involved in circular agriculture, measured on a scale where one indicated "Strongly Disagree" and five indicated "Strongly Agree". Farmers disagreed with using organic manure or compost in their farming activities (mean = 2.40, standard deviation = 1.57). This suggests an uncertainty regarding the effectiveness or benefits of using organic manure or

compost in their agricultural practices. Stockdale et al. (2002) have shown that organic inputs can improve soil fertility and reduce reliance on synthetic fertilisers, but perceptions can vary widely among farmers depending on access to resources and education.

Farmers' perceptions of disease-resistant crops generally disagree (mean = 1.74, standard deviation = 1.10). This indicates that farmers might not fully embrace the importance or effectiveness of disease-resistant crop varieties. This leaves a gap in educating farmers on the role of disease-resistant crops in improving yield and income. Farmers also tend to disagree with using botanical or organic pesticides (mean = 1.66, standard deviation = 1.04).

This contrasts with findings from studies like those by Bahlai et al., (2010), which suggest that organic pesticides can be effective alternatives to synthetic chemicals, possibly reflecting concerns about efficacy or accessibility among farmers. The farmers expressed disagreement (mean = 1.74) with erosion control practices, indicating low efforts to mitigate soil erosion. There is a relatively high level of disagreement (mean = 2.36) about the use of green manure by the Municipality's farmers.

Table 17: Farmers' Perspectives on Circular Agriculture Practices

Circular Agriculture Practices	Mean Rank*	Rank
Drought Tolerant Crops	8.45	1
Botanicals/Organics Pesticides	7.97	2
Control Erosion	7.87	3
Folder Crops to Feed Animals	7.64	4
Disease Resistance	7.60	5
Early Maturing Crops	7.07	6
Minimum Tillage	6.93	7
Organic manure/Compost	6.51	8
Plant Leguminous Crops/Trees	6.47	9
Rain Harvesting for Irrigation	6.25	10
Green Manure	6.09	11
Improved High Yielding Varieties	6.09	11
Mechanical Weed Control	6.07	13

$Kendall(W) = 0.131 ; N = 357 ; C\,hi^2 = 559.707 ; D\,F = 12 ; P < 0.001$

Source: Field Data (2024)

Table 17 outlines farmers' perspectives on various circular agriculture practices, ranking them based on their mean scores. The top-ranked practice is "Drought Tolerant Crops" with a mean rank of 8.45, followed by "Botanicals/Organics Pesticides" (mean rank of 7.97) and "Control Erosion" (mean rank of 7.87). These rankings indicate that farmers perceive drought-tolerant crops as the most valuable practice, highlighting the critical importance of resilience to climatic conditions in their agricultural strategies. On the other hand, practices such as "Mechanical Weed Control" are ranked lower with a mean rank of 6.07, suggesting less emphasis or perceived benefit from this practice compared to others.

The statistical values further support these findings. The Kendall's coefficient of concordance (W) is 0.131, indicating a weak to moderate level

of agreement among respondents regarding the importance of different practices. This suggests some level of consensus on the relative importance of these practices but also reflects variability in how practices are valued. The Chi-square value of 559.707 with 12 degrees of freedom and a p-value of <0.001 confirms that the differences in rankings are statistically significant, indicating that the variation in perceptions is unlikely to be due to random chance.

According to, De Buck et al., (2001) and Ullah et al., (2016), drought tolerance is often prioritized by farmers due to its direct impact on yield stability in the face of climate variability. Similarly, Wezel et al., (2014) and Abdallah et al., (2021) highlight the importance of organic pesticides and erosion control as key components in sustainable agricultural practices, which align with their higher rankings in this study. The lower ranking of practices like mechanical weed control might be related to Abdul-Salam et al., (2022), who notes that while mechanical controls are useful, they may be seen as less critical compared to practices that offer more immediate benefits like increased drought tolerance or improved pest management. This aligns with the findings of Madsen et al. (2021), which indicate that mixed farming practices help to improve soil fertility, enhance resilience, and increase crop yield.

Table 18: Circular Agriculture Practices of Farmers

Circular Agriculture Practices	Response (%) Yes	No
Crop Rotation	42.2%	57.8%
Usage of Organic Fertilizer/Compost	38.8%	61.2%
Cover Cropping	5.0%	95.0%
Usage of Water-Saving Techniques	56.1%	43.9%
Agroforestry	3.4%	96.6%
Pest Management Techniques	3.9%	96.1%
Usage of Renewable Energy	7.5%	92.5%
Recycling or Reuse of Agriculture waste	35.2%	64.8%

Chi Square=636.434 df=7 $p<0.001$

Source: Field Data (2024)

The table presents the adoption rates of various circular agriculture practices among farmers, with a focus on the percentage of respondents who either adopt ('Yes') or do not adopt ('No') each practice. The chi-square value of 636.434 with 7 degrees of freedom and a p-value of less than 0.001 indicates a statistically significant relationship between the type of practice and its adoption rate. This suggests that certain practices are adopted at significantly different rates, likely influenced by factors such as accessibility, awareness, or perceived benefits. For example, practices like Crop Rotation and Water-Saving Techniques show higher adoption rates (42.2% and 56.1%, respectively), highlighting their relevance or ease of implementation among farmers.

On the other hand, practices such as Agroforestry, Pest Management Techniques, and Cover Cropping exhibit very low adoption rates (3.4%, 3.9%, and 5.0%, respectively), suggesting potential barriers such as lack of knowledge, resources, or infrastructure. The significant chi-square result underscores the variability in adoption across these practices, indicating that

while some practices are embraced by a substantial portion of farmers, others remain largely underutilized. This finding points to the need for targeted interventions to address the specific challenges hindering the adoption of less popular practices, which could include increasing awareness, providing technical support, or improving access to necessary resources.

Factors that influence the adoption of Circular Agriculture

Smallholder farmers in Ghana use circular agriculture to improve agricultural sustainability, resilience, and productivity significantly. By implementing activities such as recycling agricultural inputs, improving soil health, and integrating crop and livestock systems, circular agriculture aims to reduce waste and maximise resource use. However, a multitude of circumstances impact the adoption of this innovative method. Financial constraints, a lack of expertise and training, limited market access, environmental circumstances, technological infrastructure, and insufficient institutional support contribute to these challenges.

Recognising these aspects is critical for formulating precise methods to encourage the widespread adoption of circular agriculture among small-scale farmers, thereby aiding in achieving food security and environmental sustainability. This section focuses on objective two of the study, which looked at the factors influencing smallholder farmers' adoption of circular agriculture.

Table: 19: **Factors that influence the adoption of circular agriculture practices**

Index	Coefficient	Standard Error	T-Test	Prob.
Gender	-0.0386823	0.0194246	-1.99	0.047*
Age	-0.0005792	0.0008695	-0.67	0.506^{ns}
Educational level	0.0186672	0.0088706	2.10	0.036*
Marital Status	0.029489	0.0128694	0.23	0.819^{ns}
Household Size	0.0042965	0.0041223	1.04	0.298^{ns}
Age above 18yrs	0.0174075	0.0069894	2.49	0.013**
Tenure	-0.0363286	0.0074536	-4.87	0.000***
Experience	0.0039297	0.0007641	5.14	0.000***
Land Access	-0.0791819	0.0216917	-3.65	0.000***
Land holdings	0.0037936	0.0067426	0.56	0.574^{ns}
Area Cultivated	-0.0077132	0.0085892	-0.90	0.370^{ns}
Access to Input	0.0518272	0.0116143	4.46	0.000***
Extension Services	0.0826742	0.0308733	2.68	0.008***
Farm Type	-0.0091048	0.004286	-2.12	0.034**
Number of Crops	0.000102	0.0069748	0.01	0.988^{ns}
Actual Annual Income	6.33e-06	1.50e-06	8.47	0.000***
Constant	0.5055964	0.0596818	8.47	0.000***

Log Likelihood, LR Chi^2 (16) =184.59, Pseudo R^2= -0.8207: The probability level of significance: ns= not significant, *$P < 0.05$, **$P < 0.01$;***$P < 0.001$

Source: Field Data (2024)

Table 19 displays the results of a regression analysis exploring factors that influence the likelihood of adopting Circular Agriculture. The coefficients indicate the direction (positive or negative) and magnitude of these relationships, while the standard errors, t-tests, and probability values (Prob) provide insights into the statistical significance of these factors. A coefficient with a p-value less than 0.05 suggests that the factor significantly impacts the adoption of Circular Agriculture.

The analysis shows that educational level has a positive coefficient of 0.0187 (p=0.036), indicating that higher education is associated with a greater likelihood of adopting circular agricultural practices. This finding aligns with studies by Silvius et al., (2023) and Cayzer et al., (2017), which emphasize the role of education in increasing access to information and resources. Farmers with higher education are more aware of innovative practices, making them more inclined to adopt Circular Agriculture.

The analysis also indicates a positive effect of age, with a coefficient of 0.0174 (p=0.013), implying that individuals over 18 years are more likely to adopt sustainable practices. This suggests that older individuals may have a greater appreciation for sustainable methods, possibly due to accumulated experience and a willingness to adapt to change. This finding supports research by Papangelou and Mathijs (2021), which shows that older farmers are often more receptive to agricultural innovations, particularly those promoting sustainability.

On the other hand, tenure has a negative coefficient of -0.0363 ($p<0.001$), indicating that longer tenure is associated with a lower likelihood of adopting Circular Agriculture. This suggests that farmers with more established practices might be resistant to change, a form of inertia noted by Cayzer et al., (2017) and Papangelou and Mathijs (2021). However, the positive coefficient for experience (0.0039, $p < 0.001$) suggests that while long-term tenure may impede adoption, greater hands-on experience with farming can positively influence the adoption of sustainable methods, highlighting the value of practical knowledge in overcoming resistance to innovation.

The regression also highlights that land access has a negative coefficient of -0.0792 ($p<0.001$), indicating that land ownership may hinder the adoption of Circular Agriculture. This supports findings by Bianchi et al., (2020), who suggest that traditional farming practices associated with land ownership can lead to resistance against adopting innovative methods. Farmers who own their farm lands ware willing to adopt CAP but farmers who rent are not willing to adopt due to the fact that these processes concerning CAP takes a longer period.

The analysis indicates that marital status and household size have minimal influence on the adoption of circular agriculture practices, evidenced by their high p-values of 0.819 and 0.298, suggesting that these demographic factors do not significantly affect farmers' willingness to adopt sustainable practices. Similarly, landholding and area cultivated also show no significant impact, with p-values of 0.574 and 0.370, highlighting that mere possession of land does not drive the transition to circular agriculture (Nguyen et al., 2021).

Finally, the positive coefficients for access to inputs (0.0518, $p<0.001$) and extension services (0.0827, $p=0.008$) show that better access to resources and technical support significantly increases the likelihood of adopting Circular Agriculture. Khan and Mahajan (2023) emphasize that access to agricultural inputs such as seeds, fertilizers, and extension services provides farmers with the necessary knowledge and tools to implement sustainable practices. By facilitating access to these resources, policymakers can help overcome barriers to adoption and encourage more sustainable agricultural practices.

Awareness of the Benefits of circular agriculture

Table 20: Awareness of the benefits of circular agriculture

	Responses (Awareness)		
GENDER	**No**	**Yes**	**TOTAL**
Female	32 (8.9)	37 (10.3)	**69 (19.27)**
Male	87 (24.3)	202 (56.4)	**289 (80.73)**
Total	**119 (33.2)**	**239 (66.8)**	**358 (100)**
Numbers in parenthesis are percentages		$Chi^2 = 5.807$ p value = 0.016	

Source: Field Data (2024)

Awareness of the benefits of circular agriculture is a crucial driver in adopting the practices among smallholder farmers. It emphasises the use of resources, cost-saving and climate-resilient agriculture. Farmers are more likely to adopt these practices and boost their productivity by understanding these benefits. From Table 20, 66.8% (239) of the respondents indicated that they were aware of the benefits of adopting circular agriculture, while 33.2% (119) indicated that the awareness of the benefits did not influence their adoption of the practices. According to one respondent,

> *I became aware of circular agriculture and its practices through my work as a private consultant in the agricultural sector.*

However, female respondents also claimed that;

> *I have never heard of the term circular agriculture; we use the term sustainable agriculture. The farmers practiced organic farming, using animal manure to fertilize the land.*

Another respondent also made the following comment:

> *The difficulty lies in putting awareness into large-scale practice. Though the majority are informed, the problem lies in*

the practice. They are also discouraged since they lack the resources to perform on a vast scale. However, the practice is often implemented in backyard farms.

Of the 239 respondents who indicated that they were aware of the benefits, 15.5% were females, while 84.5% were males. The chi-square test result (Chi square = 5.807 p value = 0.016) indicates a statistically significant difference in awareness of the benefits of circular agriculture between male and female respondents. Specifically, males show a higher level of awareness (56.4%) compared to females (10.3%). The p-value of 0.016 suggests that this difference is unlikely to be due to random chance, highlighting the need to address gender disparities in awareness and educational outreach efforts.

These findings highlight the role of knowledge and awareness in promoting sustainable agriculture. This aligns with the study of Kaonga (2016), which demonstrates that farmers who know the economic and environmental benefits of conservative agriculture are more inclined to adopt these practices. The respondents who became aware of circular agriculture through their work as private consultants exemplified the influence of professional networks and exposure to contemporary agricultural concepts. Conversely, the respondents who had not heard of circular agriculture but practised organic farming showed the prevalence of alternative terminology and traditional farming methods within specific communities.

Access to technical Knowledge and Resources

Moreover, access to technical knowledge and resources plays a significant role in adopting circular agriculture practices. These include economic incentives, institutional support, technology, training, and capacity

building, essential in encouraging and convincing farmers. The findings in Table 21 demonstrate a difference in the availability of technical knowledge between genders, which substantially affects the adoption of circular agriculture methods among smallholder farmers.

Table 21: Gender Differentiation of Technical Knowledge in Circular Agriculture

Gender	No	Yes
Female	67 (18.7)	2 (0.5)
Male	278 (77.7)	11(3.1)
Total	345 (96.4)	13 (3.6)

Note: Numbers in parenthesis are percentages

Source: Field Data (2024)

Only 3.6% of the respondents had access to technical knowledge and resources, whereas the majority (96.4%) did not have access to it. When broken down by gender, 18.7% of the respondents were females without technical expertise, but only 0.5% reported having access. By contrast, the percentage of males without access was 77.7%, while only 3.1% had access. A Female farmer made the following comment;

> *Farmers do lack the knowledge and awareness of circular agricultural practices. Even those who are aware of it do not put it into practice.*

From the findings, the adoption of circular agriculture is significantly impacted by the limited access to technical knowledge, particularly among smallholder farmers. It is necessary to possess technical expertise to comprehend and execute the intricate procedures associated with circular agriculture, including resource optimisation, refuse recycling, and climate resilience strategies. According to the gender disparity in access to such

knowledge, female farmers are at a substantial disadvantage, which could result in lower adoption rates and productivity gains than their male counterparts.

This disparity can potentially worsen gaps in economic empowerment and agricultural productivity between genders, entrenching poverty and food insecurity in female-headed households (Botreau & Cohen, 2020). These findings are consistent with studies on the barriers to adopting sustainable resources. Studies by Grelet et al. (2021) have stressed that a lack of knowledge and awareness impacts farmers' adoption of sustainable agricultural practices. Similarly, Tsige et al. (2020) and Duffy et al. (2021) have demonstrated that women in agriculture encounter significant obstacles when obtaining technical training, resources and extension services compared to men, which are often limited by cultural norms and gender biases.

Environmental Concerns

Environmental concerns are a significant factor influencing farmers to adopt circular agricultural practices. Farmers' environmental attitudes and perceptions strongly affect their willingness to adopt circular practices like returning crop residues to soil and using manure for compost production. From the study, the majority (81% [290]) of the farmers did not consider environmental concerns as a motivator, while only 19% (68) did. The low percentage of farmers indicated gaps in awareness and prioritisation of environmental sustainability among farmers in the Municipality. This affects the promotion and adoption of circular agriculture.

Furthermore, the findings in figure 11 reveal that among the 68 smallholder farmers who identified environmental concerns as a factor in

adopting circular agriculture practices, the level of motivation varied significantly. Only two farmers considered environmental concerns highly motivating, while 18 found them moderately motivating. Twenty-one farmers felt that environmental concerns were not motivating, and 27 considered them slightly motivating. This distribution indicates that while some farmers recognise the importance of environmental sustainability, most do not see it as a vital motivating factor in their decision to adopt circular agriculture

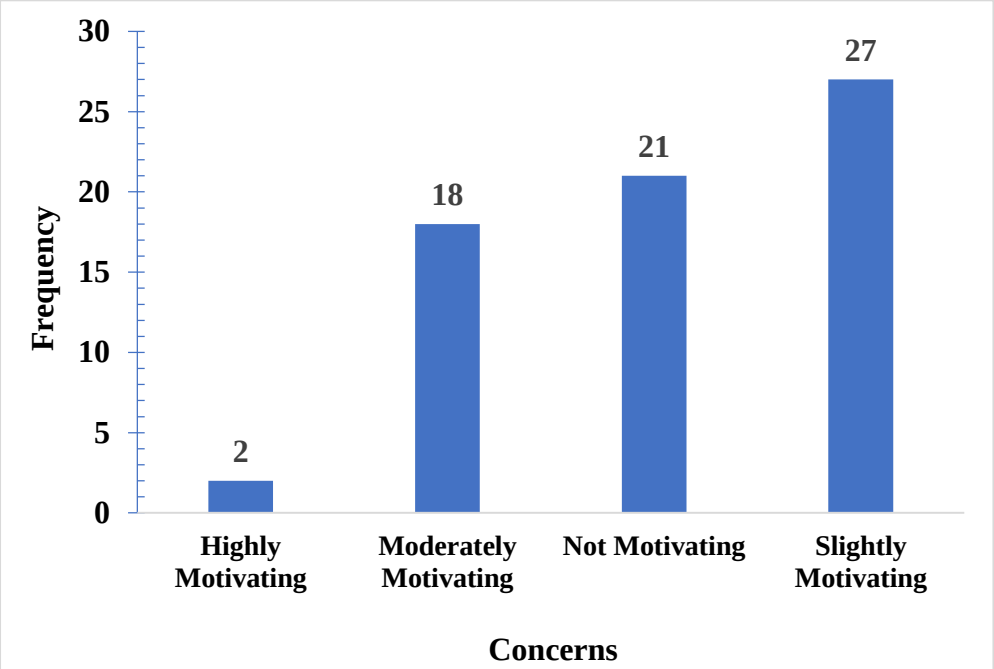

Figure 11: Extent of Environmental Concern as a Motivating Factor
Source: Field Data (2024)

Market Demand and Customer Preference

Market demand and customer preference are crucial in adopting circular agriculture practices. Customer preferences greatly influence the adoption of circular agriculture by smallholder farmers. As consumers' awareness and concern regarding their food choices' environmental and health effects grow, their demand for sustainably produced agricultural goods is anticipated to increase. The change in consumer behaviour can incentivise

farmers to embrace circular agriculture methods, prioritising resource efficiency, waste reduction, and ecological equilibrium.

When the methods are matched with consumer desires for sustainable and environmentally friendly products, farmers have the potential to tap into high-end markets, boost their profitability, and improve their competitiveness. Studies have shown that market-driven incentives, such as customer demand for environmentally friendly products, are essential in promoting sustainable farming (Sheth & Parvatiyar, 2021; Aceleanu, 2016).

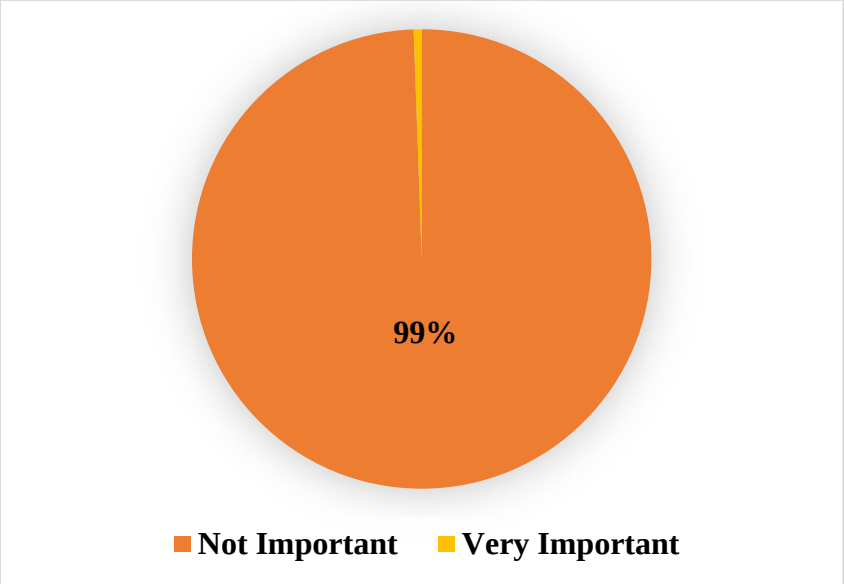

Figure 12: Market Dynamic as a Motivating Factor
Source: Field Data (2024)

From Figure 12, the results suggest that the decision of smallholder farmers to adopt circular agricultural practices is not significantly affected by market demand and customer preference for circular agriculture products. Among the 358 respondents, 99% stated that market demand and customer choice do not play a significant role in their decision-making process. Only 1% of the participants regarded these issues as highly significant. Regarding market dynamics, the farmers stressed that consumer knowledge and

awareness impacted some farmers who adopted circular agriculture practices. One farmer stated:

> *Farmers know the right thing to do, but because consumers are not educated on organic food and their benefits, they will buy anything on the mark8et. This influences some of the farmers not to adopt circular agricultural practices.*

The influence of consumer knowledge and preferences on farmer behaviour indicates the food system's interconnectedness and the need for consumer education to drive demand for sustainably produced goods. This shows that market signals or customer preferences do not influence smallholder farmers' decision to adopt circular agriculture practices. However, their choices about adoption may be more impacted by issues such as cost-effectiveness, resource optimisation, or environmental considerations (Tahat et al., 2020; Silva et al., 2019). The minimal influence of market demand and customer choice underscores the need for more robust market development and consumer awareness campaigns to establish a conducive climate for circular agriculture products, enhancing their appeal and feasibility for farmers.

Peer Influence on adoption Decision of farmers to Circular Agriculture

Other farmers have a significant influence on the adoption of circular agriculture practices. Farmers associated with others who have adopted circular practices are likelier to adopt them. Their confidence in adopting new technologies can increase because they can share knowledge, resources, and risks. For example, in Ghana, professional association farmers are more likely to adopt circular practices because they can collaborate with other farmers to share their costs and benefits. Table 22 shows that observing other farmers

adopting circular agriculture influences smallholder farmers' decision-making processes.

Table 22: Peer Influence on farmers' decision to adopt Circular agriculture
Observation of other farmers adopting circular agriculture

Response	Frequency	Percent
Yes	92	25.7
No	266	74.3
Total	**358**	**100.0%**

Source: Field Data (2024)

Specifically, 25.7% of respondents claimed that the actions of other farmers influenced their decision to implement circular agriculture, whereas 74.3% indicated that it did not. Among the respondents, the influence of the factor varied by gender: from table 22, 7.6% perceived it as extremely influential, with 4 males and 3 females in this category. A majority of 51.1% viewed it as moderately influential, comprising 42 males and 5 females. Meanwhile, 41.3% considered it not influential, with 27 males and 11 females in this group. These findings suggest that while peer influence plays a role in the adoption of circular agriculture, its impact is uneven across genders. The majority, particularly among males, view it as only moderately or not at all influential.

This highlights the need for targeted community-based strategies and peer learning opportunities that can more effectively promote sustainable agricultural practices among smallholder farmers, considering the differences in gender responses. The chi-square value of 286.000 with 1 degree of freedom and a p-value of 0.000 indicates a highly significant association between perceived influence and gender. This significant result suggests that perceptions of how influential other farmers are vary markedly between males

and females, highlighting the importance of understanding these gender differences in shaping strategies for promoting circular agriculture.

Table 23: Farmers adoption decision making process

Response	Male	Female	Frequency	Percentage
Extremely Influential	4	3	7	7.6
Moderately Influential	42	5	47	51.1
Not Influential	27	11	38	41.3
Total	**73**	**19**	**92**	**100.0%**

Chi Square = 286.000 df` = 1 p value = 0.000 N = 358

Source: Field Data (2024)

Government Policies and Support Programs

Government policies and support programs are crucial for farmers adopting circular agricultural practices. Governments can encourage the transition to circular agriculture by providing incentives such as subsidies for organic farming, reducing subsidies for overuse of inputs, and investing in research and development of new technologies like precision agriculture and rainwater harvesting. Strengthening institutions and incentives, such as secure water and land tenure rights, also helps to foster the adoption of circular practices. These measures can help farmers overcome barriers to adopting circular practices and create a more sustainable food system.

From Figure 13, the respondents indicated whether there was an incentive, government policy or support program that encouraged their circular agricultural practices. Most smallholder farmers (95.0%) indicated that their adoption of circular agriculture is not based on the government's support and policies. However, 5% of the farmers indicated that they did receive some form of incentives from the government that influenced their adoption of circular agricultural practices. Moreover, 5% of the respondents indicated that they received some form of incentive from the government that

encouraged their involvement in circular agricultural practices, further indicating the effectiveness of these policies and incentives. The farmers who did receive incentives reported that these policies were very effective; this indicates that well-designed and adequately executed government interventions can significantly enhance the adoption of sustainable practices.

These findings align with the work of Adesida et al. (2021), which shows the importance of government subsidies and secure land tenure in promoting sustainable agricultural practices. Similarly, Adenle et al. (2019) highlighted the necessity of governmental investment in agricultural research and development to drive innovation and adoption of sustainable technologies. Therefore, to increase the uptake of circular agriculture, governments must expand their support programs, ensure accessibility to all farmers, and emphasise the effectiveness of these interventions in promoting long-term sustainability and food security.

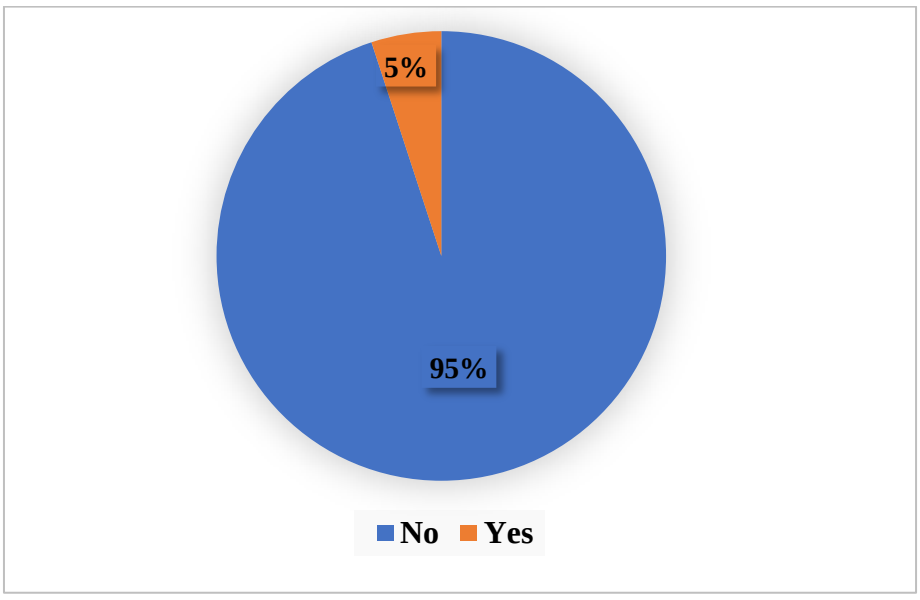

Figure 13: Extent of Environmental Concern as a Motivating Factor
Source: Field Data (2024)

Traditional and other Factors that influence the Adoption of Circular Agriculture

Traditional and other motivating factors influencing farmers' adoption of circular agriculture practices include environmental concerns, economic incentives, and social and other factors. Table 21 shows that cultural and traditional beliefs have little effect on adopting circular agriculture (CA) among smallholder farmers. Only 1.1% of respondents stated that these beliefs influence their decisions. This indicates that cultural issues do not significantly impede the implementation of CA techniques. On the other hand, the main reasons for adopting CA are primarily practical and connected to actual advantages. According to 79.9% of participants, the primary driver is the improvement of soil fertility and health. Subsequently, environmental sustainability impacts 12% of the farmers, while economic benefits are acknowledged by 6.7%. Regarding the economic viability of circular agriculture, farmers perceive it to be poor compared to conventional farming methods. According to a Male farmer:

> *The economic feasibility of circular agriculture appears to be lower when compared to conventional farming methods. This is primarily due to consumers' limited concern about whether a product is sourced from circular agriculture. As a farmer, the decision to practice circular agriculture ultimately depends on individual preferences and circumstances.*

The farmers further stated that selling organic products is not profitable, so most farmers are encouraged to engage in sustainable agricultural practices. According to a respondent,

> *The price of the product will impact my decision to adopt it. As a farmer, I would not opt for circular agriculture (CA) methods and would maintain the exact pricing of those using synthetic fertilisers. This decision stems from the fact that CA products are natural, a widely recognised attribute.*

The product's price significantly influences the adoption of CA practices, consistent with prior research in the field (Kiss, Ruszkai & Takács-György, 2019; Muhie, 2022). El Janati et al. (2021) have highlighted the pivotal role of economic considerations in farmers' decisions regarding agricultural practices. The respondent's statements exemplify the importance of price as a determining factor in adopting circular agricultural practices. Despite the recognised benefit of such practices, including the natural attributes of the products, the reluctance to adopt them at higher prices suggests that economic factors outweigh environmental concerns for some farmers.

Table 24, shows that cultural and traditional beliefs have minimal influence on the adoption of Circular Agriculture (CA), with only 1.1% of respondents (4 individuals) indicating that these beliefs affect their decision-making. In contrast, 98.9% (354 individuals) reported that cultural and traditional beliefs do not influence their adoption of CA practices. This suggests that such beliefs are not significant barriers to the adoption of CA among the surveyed population. The data indicates that other factors may play a more critical role in shaping farmers' decisions to adopt CA practices.

Table 24: Traditional and Other Primary factors Influencing CA adoption

Influence of Cultural/traditional beliefs on CA adoption		
	Frequency	**Percent**
Yes	4	1.1%
No	354	98.9%
Total	**358**	**100.0%**

Source: Field Data, 2024

Moreover, in Table 25, market demand for sustainable goods and reductions in input costs had a minimal impact on farmers adopting circular agriculture practices, influencing only 0.8% and 0.6% of respondents, respectively. The minimal impact of market demand for sustainable goods and reductions in input costs on farmers adopting circular agriculture practices suggests that other barriers, such as financial constraints and lack of support systems, play more significant roles in their decision-making process.

Table 25: Other Primary factors influencing CA adoption

Other Factors	**Frequency**	**Percentage**
Economic Benefits	24	6.7%
Environmental Sustainability	43	12.0%
Improved Soil Fertility and Health	286	79.9%
Market demand for sustainable goods	3	0.8%
Reduction of Input Cost	2	0.6%
Total	**358**	**100.0%**

Source: Field Data (2024)

Smallholder farmers tend to prioritize immediate, tangible benefits that directly improve their agricultural productivity, as shown by the strong impact of enhanced soil fertility and health. This reflects a practical approach to farming, where clear improvements in soil quality and crop yields are the most compelling reasons for adopting new methods. The relatively modest impact of environmental sustainability indicates a growing awareness of its long-term

ecological benefits, though it remains secondary to more immediate agricultural needs. The limited influence of economic benefits, market demand, and cost reduction suggests that these factors currently hold less sway, potentially due to market dynamics or the farmers' economic conditions.

The findings align with the existing research, highlighting that smallholder farmers typically adopt new agricultural methods primarily for their direct advantages regarding crop productivity and soil health. For example, Rodriguez et al. (2009) discovered that implementing sustainable agriculture methods is most effective when farmers can clearly and immediately observe the positive impacts on their soil quality and crop production. Helgason et al. (2021) emphasised that enhancing soil fertility is crucial for smallholder farmers to embrace conservation agriculture methods. The impact of cultural ideas on traditional agricultural methods diminishes as farmers choose practices that provide tangible advantages (Šūmane et al., 2018).

Nevertheless, the limited significance of environmental sustainability indicates a growing consciousness among farmers, possibly influenced by the growing recognition of the effects of climate change. Economic advantages and market demand have a limited influence, indicating a deficiency in the structure of economic incentives. Enhancing market access for sustainably produced items and providing financial incentives for adopting conservation agriculture methods could increase the attractiveness of these practices.

Barriers to Adopting Circular Agriculture Practices Among Smallholder Farmers

This section focuses on objective three of the study, which seeks to identify the barriers smallholder farmers in Yilo-Krobo Municipality face when adopting circular agricultural practices. Smallholder farmers confront many barriers to implementing circular agriculture, including financial, educational, and infrastructure issues. This section presents the perception of smallholder farmers on the barriers they face when adopting circular agriculture in the Yilo-Krobo Municipality. Table 26 presents the farmers' findings on the barriers influencing circular agriculture adoption.

The first item in Table 26 addresses farmers' perception of the lack of financial resources as a barrier to adopting circular agricultural (CA) practices. Most respondents (53.4% agreeing and 34.9% strongly agreeing) identify this as a significant barrier. Only a small percentage disagree (5.9%) or strongly disagree (4.7%). On the issue of financial reasons, a respondent stated:

> *Farmers have problems practising circular agriculture because most farmers want quick results. With organic or circular agriculture, most residues take longer before decomposing, but with inorganic fertiliser, as soon as you apply it within 2-3 or close to a week, you will start seeing the results or the improvement. As a result, most farmers are interested in the inorganic way of farming because of the profit and fast development of their crops.*

Another respondent also stressed that:

> *Farmers cannot focus on circular agriculture for economic reasons; thus, to achieve quick growth and production, they use a variety of fertilisers and pesticides. Because of methods like crop rotation, mixed farming, shifting cultivation (advanced land), and intercropping, circular agriculture can only be carried out on a limited scale by farmers who eat their produce with their families alone. This is because the investment is high, and the returns on profit are low. When considering commercial farmers, they do not like to do this development at this time.*

Table 26: Perception of Farmers on the Barriers of Circular Agriculture

Items	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean Score	Rank
Lack of Financial resources is a barrier to adopting circular agricultural practices	17 (4.7)	21 (5.9)	4 (1.1)	191 (53.4)	125 (34.9)	3.25	3
Insufficient access to modern farming technologies and equipment is a barrier to adopting CA practices.	4 (1.1)	16 (4.5)	10 (2.8)	205 (57.3)	123 (34.4)	3.17	4
Limited knowledge or awareness about CA practices is a barrier to adoption.	0 (0.0)	20 (5.6)	6 (1.7)	213 (59.5)	119 (33.2)	3.09	5
Lack of training or technical support for implementing CA practices is a barrier.	2 (0.6)	18 (5.0)	0 (0.0)	245 (68.4)	93 (26.0)	2.79	6
An inadequate market demand or price incentive for CA products is a barrier.	38 (10.6)	140 (39.1)	11 (3.1)	115 (32.1)	54 (15.1)	4.23	2

Social or cultural norms discourage the adoption of CA practices.	53 (14.9)	156 (43.6)	4 (1.1)	93 (26.0)	52 (14.5)	4.47	1

Chi-square value = 443.195 df=5 Kendall Coefficient=0.248 p value=0.000

Note: SD= Strongly Disagree D=Disagree N=Neutral A=Agree SA=Strongly Agree

Numbers in parenthesis are percentages

Source: Field Data (2024)

Table 26, presents farmers' perceptions of various barriers to adopting circular agriculture (CA) practices, with each item ranked according to its mean score. The barrier perceived as most significant is "Social or cultural norms discourage the adoption of CA practices," with a mean score of 4.47, indicating that this factor is considered a major obstacle by the majority of respondents. Rust et al. (2023) suggests that while social norms can hinder innovation, they can also facilitate the spread of sustainable practices when aligned with community values.

This is followed closely by "Inadequate market demand or price incentive for CA products," which has a mean score of 4.23, suggesting that market dynamics are also a significant concern for farmers. However, most farmers believe that social and cultural norms do not discourage adopting CA practices. Mellon-Bedi et al. (2020) show that market incentives and consumer demand are crucial in encouraging farmers to adopt sustainable practices. Farmers may lack the motivation to invest in and transition to CA practices without sufficient market demand.

The item "Lack of financial resources" ranks third with a mean score of 3.25, indicating that while financial constraints are recognized as a barrier, they are perceived as less critical than social norms and market demand. (Mgbenka et al., 2016; Liu & Ramakrishna, 2021) as farming activities in the

Municipality are profit driven. Studies by Yigezu et al. (2018) emphasise that initial investment costs for new technologies and sustainable practices are often prohibitive for farmers, limiting their ability to adopt circular agriculture.

Similarly, "Insufficient access to modern farming technologies and equipment" and "Limited knowledge or awareness about CA practices" have mean scores of 3.17 and 3.09, respectively, highlighting that these issues are viewed as moderate barriers to CA adoption. This statement aligns with the findings of Yokamo (2020), which suggests that access to modern agricultural technologies is crucial for adopting sustainable practices.

Technology transfer and the availability of advanced farming equipment are essential for enhancing productivity and sustainability in agriculture, yet they remain out of reach for many due to cost and distribution challenges. Also, Aregay et al., (2018) posit that knowledge dissemination and awareness programs are critical in influencing farmer behaviour and encouraging the uptake of innovative practices. Farmers Agricultural extension services, crucial for sharing technical knowledge, frequently fail to reach smallholder farmers, particularly women (Cao & Solangi, 2023) are less likely to adopt new, sustainable methods without proper knowledge.

Notably, "Lack of training or technical support for implementing CA practices" has the lowest mean score of 2.79, suggesting that while this is acknowledged as a barrier, it is not seen as a primary obstacle compared to others. Zakaria et al. (2020) noted that training and technical support are vital components in adopting new agricultural practices in Ghana. Effective training programs improve technical skills and boost farmer confidence in applying new methods.

The statistical analysis further supports these perceptions. The Chi-square value of 443.195 with 5 degrees of freedom and a p-value of 0.000 indicates that there are significant differences in the perceptions of barriers among farmers. This suggests that the factors influencing CA adoption are not uniformly perceived and that these differences are statistically significant.

The Kendall coefficient of 0.248 reflects a moderate positive association between the various barriers. This coefficient suggests that while there is some level of correlation in the perception of barriers, it is not very strong. The moderate correlation indicates that while farmers' perceptions of one barrier might relate to their perceptions of others, the relationship is not particularly strong, implying diverse views on the relative importance of these barriers.

Role of Stakeholders in Promoting Circular Agriculture Practices Among Smallholder Farmers in Yilo-Krobo Municipality

This section presents the findings on the study's fourth objective, which seeks to analyse the role of stakeholders in promoting circular agriculture practices among smallholder farmers in the Yilo-Krobo Municipality. Stakeholders, including government agencies, NGOs, local agricultural extension services and private entities, significantly influence the adoption of circular agriculture. These entities provide essential support such as financial aid, subsidies, farming technologies and training programs. This section focuses on the role of these stakeholders, which are presented below.

Government Agencies

Government agencies are crucial in promoting CA practices among smallholder farmers by providing essential support and resources. Figure 14

shows that most (93%) of the farmers indicate that they do not receive any form of support from the government. A farmer made the following statement:

> *We do not receive any support from the government for our farming activities. We do and buy everything ourselves. This makes it difficult for us to engage in any new practices because the traditional methods are cheaper.*

This lack of support significantly hinders the implementation of sustainable farming techniques in the Yilo-Krobo Municipality. The absence of support leaves farmers to rely on their limited resources, hindering their ability to adopt and sustain new agricultural practices (Kassie et al., 2013). This perpetuates traditional methods that are less sustainable, impacting the environmental health and long-term viability of agricultural production in the Municipality.

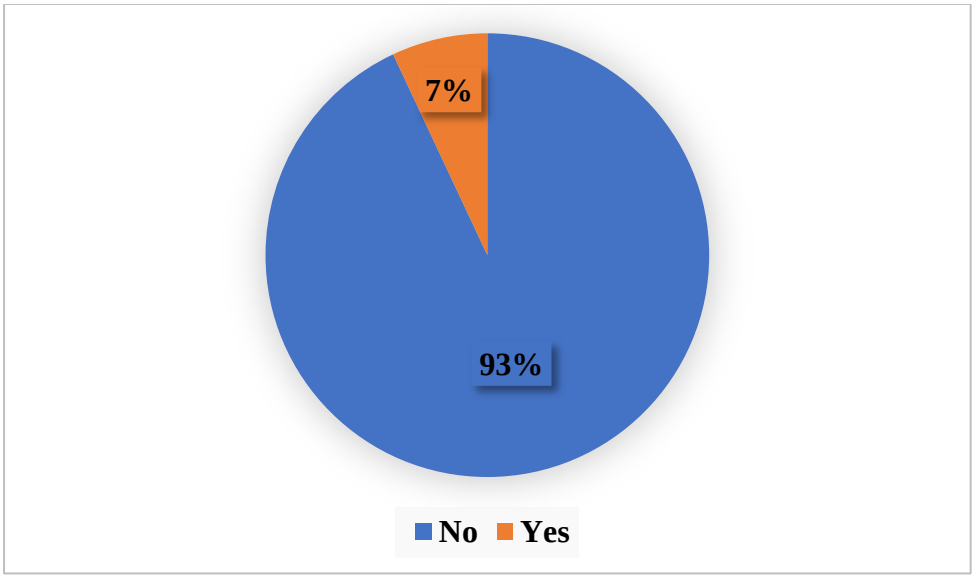

Figure 14: Government Support
Source: Field Data (2024)

Non-Governmental Organisations

Non-governmental organisations (NGOs) play an essential role in developing circular agriculture methods among Yilo-Krobo Municipality's smallholder farmers by providing necessary resources, training, and assistance. They help farmers access new agricultural technologies, provide financial support or microloans, and run educational programmes to increase their knowledge and understanding of sustainable methods (Wijaya et al., 2018). NGOs also help establish market links, allowing farmers greater market access and incentives for their goods.

From the study, all the respondents indicated that they do not receive any form of assistance or support from NGOs in the Municipality regarding circular agriculture. This unanimous response reveals a gap in the collaborative efforts to promote and implement CA practices effectively. Studies have shown that successful implementation of sustainable agriculture practices often requires a multi-stakeholder approach, including the active participation of NGOs (Wijaya et al., 2018; Cheyns & Riisgaard, 2014). The lack of NGO involvement means missed resource mobilisation, knowledge sharing and policy advocacy opportunities.

Agricultural Extension Services

Agricultural extension services are vital in fostering circular agricultural techniques among smallholder farmers in the Yilo-Krobo Municipality by providing crucial knowledge, training, and assistance. These services promote the sharing of information on sustainable agricultural methods, recycling of resources, and effective utilisation of inputs, which are fundamental components of circular agriculture. From Figure 15, most

respondents (92%) indicated they do not receive any support from the Agric extension services. However, 8% of the farmers indicated that they receive support from the extension officers in the Municipality. They further indicated training and knowledge on crop planting and fertilisers to apply on their farms. According to a respondent:

> *The MOFA will sometimes organise workshops for farmers in the Municipality. It often covers sustainable agriculture in the workshop. However, we have not encountered anything related to circular agriculture yet.*

There is a notable absence of specific guidance or workshops on circular agriculture practices, as indicated by a respondent's comment about the workshops organised by the Ministry of Food and Agriculture (MOFA). This shows a missed opportunity for extension services to promote and educate farmers on sustainable and circular agriculture methods, potentially hindering broader adoption and implementation (Espenshade, Reimer & Kauffman, 2022).

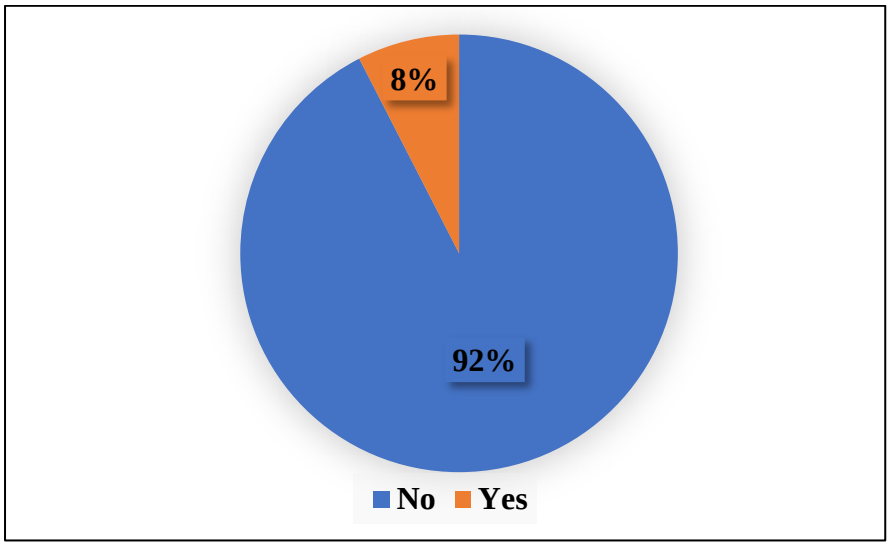

Figure 15: Agric Extension Services Support

Source: Field Data (2024)

Community and Cooperative Associations

Community and Cooperative Associations provide a platform for knowledge sharing, collective action, and resource pooling, which is essential for adopting sustainable practices. They facilitate access to training, modern farming technologies, and financial resources, overcoming individual limitations farmers face. Farmers are often members of these associations because of the benefits they derive from them. Figure 16 shows that the majority (99%) of the farmers are not part of these associations in the Municipality. This lack of membership has significant implications for promoting and adopting CA practices.

Without these entities' support, Municipality farmers may struggle to obtain the knowledge, technology and financial assistance needed to transition to circular agriculture (Gashaw & Kibret, 2018). Moreover, the respondents further indicated that the community associations and groups, including input suppliers, do not promote or support circular agriculture practices in the Municipality. This is the primary reason for their disinterest in the community and cooperative associations in the Municipality.

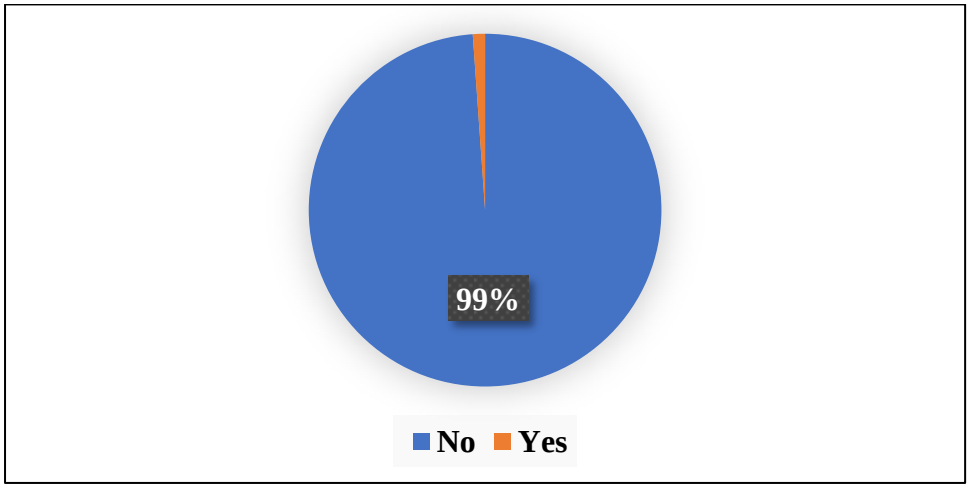

Figure 16: Membership of Community and Cooperative Associations
Source: Field Data (2024)

The absence of advocacy for sustainable practices indicates that farmers lack essential support systems and networks that could facilitate the adoption of circular agriculture. Concerning support systems, most farmers (99%) indicated no supportive community networks or collective actions for promoting circular agriculture. However, 1% indicated that there used to be associations that promoted sustainable agriculture, but they have collapsed due to financial problems. The collapse of previous associations due to financial issues further indicates the necessity for stable funding and organisational structures to sustain these efforts (Patra & Agasty, 2013).

Chapter Summary

The chapter comprehensively analysed the results and discussions based on data collected from 358 smallholder farmers and nine key informants. The chapter began by examining the socio-demographic characteristics of the farmers, revealing a gender imbalance with 80.7% males and 19.3% females engaged in circular agriculture. Findings also highlighted farmers' varying levels of knowledge regarding circular agriculture practices, indicating a significant gap in awareness and understanding. The chapter delved into the role of stakeholders, such as government agencies and NGOs, in promoting sustainable farming techniques, emphasising the need for increased support and resources to facilitate adoption. Moreover, barriers to adopting circular agriculture practices, including financial constraints and limited resource access, were identified as crucial challenges hindering widespread implementation. Recommendations for tailored interventions, community engagement, and financial support programs were proposed to

enhance agricultural sustainability and promote adopting circular agriculture practices among smallholder farmers in the Yilo-Krobo Municipality.

Plate 1: Some Images of Livestock

Plate 2: Some Images of Smallholder farmers

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter presents the summary, conclusions and recommendations of the study based on the study findings. The study assessed smallholder farmers' circular agricultural practices and behaviours in the Yilo Krobo Municipality. The study used a descriptive research design with simple random and purposive sampling techniques to interview 358 respondents from communities in the Yilo-Krobo Municipality. A questionnaire and interview guide were used to collect data in the study. The summary, conclusions and recommendations of the study are presented below.

Summary

This section presents the summary of the study findings. The summary contains the socio-demographics and the findings of the four study objectives. The socio-demographic characteristics of smallholder farmers in the Yilo-Krobo Municipality reveal a diverse yet predominantly male population, with 80.7% of farmers being male and only 19.3% female, indicating a significant gender imbalance influenced by socio-cultural barriers. The age distribution shows that most farmers are middle-aged to older, with the largest group (26.8%) falling within the 50-59 age bracket, while younger farmers (20-29) represent only 3.ss6% of the population, suggesting a potential generational gap in agriculture. Most farmers (85.5%) have an annual expenditure of less than GH₵ 2000. Most of the farmers (93.3%) reportedly lack access to extension services, which are vital for enhancing productivity. The findings

also indicate that a significant portion of farmers (49.5%) rate their knowledge of circular agriculture as low or very low.

Furthermore, when it comes to the circular agricultural practices employed by smallholder farmers in the Yilo-Krobo Municipality, the farmers perceive and adopt various sustainable farming techniques. The data reveals a general reluctance among farmers to adopt practices such as organic manure/compost, disease-resistant crops, and botanical or organic pesticides, with mean scores generally leaning towards disagreement on their effectiveness or benefits. Despite acknowledging the advantages of these practices in boosting soil fertility and decreasing reliance on synthetic chemicals, farmers typically report only moderate use of water-saving techniques and organic fertilisers. Key barriers to wider adoption appear to be limited access to resources, insufficient education on sustainable practices, and economic concerns. Additionally, a significant percentage of farmers practice mixed farming, which potentially enhances land fertility and food security, but the uptake of more labour-intensive or cost-intensive practices like agroforestry and cover cropping remains minimal.

The findings revealed several factors influencing the adoption of circular agriculture practices, the analysis reveals several significant factors influencing the adoption of Circular Agriculture. Socio-economic factors, particularly access to resources and education, play a more critical role in influencing agricultural decisions and the adoption of sustainable practices. Enhancing access to inputs and extension services has been shown to correlate positively with the adoption of circular agriculture methods, emphasizing the need for targeted support in these areas.

Marital status and household size, along with landholding and area cultivated, exhibit minimal influence on the adoption of circular agriculture practices, as indicated by their high p-values of 0.819, 0.298, 0.574, and 0.370. This suggests that these demographic factors and land possession do not significantly affect farmers' willingness to embrace sustainable practices.

Other factors influencing the adoption of circular agriculture practices includes, financial constraints, lack of expertise, limited market access, environmental conditions, inadequate technological infrastructure, and insufficient institutional support are key challenges hindering the widespread adoption of circular agriculture. Awareness of the benefits of circular agriculture is significant, with 66.8% of respondents acknowledging its advantages. However, only 3.6% have access to the necessary technical knowledge and resources, demonstrating a significant gap in capacity and resource availability. Gender disparities were also evident, with only 0.5% of female respondents having access to these resources compared to 3.1% of males. Only 19% of farmers are motivated by environmental concerns, indicating a low priority for environmental sustainability. Market demand and customer preferences similarly play a minimal role, affecting only 1% of respondents. Peer practices had a limited influence, affecting 25.7% of farmers through observation. Government support was scant, with only 5% of respondents reporting that policies and programs have encouraged their practices. These findings revealed the need for more targeted interventions, such as enhancing education, improving resource access, and reinforcing institutional support to foster the adoption of sustainable and circular agricultural methods among Ghana's smallholder farmers.

The study revealed several key barriers affecting the adoption of circular agriculture among smallholder farmers in the Yilo-Krobo Municipality. Financial constraints emerge as a significant hurdle, with 88.3% of farmers citing high initial investment costs and lower returns on circular practices compared to conventional farming as major obstacles. Furthermore, 91.7% of farmers report that lack of access to modern farming technologies and market limitations compound these challenges. Deficits in knowledge and awareness are also critical, recognized by 92.7% of farmers as impediments, underscoring the urgent need for improved educational and extension services. Additionally, 94.4% of respondents point to a lack of training or technical support as a significant gap in the support systems necessary for effectively implementing circular agriculture. Market demand and price incentives for circular agriculture products are deemed inadequate by 47.2% of farmers, highlighting the necessity for more robust market development. Social or cultural norms also play a role, with 40.5% of farmers perceiving them as a barrier, indicating that community perceptions and traditional practices may influence adoption rates variably.

Lastly, the findings on stakeholders' role in promoting circular agriculture in Yilo-Krobo Municipality revealed significant support and resource gaps. Most (93%) farmers reported receiving no support from government agencies, which limited their adoption of sustainable farming practices and kept them dependent on traditional, less sustainable methods. Similarly, all respondents noted a lack of support from NGOs, missing key opportunities for gathering resources, sharing knowledge, and advocating for policies that were vital for effective circular agriculture. Agricultural extension

services were also lacking, with 92% of farmers receiving no specific guidance on circular agriculture, even though there were some general workshops on sustainable practices. Additionally, community and cooperative associations, which could significantly help with knowledge sharing and pooling resources, failed to engage effectively, with 99% of farmers not involved in such groups.

Conclusions

The following are the conclusions of the study based on the summary of findings and the objectives of the study.

The socio-demographic characteristics of smallholder farmers in the Yilo-Krobo Municipality reveal a predominantly male population with limited access to extension services and low knowledge of circular agriculture practices. The age distribution suggests a potential generational gap, with most farmers being middle-aged to older and a small percentage of younger farmers. The findings highlight the need to address gender imbalances and engage younger generations in sustainable agriculture.

Smallholder farmers in the Yilo-Krobo Municipality are reluctant to adopt certain circular agriculture practices, despite acknowledging their benefits. The adoption of sustainable practices is hindered by limited access to resources, insufficient education, and economic concerns. Mixed farming is practiced by a significant percentage of farmers, but more labor-intensive or cost-intensive practices like agroforestry and cover cropping have minimal uptake.

Socio-economic factors, particularly access to resources and education, play a critical role in the adoption of circular agriculture practices. Enhancing

access to inputs and extension services positively correlates with the adoption of sustainable methods, emphasizing the need for targeted support. Demographic factors and land possession do not significantly affect farmers' willingness to embrace sustainable practices.

Financial constraints, lack of expertise, limited market access, inadequate technological infrastructure, and insufficient institutional support are key challenges hindering the widespread adoption of circular agriculture. Awareness of the benefits of circular agriculture is significant, but access to technical knowledge and resources is limited, particularly for female farmers. Targeted interventions are needed to enhance education, improve resource access, and reinforce institutional support for the adoption of sustainable agricultural practices.

The findings indicate a critical lack of support and resources for smallholder farmers in the Yilo-Krobo Municipality, with a staggering 93% reporting no assistance from government agencies. This absence of support not only hampers their ability to adopt sustainable farming practices but also perpetuates reliance on traditional methods that may be less environmentally sustainable. The lack of engagement from NGOs and ineffective agricultural extension services further exacerbate these challenges, highlighting the urgent need for improved collaboration and resource allocation to foster sustainable agricultural practices in the region. Addressing these gaps is essential for empowering farmers and enhancing the overall sustainability of agricultural systems in Yilo-Krobo Municipality.

Recommendations

The following recommendations were made based on the conclusions and objectives of the study. The recommendations are grouped into two sections: practical recommendation for farmers and policy and support recommendation for stakeholders.

Practical Recommendation for Smallholder Farmers

Farmers should begin integrating organic manure and compost into their soil management routines. They can start by dedicating a small portion of their land to experiment with these practices, gradually increasing the area as they gain confidence. Local agricultural extension officers should provide training on the preparation and application of organic fertilisers to ensure effective use.

Farmers should use moderate water-saving techniques, such as drip irrigation and mulching, to conserve water and improve crop yields. Extension services should facilitate workshops on the installation and maintenance of these systems, with demonstrations on how to optimise water use in different crop cycles.

Farmers are encouraged to adopt disease-resistant crop varieties that are suitable for local conditions. They should work closely with agricultural extension services to access and understand how to cultivate these crops effectively, ensuring higher yields and reduced reliance on synthetic pesticides.

Farmers should begin integrating agroforestry and cover cropping into their farming systems, even if on a small scale, to improve soil health and

biodiversity. Community-based initiatives can help form groups where farmers share knowledge and resources to implement these practices more effectively.

Policy and Support Recommendations for Stakeholders

Government and financial institutions should develop microcredit schemes and subsidies tailored for smallholder farmers to alleviate financial constraints. This could include low-interest loans for purchasing organic inputs or incentives for adopting sustainable practices, ensuring farmers have the financial capacity to implement circular agriculture methods.

Agricultural extension services should be expanded and better equipped to provide targeted training and ongoing support to farmers in the Yilo-Krobo Municipality. This should include hiring more extension officers, providing them with adequate resources, and developing training programs that focus on the practical application of circular agriculture techniques.

Stakeholders, including government agencies and NGOs, should work to improve market access for smallholder farmers by developing better infrastructure, such as roads and storage facilities, and by establishing cooperatives that can negotiate better prices for their produce. This will help farmers realise the economic benefits of adopting circular agriculture practices.

The Government and Ministry of Agriculture should design and implement policies that provide tangible incentives for farmers who adopt circular agriculture practices. These could include tax breaks, grants, or recognition programs for farmers who demonstrate significant progress in sustainable farming. These policies should focus on creating a favourable

market environment for organic products, ensuring farmers have the motivation and means to transition to circular agriculture.

Suggestions for further studies

Further research should focus on developing tailored strategies to enhance the adoption of circular agriculture practices among smallholder farmers. This could involve exploring innovative financial models, such as microcredit schemes or subsidies, to alleviate the financial constraints these farmers face. Additionally, research should investigate the effectiveness of targeted training programs and extension services in increasing farmers' confidence in circular practices. It would also be valuable to assess the potential of market-based incentives and technological interventions in overcoming existing barriers, such as inadequate infrastructure and limited market access.

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APPENDICES

APPENDIX 1

QUESTIONNAIRE FOR CIRCULAR AGRICULTURE PRACTICE-BEHAVIOUR

Title: Assessing Circular Agriculture Practices-Behaviour among Smallholder farmers at Yilo-Krobo Municipality, Ghana"

Dear Sir/Madam,

I am Rita Tetteh, a postgraduate student at the Department of Geography and Regional Planning, University of Cape Coast. This questionnaire aims to gather information for a study on the **circular agriculture practices-behaviour of smallholder farmers in the Yilo-Krobo Municipality**. I humbly want to seek your consent to participate in this study. Your participation is voluntary, and you may refuse to participate in or withdraw from this study. However, your participation in this study is relevant since the intention is to aid in policy drafting and implementation. The interview would last between 30 and 40 minutes to complete.

Section 1: Socio-Demographic Characteristics of Respondents

1. Gender a. Male b. Female
2. Age: …….
3. Education Level
   a. No Formal Education b. Basic/Junior High Education
   b. Senior High School/Technical d. Tertiary Education
4. What are the total years of schooling? _____
5. Marital Status
   a. Single b. Married c. Divorced d. Widowed
6. What is your religion? (a) Christian (b) Muslim (c) Traditional (d) None
7. What is your household size? _____

8. What is the number of individuals of age above 18 years? _____
9. What is the number of individuals of age below 18 years? _____
10. How many years have you engaged in farming? ……
11. Do you have access to land? Yes No
12. What is the type of tenure arrangement to the land? (a) Rent (b)Lease (c)Title deed (d)Sharecropping (e) communal ownership
13. What is the total land size or holdings? _____
14. What amount of land area under cultivation? _____
15. What is the total land area under fallow? _____
16. How do you rate your access to agriculture inputs (such as seeds, fertilizers, pesticides)?
    a. Limited b. Moderate c. Abundant/Sufficient
17. Do you have access to agricultural extension service or support?
    a. Yes b. No
18. What type of farming do you engage in?
    a. Crop farming b. Livestock farming c. Mixed farming
19. State the types of crops you have on your farm_____
20. State the kinds of domestic animals you keep
    _____
21. What is your annual income from farming activities?
    a. Less than GH₵ 1,000 b. GH₵ 1,000 - GH₵ 5,000
    c. GH₵ 5,000 - GH₵ 10,000 d. GH₵ 10,000 - GH₵ 20,000
    e. Above GH₵ 20,000
22. What is your exact annual income on farm activities? _____
23. What is your monthly expenditure? _____
24. Do you receive remittances: A. Yes B. No?
25. If yes to Question 13, how much do you receive as remittance? _____

26. Are there social expectations or pressures within your community to practice specific agriculture methods?
    a. Yes b. No
27. If yes, how influential are some of the social pressures in shaping your farming practices?
    a. Not influential b. Moderately Influential c. Highly Influential
28. Are you a member of an association or cooperative organization? _____
29. If yes, can you state some of the specific agriculture methods? _____
30. How would you rate your access to local and regional markets to sell your agricultural produce?
    a. Limited Access b. Moderate d. Excellent Access
31. Do you have knowledge/Awareness/Training on circular agriculture practices?
    a. Yes b. No
32. If yes, how did you become aware of circular agriculture practices?
    a. Through government programs/initiatives
    b. Through agricultural training or extension services
    c. Through peers or fellow farmers
    d. Through media or online sources
    e. Other (please specify) …….
33. If yes, how do you rate your knowledge about circular agriculture practices?
    a. Very Low b. Low c. Moderate d. High
    d. Very High

Section 2: Circular Agricultural Practices Used by Smallholder Farmers

Circular agriculture involves the use of following farming practices

	PRACTICES	**RATING**				
Serial No.		**Strongly Disagree 1**	**Disagree 2**	**Neutral 3**	**Agree 4**	**Strongly Agree 5**
1	Organic manure /Compost					
2	Disease Resistance crop					
3	Botanical/Organics pesticide					
4	Control Erosion					
5	Green Manure					
6	Improved Varieties (High yielding)					
7	Drought tolerant crops					
8	Plant Leguminous plants /trees					
9	Rain harvesting for irrigation					
10	Early Maturing plants					
11	Folder crops to feed animals					
12	Mechanical weed (control/hoes/cutlass /hand weeding)					
13	Minimum tillage					

34. Do you practice crop rotation on your farm?

a. Yes b. No

35. Do you incorporate organic fertilizers or compose into your farm practices?
    a. Yes b. No
36. Do you use cover crops to improve soil fertility and prevent erosion?
    a. Yes b. No
37. Do you employ water-saving techniques, such as drip irrigation or rainwater harvesting?
    a. Yes b. No
38. Do you engage in agroforestry practices, such as planting trees alongside crops or livestock?
    a. Yes b. No
39. Do you use integrated pest management techniques to control pests and diseases on your farm?
    a. Yes b. No
40. Have you adopted any form of renewable energy, such as solar power, for your agricultural activities?
    a. Yes b. No
41. Do you engage in recycling or reusing agricultural waste materials on your farm?
    a. Yes b. No
42. Are you involved in collaborative farming initiatives, such as farmer cooperatives or community-supported agriculture?
    a. Yes b. No
43. How would you rate your farm's overall level of circular agriculture practices?
    a. Very low b. Low c. Moderate d. High e. Very high

Section 3: Factors Influencing Adoption of Circular Agricultural Practices

28 Are you aware of the potential benefits of adopting circular agricultural practices?
    a. Yes b. No

29 Do you have access to the necessary resources (e.g., seeds, fertilizers, equipment) required for adopting circular agriculture practices?
    b. Yes b. No

30 Do you have access to knowledge, technical support or guidance for implementing circular agriculture practices?

a. Yes b. No

31 If yes, what sources provide technical support?

a. Agricultural extension services
b. NGOs
c. private consultants
d. Others (Specify)…….

32 Are environmental concerns a motivating factor for adopting circular agriculture practices?

a. Yes b. No

33 If yes, to what extent are environmental concerns motivating for adopting circular agriculture practices?

a. Not at all motivating b. slightly motivating c. moderately motivating
d. Highly motivating d. extremely motivating

34 How significantly do market demand and customer preference for circular agriculture products influence your decision to adopt circular agriculture practices?

a. Very Important b. Not Important

35 Have you observed other farmers in your community adopting circular agriculture practices?

a. Yes b. No

36 If yes, to what extent does your peers' adoption of circular agriculture practices influence your decision to adopt them?

a. Not influential b. Moderately influential c. Extremely influential

37 Are there any government policies or support programs incentivizing or encouraging circular agriculture practices?

a. Yes b. No

38 If yes, how effective do you think these government policies/support programs are in promoting the adoption of circular agriculture practices?

a. Very Effective b. Not Effective

39 What are the primary reasons motivating you to adopt circular agriculture practices?

a. Environmental sustainability
b. Economic benefits
c. Improved soil fertility and health
d. Reduction of input costs
e. Market demand for sustainable products
f. Compliance with regulations
g. Other (please specify) …….

40 Are there any cultural or traditional beliefs that promote adopting circular agriculture practices?

a. Yes b. No

41 If yes, please specify the cultural or traditional beliefs promoting circular agriculture?

……

Section 4: Barriers to the Adoption of Circular Agricultural Practices

42 Lack of financial resources is a barrier to adopting circular agriculture practices.

a) Strongly disagree b) Disagree c) Neutral d) Agree e) Strongly agree

43 Insufficient access to modern farming technologies and equipment is a barrier to adopting circular agriculture practices.

a) Strongly disagree b) Disagree c) Neutral d) Agree e) Strongly agree

44 Limited knowledge or awareness about circular agriculture practices is a barrier to adoption.

a) Strongly disagree b) Disagree c) Neutral d) Agree e) Strongly agree

45 Lack of training or technical support for implementing circular agriculture practices is a barrier.

a) Strongly disagree b) Disagree c) Neutral d) Agree e) Strongly agree

46 An inadequate market demand or price incentive for circular agriculture products is a barrier.

a) Strongly disagree b) Disagree c) Neutral d) Agree e) Strongly agree

47 Social or cultural norms discourage the adoption of circular agriculture practices.

a) Strongly disagree b) Disagree c) Neutral d) Agree e) Strongly agree

Section 5: Stakeholders' Role in Promoting Circular Agriculture Practices

Government Organization

48 Are you aware of any government initiatives or programs promoting circular agriculture practices?

a. Yes b. No

49 If yes, please specify the government initiatives or programs you know of?

……

50 How do you perceive the government's efforts to promote circular agriculture practices effectively?

……

Non-Governmental Organizations (NGOs)

51 Have you received any support or assistance from NGOs regarding circular agriculture practices?

a. Yes b. No

52 If yes, please specify the type of support or assistance received?

……

53 How effective do you perceive the role of NGOs in promoting circular agriculture practices?

……

Agricultural Extension Services:

54 Have you received any guidance or support from agricultural extension services regarding circular agriculture practices?

a. Yes b. No

55 If yes, how helpful do you consider the support provided by agricultural extension services?

……

Input Suppliers

56 Do your community's input suppliers (e.g., seed companies, fertilizer suppliers) promote or support circular agriculture practices?

a. Yes b. No

57 If yes, how influential are input suppliers in promoting adopting circular agriculture practices?

……

Farmer Cooperatives or Associations:

58 Are you a member of any farmer cooperatives or associations that support or promote circular agriculture practices?

a. Yes b. No

59 If yes, how has the cooperative or association supported your adoption of circular agriculture practices?

……

Local Community

60 Is there a supportive community network or collective action for promoting circular agriculture practices in your community?

a. Yes b. No

61 If yes, how has the local community contributed to promoting and supporting circular agriculture practices?

……

Overall Stakeholder Collaboration:

62 How effective do you think the collective efforts of stakeholders (such as government, NGOs, research institutions, input suppliers, and farmer cooperatives) are in promoting and supporting circular agriculture practices among smallholder farmers in Yilo-Krobo Municipality?

a. Not effective at all
b. Ineffective
c. Neutral
d. Effective
e. Highly effective

Farmers' perceptions of environmental problems associated with conventional agriculture

Indicator	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5
Reduces soil fertility					
Effects human health					
Reduces fish catch					
Soil toxicity					
Water contamination					
Increases crop diseases					
Soil compaction					
Increases soil salinity					
Increases soil erosion					
Increase insect infestation					
Kills pollinators					
Weedicide destroy Beneficial crops (e.g. Cocoyam)					
Snails are disappearing					
Wild honey is uncommon					

Farmers' perceptions or knowledge on safety application of pesticides (agrochemicals) on the farm

Serial No.	Indicators	Rarely	Sometimes	Often	Always
1	Use of Apron: Protective clothing				
2	Use Hand gloves				
3	Wear Boots				
4	Wear protective Goggles				
5	Wear Headgear (Cap/hat)				
6	Use respirators/Gas Mask during spraying				
7	Calibrations/Right Concentration				
8	Follows manufacturing Instructions				
9	Read Labels				

10	Spray pesticides during windy days				
11	Spray pesticides immediately after rainfall				
12	Bath after spraying				
13	Wash hand before eating and drinking				
14	Apply fertilizer during dry season				
15	Apply fertilizer very close to the plant				
16	Use empty pesticides bottles containers after application				
17	Harvest vegetable & fruits less than 7 days after spraying				
18	Apply pesticides close to water body				
19	Use pesticide for fishing or trap wild animals (grass cutter/rat) for food				
20	Use agro-pesticides to control household pests				

RESEARCH INSTRUMENT B

UNIVERSITY OF CAPE COAST

DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING

INTERVIEW GUIDE FOR STAKEHOLDERS

Dear Sir/Madam,

I am Rita Tetteh, a postgraduate student at the Department of Geography and Regional Planning, University of Cape Coast. This questionnaire aims to gather information for a study on the **circular agriculture practices-behavior of smallholder farmers in the Yilo-Krobo Municipality**. I humbly want to seek your consent to participate in this study. Your participation is voluntary, and you may refuse to participate in or withdraw from this study. However, your participation in this study is relevant since the intention is to aid in policy drafting and implementation. The interview would last between 30 and 40 minutes to complete.

Thank you.

Introduction:

1. Can you please introduce yourself?

Section 1: Circular Agriculture Practices Used by Smallholder Farmers

2. Can you describe the specific circular agriculture practices that are employed in the communities in the Yilo-Krobo Municipality?
3. How did you become aware of these circular agriculture practices?
4. What are the benefits you perceive from practicing circular agriculture methods?
5. Are there any challenges or limitations you have encountered while implementing circular agriculture practices?

Section 2: Factors Influencing Adoption of Circular Agriculture Practices

6. What factors influenced your decision to adopt circular agriculture practices?
7. How do you perceive the economic viability of circular agriculture practices compared to conventional farming methods?
8. Have you faced any barriers or limitations in adopting circular agriculture practices? If yes, please explain.
9. How necessary is knowledge and awareness about circular agriculture practices in influencing adoption?

10. What role does access to resources and technical support play in adopting circular agriculture practices?

Section 3: Barriers to Adopting Circular Agriculture Practices

11. What are your main challenges or barriers in adopting circular agriculture practices?
12. Do financial constraints affect the implementation of circular agriculture practices, and how?
13. Are there any social or cultural factors that hinder the adoption of circular agriculture practices?
14. How do you perceive the role of market access and demand in adopting circular agriculture practices?

Section 4: Role of Stakeholders in Promoting Circular Agriculture Practices

15. Have you received support or assistance from government programs or initiatives regarding circular agriculture practices?
16. Are any non-governmental organizations or research institutions providing guidance or support for circular agriculture practices?
17. Have you engaged with agricultural extension services or local authorities for information or resources on circular agriculture practices?
18. Do input suppliers or financial institutions play a role in promoting the adoption of circular agriculture practices?
19. How effective do you perceive the collective efforts of stakeholders in promoting and supporting circular agriculture practices?

Conclusion

20. Do you have any additional information or insights related to the study topic?

Thank you