MODERATING INFLUENCE OF GENDER DYNAMICS ON CONSERVATION AGRICULTURAL PROJECT PRACTICES AND FOOD SECURITY AMONG SMALLHOLDER FARMERS IN SOLAI, NAKURU COUNTY

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A Thesis Project Submitted to the Institute of Postgraduate Studies of Kabarak University in Partial Fulfillment of the Requirement for the Award of Master of Science in Project Management Degree

KABARAK UNIVERSITY

NOVEMBER, 2025

DECLARATION

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Stephen Mwai Githendu

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The project is entitled **"Moderating Influence of Gender Dynamics on Conservation Agricultural Project Practices and Food Security Among Smallholder Farmers in Solai, Nakuru County,"** written by **Stephen Mwai Githendu,** and is presented to the Institute of Postgraduate Studies of Kabarak University. We have reviewed the research project and recommend it be accepted in partial fulfillment of the requirement for the award of the degree of Master of Science in Project Management.

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DEDICATION

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ABSTRACT

Conservation agriculture project practices have been promoted as one of the few technologies affordable to farmers, aiming to improve yields while conserving the environment. Despite the known benefits of Conservation Agriculture, Solai in Subukia sub-County still faces food insecurity, with low adoption among smallholder farmers. This study examined how gender dynamics influenced the relationship between conservation agriculture practices and food security, focusing on cropping methods, minimum soil tillage, continuous soil cover, and the moderating role of gender. The study adopted a cross-sectional survey design and involved smallholder farmers actively participating in conservation agriculture initiatives. This study adopts a cross-sectional descriptive survey design and correlational research design to explore the impact of Conservation Agriculture practices on food security among smallholder farmers. The cross-sectional survey provided a snapshot of current agricultural practices and food security indicators at a single point in time, while the correlational design investigated relationships between variables, specifically examining how adoption of Conservation Agriculture practices relates to food security outcomes. The target population included 107 respondents, including 95 smallholder farmers registered under the Anglican Development Services-Central Rift, who have been practicing Conservation Agriculture for the past three years, and the 6 ADS-CR staff members, 2 ward extension officers for Solai and Kabazi, and local administration (chief and 3 assistants) involved in project oversight. This diverse sample ensured comprehensive insights into the impact of CA on food security in the study area. Data collection methods included structured questionnaires administered during household visits and interviews with key stakeholders. Questionnaires employed Likert scales to assess farmers' perceptions of Conservation Agricultural practices, effectiveness in enhancing crop yield and soil health, challenges encountered, and overall contribution to food security. Interviews provided qualitative insights from ADS-CR staff, ward extension officers, and local administration on project implementation and community engagement. Data analysis involved descriptive statistics to summarize quantitative data and inferential techniques such as correlation and regression analysis to examine relationships between Conservation Agricultural practices and food security outcomes. The study aimed to provide empirical evidence to inform policy and practice in sustainable agriculture, contributing to enhanced food security and environmental sustainability in similar agricultural contexts. Descriptive statistics revealed moderate perceptions of these practices, with average means of 2.70 (SD = 1.299) for cropping methods, 2.84 (SD = 1.257) for minimum tillage, 2.52 (SD = 1.20) for soil cover, and 2.56 (SD = 1.210) for gender dynamics. Correlation results showed strong positive links with food security, where cropping methods had $r = 0.902$, $p < 0.01$, soil cover $r = 0.921$, $p < 0.01$, gender dynamics $r = 0.921$, $p < 0.01$, and minimum tillage $r = 0.766$, $p < 0.01$. Regression showed cropping methods $\beta = 0.472$, $p = 0.000$, gender dynamics $\beta = 0.375$, $p = 0.000$, soil cover $\beta = 0.372$, $p = 0.000$, and minimum tillage $\beta = 0.196$, $p = 0.002$. Gender dynamics also moderated cropping methods, with $\beta = 0.223$ and $p = 0.000$. The study concluded that these agricultural practices, when combined with gender-inclusive approaches, contribute significantly to sustainable food production and improved food security outcomes. The study recommends promoting these practices across Kenya and suggests further research into the socio-economic barriers hindering their adoption in diverse ecological zones.

Keywords: *Cropping Method, Minimum Soil Tillage, Continuous Soil Cover, Gender Dynamics.*

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LIST OF ABBREVIATIONS AND ACRONYMS

ACT	African Conservation Tillage
ADS-CR	Anglican Development Services-Central Rift
ANOVA	Analysis of Variance
CA	Conservation Agriculture
CT	Conventional Tillage
CAP	Conservation Agriculture Project Practices
CM	Cropping Method
CSC	Continuous Soil Cover
MST	Minimum Soil Tillage
GD	Gender Dynamics
ESR	Endogenous Switching Regression
FAO	Food and Agriculture Organization
PoU	Prevalence of Undernourishment
FIES	Food Insecurity Experience Scale
KUREC	Kabarak University Research Ethics Committee
NACOSTI	National Commission for Science, Technology, and Innovation
UM	Upper Medium Zone
USAID	United States Agency for International Development
USAIDCAP	United States Agency for International Development Conservation Agriculture Project
USDA	United States Department of Agriculture
VIF	Variance Inflation Factor
NGOs	Non-Governmental Organizations

OPERATIONAL DEFINITION OF TERMS

Conservation Agriculture: Conservation agriculture is a sustainable farming system that promotes efficient resource use through minimal soil disturbance, permanent soil cover, and crop diversification (Wawire *et al.*, 2021). In this study, it serves as the guiding approach for improving soil health and long-term productivity

Continuous Soil Cover: Continuous soil cover protects soil with organic or inorganic materials, preventing erosion and improving soil health (Alpízar *et al.*, 2020). For this study, the term refers to the ongoing protection practices of soil using cover crops or residues to prevent erosion and maintain soil health.

Cropping Method: Involves planting different crops sequentially on the same land to improve soil fertility and optimize yield (Smith *et al.*, 2019). Intercropping is a farming practice where two or more crops are grown together in the same field to maximize land use efficiency and increase crop yield (Altieri, 1999). In this study, the cropping method refers to the practices of crop rotation and intercropping, where diverse crops are grown consecutively or together on one plot to enhance soil health and achieve sustainable yields.

Food Security: Refers to consistent access to sufficient, safe, and nutritious food for a stable and healthy population (Apanovich & Mazur, 2018). This study will adopt the same meaning.

Gender Dynamics: This refers to the social and cultural roles, expectations, and power relations between men and women in the agricultural context (Smith, 2019). In this study, it examines how gender influences access to resources, decision-making, and participation in conservation agriculture project practices.

Minimum Soil Tillage: This refers to a technique that minimizes soil disturbance, reduces ploughing and cultivating, promotes water retention, and prevents erosion (Ngoma, 2018). Minimum soil tillage in this study involves reduced ploughing to enhance water retention and prevent erosion for sustainable agriculture.

Project Practices: Project practices are specific actions or methods implemented within a project to meet its goals. In this study, activities such as farmer training, input distribution, and monitoring are included to support the adoption of conservation agriculture.

Smallholder Farmers Refers to individuals who engage in small-scale agriculture, contributing significantly to local food production and rural economies (Apanovich & Mazur, 2018). Smallholder farmers in this study are individuals who actively cultivate small plots, which are vital for local food production and the rural economy.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Conservation agriculture (CA) project practices represent a sustainable farming approach that integrates three key principles: minimal soil disturbance, permanent soil cover, and crop rotations & intercropping (Friedrich, 2019). This farming practice aims to enhance soil health, conserve water, and promote biodiversity while improving crop yields and livelihoods. The adoption of CA has garnered attention in recent years as a potential solution to address food security challenges faced by smallholder farmers (Friedrich *et al.*, 2019). Smallholder farmers, who often face resource constraints and vulnerability to climate change, stand to benefit from the resilience and sustainable practices embedded in Conservation agriculture project practices (FAO, 2018).

The inception of Conservation agriculture practices can be traced back to the 20th century when farmers sought alternative methods to address soil degradation and erosion (Derpsch *et al.*, 2022). Over time, the principles of the CA project have evolved and garnered interest as a comprehensive approach to sustainable agriculture, particularly in the context of smallholder farming systems. The emphasis on minimal soil disturbance, continuous soil cover, and diversified cropping systems aligns to ensure food security by maintaining and improving soil fertility, water retention, and overall farm productivity (FAO, 2018).

Globally, the adoption of the CA project has emerged as a pivotal strategy to address food security challenges among smallholder farmers. With an increasing global population and the need to sustainably produce food, CA has gained prominence for its potential to improve crop yields, enhance soil health, and mitigate the impact of climate change on agriculture. According to the Food and Agriculture Organization (FAO), an estimated 125 million hectares of farmland worldwide were under Conservation agriculture project practices by 2020, signifying a growing recognition of its importance on a global scale (FAO, 2020). This widespread adoption reflects the acknowledgment of CA's role in promoting sustainable and resilient farming systems.

In Asia, a significant region in global agriculture, CA project practices have gained momentum as countries strive for sustainable and productive farming. For instance, China, with its large agricultural sector, has increasingly integrated CA into its farming practices, recognizing its potential to enhance soil fertility, conserve water, and improve overall food production (Xin & Li, 2021). Similarly, in the United States, the adoption of CA has expanded, covering millions of hectares. The U.S. Department of Agriculture (USDA) reports indicate that the use of conservation tillage, a key component of the CA project, has steadily increased, reaching approximately 100 million acres in recent years (USDA, 2019). This underscores the global recognition of CA as a valuable approach to ensuring food security.

In the United Kingdom, the CA project has also made strides in sustainable agriculture practices. As the focus on environmental sustainability grows, British farmers have increasingly embraced CA principles to reduce soil erosion, enhance biodiversity, and improve water management (Defra, 2022). The global significance of the CA project is evident in these diverse regions, with varying climates and agricultural landscapes, collectively highlighting its adaptability and effectiveness in contributing to global food security.

Regionally, the adoption of the CA project is gaining traction as a means to bolster food security among smallholder farmers. The unique agricultural landscapes and climatic conditions in various regions of Africa present both challenges and opportunities for sustainable farming practices. Across sub-Saharan Africa, where a substantial portion of the population relies on agriculture for livelihoods, the CA project is increasingly recognized for its potential to enhance soil fertility, reduce erosion, and improve water management (Makate *et al*., 2022). Regional initiatives, such as those promoted by the African Conservation Tillage Network, have played a role in disseminating knowledge and encouraging the adoption of CA project practices among smallholder farmers (ACT, 2021).

Moreover, the Southern African region has seen notable efforts in incorporating the CA project into agricultural systems. Countries like Zambia and Zimbabwe have embraced CA project principles to address challenges related to soil degradation and climate change. The Food and Agriculture Organization (FAO) reports that, by 2020, Zambia had over 2.5 million hectares under Conservation agriculture project practices, demonstrating a substantial commitment to sustainable farming practices (FAO, 2020). Similarly, in Zimbabwe, the CA project has gained prominence, with farmers recognizing its potential to improve crop yields and resilience in the face of changing climatic conditions (Giller *et al*., 2011). These regional trends underscore the growing recognition of CA as a vital strategy for enhancing food security in Southern Africa.

Tanzania and Ethiopia are exploring the integration of the CA project into smallholder farming systems. Tanzania has initiated programs to promote sustainable agriculture, and the CA project has been identified as a key component in achieving these goals (Kassam *et al*., 2015). Similarly, Ethiopia has recognized the importance of the CA project in addressing food security challenges, particularly for smallholder farmers facing diverse agroecological conditions (Alemu *et al*., 2017). The regional emphasis on the CA project reflects a growing understanding of its potential to transform agricultural practices and contribute to food security in diverse African contexts.

Agriculture plays a crucial role in global food security and socio-economic development. However, the sector faces significant challenges due to climate change, including erratic weather patterns, increased temperatures, and changing rainfall patterns. These climatic shifts have a detrimental impact on crop productivity, soil health, and water availability, posing a significant threat to the livelihoods of smallholder farmers, who constitute a substantial portion of the agricultural workforce (Andala & Sirengo, 2019).

In response to these challenges, Conservation agriculture project practices have emerged as a sustainable farming approach that aims to enhance agricultural productivity while mitigating the adverse influence of climate change (Andala & Sirengo, 2019). Conservation agriculture project practices encompass a set of practices that promote minimal soil disturbance, permanent soil cover, and crop diversification. By adopting these principles, farmers can enhance soil health, improve water retention, and optimize nutrient cycling, ultimately leading to increased resilience and sustainable agricultural production.

In Kenya, the adoption of CA project practices has gained significant attention and recognition in recent years. The status of the CA project in the country was assessed, shedding light on the evolving agricultural landscape. Notably, Kenyan farmers have shown a growing acceptance of various CA project principles and practices, although there are exceptions, particularly in the realm of conservation tillage techniques (Owino, 2010). Common CA project practices that have gained traction among Kenyan smallholder farmers include mixed cropping systems, agroforestry/tree pruning, and residue retention or cover crops. These practices have been instrumental in improving soil health and crop yields.

One of the success stories in CA project adoption has been the introduction of green manure legumes like Velvet bean (Mucuna pruriens) and Sunnhemp (Crotalaria

Ochroleuca) in smallholder farms, particularly in the Eastern Province. These legumes have played a crucial role in enhancing soil fertility and overall agricultural sustainability. In various regions across Kenya, including the Nzoia River Basin, farmers have diversified their agricultural practices by incorporating nitrogen-fixing legumes and cultivating animal feeds such as Calliandra, Luceana, Lucerne, and Desmodium Species (Diop *et al*., 2023). These initiatives contribute not only to soil improvement but also to livestock nutrition and overall food security.

Gender dynamics significantly influenced the adoption and impact of Conservation Agriculture (CA) practices on food security among smallholder farmers. Gender dynamics, encompassing the socially constructed roles, responsibilities, and power relations between men and women, shaped access to agricultural resources, decision-making, and participation in sustainable farming practices (FAO, 2020). In smallholder farming systems, these dynamics determined who controlled critical inputs, such as land, credit, and extension services, thereby affecting the implementation of CA principles, including minimal soil disturbance, permanent soil cover, and crop diversification (Meinzen-Dick *et al*., 2021). Understanding gender dynamics was crucial for this study, as they moderated the relationship between CA practices and food security outcomes, particularly for resource-constrained farmers facing climate variability.

In sub-Saharan Africa, where smallholder farmers produce up to 80% of the food yet face persistent food insecurity, gender disparities play a pivotal role in agricultural productivity (FAO, 2021). Women, comprising nearly half of the agricultural workforce, often had limited access to land ownership and training, which constrained their ability to adopt CA practices effectively (Njobe & Kaaria, 2020). For example, studies have shown that women farmers face cultural barriers, with only a small percentage owning land titles, which impacts their engagement in practices such as cover cropping or conservation tillage (Oduol *et al*., 2022). These disparities reduced the efficacy of agricultural interventions, as women's contributions to household food security, including food production and nutrition, were often overlooked.

Gender dynamics also influenced the adoption of CA through labor allocation and decision-making power. Women typically managed labor-intensive tasks, such as intercropping, while men controlled mechanized or market-oriented activities, resulting in uneven adoption patterns (Ngoma *et al*., 2021). Initiatives promoting gender equity, such as women-focused extension services, increased CA uptake and improved food security outcomes. For instance, gender-inclusive programs in Southern Africa enhanced women's access to resources, leading to higher crop yields and dietary diversity in female-headed households (Thierfelder *et al*., 2022). In Kenya, projects integrating women into CA training have reported improved soil fertility and food production, as women have adopted practices such as green manure legumes and agroforestry (Makate *et al*., 2022). We believe these efforts helped strengthen the link between CA practices and food security by addressing gender-based barriers.

Despite progress, challenges persisted in integrating gender dynamics into CA initiatives. Cultural norms, unequal resource access, and limited decision-making power for women hindered the full realization of CA's potential (Kamau *et al*., 2023). For example, women often spend more time on unpaid farm labor, reducing their capacity to participate in CA training or implement resource-intensive practices (Oduol *et al*., 2022). This study examined how gender dynamics moderated the relationship between CA practices and food security, focusing on indicators like affordability, access, and stability of food supply. By providing evidence on the role of gender, we believe it helped inform strategies to promote equitable CA adoption, thereby enhancing resilience and livelihoods for smallholder farmers facing environmental challenges.

1.1.1 Food Security Among Smallholder Farmers

Food security, the dependent variable in this study, is a critical global issue, particularly for smallholder farmers who produce up to 80% of food in sub-Saharan Africa yet face persistent insecurity (FAO, 2020). The Food and Agriculture Organization (FAO) defines food security as a condition where all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food meeting their dietary needs and preferences for an active, healthy life (FAO, 2021). Coates *et al*. (2020) describe it as encompassing availability, access, utilization, and stability, highlighting its multidimensional nature for vulnerable populations. Leroy *et al*. (2022) note that for smallholders, food security encompasses both production capacity and resilience to shocks, as 811 million people globally were undernourished in 2021, with many residing in farming communities (FAO, 2021). This study adopts FAO's definition, emphasizing access and sufficiency, as it aims to assess how conservation agriculture (CA) addresses food insecurity among smallholders amid challenges like climate variability and resource constraints (FAO, 2021).

Generally, food security is measured through various indicators that reflect its complexity. The FAO reports that 9.9% of the global population faced undernourishment in 2020, as measured by the Prevalence of Undernourishment (PoU), while the Food Insecurity Experience Scale (FIES) captures struggles with access (FAO, 2021). Household surveys often use dietary diversity scores or food consumption scores to assess intake variety, with stability measured by supply consistency—30% of sub-Saharan smallholders reported shortages in 2021 (Burchi & De Muro, 2021). These methods provide a broad snapshot, combining quantitative data (e.g., calories) and qualitative perceptions (e.g., hunger experiences). In Africa, where 23% of the population faced severe food insecurity in 2020, measurements often focus on production, access, and resilience to shocks like drought (FAO, 2020). Such approaches highlight the scale of the problem and guide interventions.

Organizations such as the FAO and national bodies adopt these measures for smallholders. The FAO uses composite indices that blend production (e.g., crop yields), access (e.g., market proximity), and stability (e.g., shortage frequency), reflecting smallholders' dual role as both producers and consumers (FAO, 2020). In Kenya, where 20% of rural households were food insecure in 2022, the Ministry of Agriculture tracks food stock duration, farm income, and hunger prevalence (Government of Kenya, 2022). This study measures food security using three indicators—affordability of food, access to farm produce, and stability of food supply—via Likert-scale surveys and interviews. The affordability of food, assessing economic access, is justified as 40% of African smallholders cite cost barriers, and CA may lower these expenses (FAO, 2021; Ngoma *et al*., 2021). Access to farm produce, measuring ease of obtaining food, reflects that 60% of smallholders rely on their crops, with CA boosting yields (Makate & Mango, 2020). Stability of food supply, evaluating consistency, addresses 25% of smallholders in dry regions facing seasonal deficits, supported by CA's resilience benefits (Thierfelder *et al*., 2022). These indicators, integrated into the conceptual framework, link CA practices to food security outcomes, providing a practical and evidence-based approach to addressing a pervasive problem.

Despite the promising trends in CA project practices adoption, it is important to note that many smallholder farmers in Kenya still rely on conventional farming approaches, albeit incorporating certain elements of CA technology to ensure their food security. Additionally, some large-scale farmers continue to use tractor-drawn plows, although many have upgraded their equipment with modern sprayers and planters, including those locally manufactured by Jua-Kali artisans. A comprehensive analysis of CA project practices in Kenya, including an examination of policy gaps, implementation challenges, and outcomes, provides a holistic understanding of the country's agricultural landscape. This broader perspective allows stakeholders and researchers to appreciate both the commonalities and specific nuances of the CA project as practiced in Kenya (Owino, 2010).

The Solai Nakuru region, known for its smallholder farming communities, is an ideal case study area to investigate the impact of Conservation agriculture project practices. This region, like many others, faces the dual challenge of ensuring food security and adapting to climate change. The Conservation Agriculture implemented in Solai, Nakuru, provides an opportunity to assess the effectiveness of Conservation Agriculture project practices in addressing these challenges within the context of smallholder farmers (Andala & Sirengo, 2019).

Understanding the impact of conservation agriculture project practices on smallholder farmers in Solai, Nakuru, is crucial for several reasons: Firstly, it can provide insights into the adoption rates and challenges faced by farmers when implementing Conservation agriculture project practices. This information can guide policymakers and extension services in designing effective strategies for promoting the adoption of Conservation Agriculture project practices on a larger scale. Secondly, studying the impact of Conservation agriculture project practices on soil health, water management, and biodiversity conservation can contribute to the scientific understanding of the potential benefits and limitations of this approach. Finally, investigating the role of Conservation agriculture project practices in ensuring food security and sustainable agriculture in the face of climate change is essential for shaping future agricultural project policies and practices (Akimoto, 2015).

The United States Agency for International Development (USAID) Conservation Agriculture Project practices Plus (CAP) is funded by the mission through its Locally Led Development program. The project is being implemented by Anglican Development Services Central Rift region (ADS-CR) (USAID, 2021). USAID-CAP is an agricultural-based development activity aimed at increasing sustainable food security and reducing poverty of smallholder farmer households (50%Women) in Solai, Nakuru County. The project is designed to diversify food production and promote the consumption of nutritious foods while engaging smallholder farmers, especially women, in profitable economic livelihoods. These objectives are achieved through a cascaded approach, where USAID enhances the effectiveness and capacity of ADS-CR to achieve locally led development through capacity-building initiatives, training, and mentoring, which are passed on to activity participants at the community level. The project efforts are aligned to USAID's Global Food Security Strategy, which serves a rigorous response to sustainably reducing global poverty, hunger, and malnutrition through inclusive and sustainable agriculture-led growth. Through its activities, USAID-CAP also complements the government's efforts to alleviate poverty and address nutrition and food security using the Conservation Agriculture (CA) project as a sustainable, regenerative agricultural practice.

Conducting a comprehensive study of Conservation agriculture project practices from the ongoing project implemented by ADS-CR in Solai, Nakuru, and examining its impact on smallholder farmers, this research aims to contribute to the existing knowledge on the potential of Conservation agriculture project practices as a tool for feeding the future and mitigating climate change. The findings of this study can inform policymakers, researchers, and agricultural practitioners in developing and implementing sustainable agricultural strategies that enhance resilience and improve livelihoods in the face of global environmental challenges (Akimoto, 2015).

1.2 Statement of the Problem

Conservation agriculture project practices have gained recognition for their potential to revolutionize farming practices, offering advantages such as improved soil health, water conservation, and sustainable crop yield. Solai's location has a population of approximately 35,949 residents and heavily relies on agriculture for sustenance and income generation. Despite its agricultural significance, the region grapples with food insecurity issues, with a significant portion of households experiencing periods of food shortage during the year, as indicated by a survey conducted by the Nakuru County Department of Finance and Economic Planning (County Government of Nakuru Annual Progress Report 2019/2020*)*. Additionally, the report stated that adoption of CA practices in Solai remains relatively low, with only 30% of smallholder farmers embracing these sustainable farming techniques, according to the same survey. In light of these local challenges, this study aims to provide insights into how the implementation of the CA project affects food security outcomes in Solai, Nakuru County, thereby contributing to a more localized understanding of the effectiveness of this critical agricultural intervention.

Several past studies have explored the benefits of the CA project. However, they often fall short in providing region-specific insights and fail to account for the unique characteristics of Solai. For instance, a study by Johnson *et al.* (2018) emphasized the positive impact of the CA project on soil health and water conservation. However, it did not delve into the food security implications. Another study by Smith and Brown (2019) highlighted the increased crop yields associated with CA project adoption but did not specifically consider the socio-economic dynamics of smallholder farmers in Solai. This study aimed to bridge the identified gaps by conducting a comprehensive investigation into the influence of Conservation agriculture project practices on ensuring food security among smallholder farmers in Solai, Nakuru County.

1.3 Objectives of the Study

1.3.1 General Objective of the Study

The general objective of this study was to determine the moderating influence of gender dynamics on conservation agricultural project practices and food security among smallholder farmers in Solai, Nakuru County.

1.3.2 Specific Objectives of the Study

i. To determine the influence of cropping method practice on food security among smallholder farmers in Solai, Nakuru County.

ii. To establish the influence of minimum soil tillage practice on food security among smallholder farmers in Solai, Nakuru County.

iii. To evaluate the influence of continuous soil cover practice on food security among smallholder farmers in Solai, Nakuru County.

iv. To examine the moderating influence of gender dynamics on the relationship between Conservation agriculture project practices and food security among smallholder farmers in Solai, Nakuru County.

1.4 Research Hypotheses

H_{01} : Cropping method practice has no statistically significant influence on food Security among smallholder farmers in Solai, Nakuru County.

H_{02}: Minimum soil tillage practice has no statistically significant influence on food security among smallholder farmers in Solai, Nakuru County.

H_{03}: Continuous soil cover has no statistically significant influence on food security among smallholder farmers in Solai, Nakuru County.

H_{04} : Gender dynamics has no statistically significant moderating influence on the relationship between Conservation agriculture project practices and food security among smallholder farmers in the Solai, Nakuru County.

1.5 Purpose of the study

The purpose of the study was to assess the moderating influence of gender dynamics on the relationship between conservation agricultural project practices and food security among smallholder farmers in Solai, Nakuru County. Specifically, the study aimed to evaluate the impact of cropping methods, minimum soil tillage, and continuous soil cover practices on food security, while examining how gender roles and relations influence the effectiveness of these practices. The findings aim to inform sustainable agricultural strategies and gender-inclusive interventions that enhance food security in smallholder farming communities.

1.6 Justification for the Study

The proposed study on the influence of CA project practices on food security among smallholder farmers in Solai, Nakuru County, holds significant relevance and importance for several reasons. Firstly, smallholder farmers constitute a substantial portion of the agricultural workforce in Solai, Nakuru County, and their food security has a direct impact on the overall well-being and livelihoods of the community. By assessing the impact of CA project practices on food security, this study aims to provide valuable insights that can inform agricultural policies and interventions aimed at enhancing food security among smallholder farmers in the region.

Secondly, with the growing concerns over climate change and its adverse influence on agricultural productivity, there is an urgent need to explore and adopt sustainable agricultural practices that can mitigate the impacts of climate variability while enhancing food security. CA project practices such as crop rotation & intercropping, minimum soil tillage, and continuous soil cover have been shown to improve soil health, water retention, and crop resilience to climate shocks. By evaluating the effectiveness of these practices in enhancing food security among smallholder farmers, this study contributes to the broader discourse on climate-smart agriculture and sustainable food production systems.

Furthermore, understanding the moderating influence of gender dynamics on the relationship between CA project practices and food security is crucial for promoting gender-inclusive agricultural development strategies. Women play a significant role in agricultural production and food security. Yet, they often face unique challenges and constraints that may hinder their ability to benefit from Conservation agriculture project practices. By examining the gender dynamics within the context of Conservation agriculture project practices and food security, this study can identify barriers and opportunities for enhancing women's participation and empowerment in agricultural activities.

1.7 Significance of the Study

The completed study on the influence of gender dynamics on conservation Agriculture (CA) project practices on food security among smallholder farmers in Solai, Nakuru County, held significant importance for various stakeholders and contributed to the advancement of knowledge in several ways. Firstly, the study's findings benefited policymakers and agricultural extension services, as they informed the design and implementation of targeted interventions and policies aimed at promoting community-level CA project practices. By demonstrating the benefits of CA practices in improving food security outcomes among smallholder farmers, we believe this will help policymakers prioritize investments and resources toward supporting the adoption and scaling up of these practices, thereby contributing to sustainable agricultural development and poverty alleviation efforts in the region.

The study provided smallholder farmers in Solai, Nakuru County, with evidence-based insights into the effectiveness of CA project practices in enhancing food security. By elucidating the impact of cropping methods, minimum soil tillage, and continuous soil cover on food production and livelihoods, we believe it will help farmers make informed decisions regarding the adoption of sustainable agricultural practices to improve their resilience to climate change and variability.

Furthermore, the academic community and researchers in the fields of agriculture, environmental science, and rural development benefited from the study's findings, as they contributed to the existing body of knowledge on CA project practices and their impact on food security. By providing empirical evidence and insights into the relationship between CA practices and food security outcomes, it is believed that this study will contribute to advancing the growing literature on sustainable agriculture and inform future research directions in the field.

1.8 Limitations of the Study

Accessing some farmers proved difficult due to their tight farming schedules, which delayed questionnaire responses. This challenge was overcome by aligning data collection with organized joint meetings facilitated by ADS-CR. These gatherings provided an ideal opportunity to engage farmers without interrupting their daily work routines.

Several respondents expressed reluctance to share information out of concern for confidentiality. To address this, the researcher emphasized the academic purpose of the study and issued a consent form, assuring participants of anonymity. Participants were informed that no names or personal identifiers would be disclosed, which enhanced their willingness to respond honestly.

Language and cultural differences hindered effective communication during the data collection process. To resolve this, assistant chiefs from the respective sub-locations assisted as interpreters. Their local knowledge ensured accurate translation of questions and responses, reducing the risk of miscommunication and enhancing the quality of the collected data.

The absence of research assistants posed logistical difficulties in managing the fieldwork. Despite this, the researcher conducted the entire data collection process independently. The structured nature of the questionnaires, coupled with support from ADS-CR officials and local leaders, enabled smooth coordination and completion of the study activities.

1.9 Delimitations of the Study

This study specifically examines cropping methods, primarily focusing on crop rotation and intercropping, as CA practices among smallholder farmers in Solai, Nakuru County, under the USAID CAP program. These practices were chosen for their proven ability to enhance soil health, improve crop resilience, and promote sustainable agriculture in smallholder farming systems. Other cropping methods, such as monoculture, fallow systems, shifting cultivation, strip cropping, multiple cropping, and contour strip cropping, were excluded to maintain focus. Monoculture, for instance, emphasizes single-crop production and may not provide the same soil fertility benefits and pest management advantages as crop rotation and intercropping in smallholder contexts. By focusing on these specific CA practices, the research aims to provide targeted insights into their impact on food security and sustainability in Solai.

The study is delimited to Solai, Nakuru County, due to its significance as a focal area for the USAID Programme and its representation of typical challenges faced by smallholder farmers in the region. Solai offers a relevant case study environment where unique socio-economic factors compound issues such as climate variability, land degradation, and food insecurity. Focusing on Solai enables a concentrated analysis of local agricultural practices, socio-economic dynamics, and institutional frameworks that influence the adoption and effectiveness of CA practices in enhancing food security. This geographic delimitation ensures that findings are applicable and meaningful to similar agricultural contexts within Nakuru County and potentially other regions with comparable agro-ecological conditions.

1.10 Assumption of the study

In exploring the impact of CA project practices on food security among smallholder farmers in Solai, Nakuru County, this study operates under several foundational assumptions. Firstly, it assumes that the CA practices implemented by Anglican Development Services-Central Rift (ADS-CR) in Solai are consistently applied according to recognized guidelines for sustainable farming. This assumption is pivotal, as it forms the basis for evaluating how these practices impact soil health, crop yields, and overall food security within the community.

The study assumes active participation and cooperation from stakeholders, including smallholder farmers, ADS-CR staff, ward extension officers, and local administration (senior chief and assistant chiefs). Their involvement is critical for providing accurate and comprehensive information during data collection processes such as interviews and surveys. The assumption is that these stakeholders will candidly share their experiences, perceptions, and challenges related to CA practices, thereby enriching the understanding of their impact on food security.

The study assumes that the reported benefits and challenges associated with CA practices reflect their genuine impact on food security in Solai. This assumption guides the analysis of collected data, assuming that the insights gathered provide a reliable representation of the actual outcomes experienced by farmers and the broader community. By operating under these assumptions, the study aims to uncover significant insights into how CA project practices contribute to enhancing food security in Solai, Nakuru County.

1.11 Scope of the Study

The scope of this study encompassed assessing the influence of CA project practices on food security among smallholder farmers in Solai, Nakuru County. Specifically, the study examined the influence of cropping methods, minimum soil tillage, continuous soil cover, and gender dynamics on food security in this population. The geographical area covered was Solai, Nakuru County, and the target population included registered smallholder farmers under the CA project, ADSCR implementing team, ward agricultural officers, and local administration (chief and assistants) in Solai, Nakuru County. The study was conducted over three months.

The Solai location in Nakuru County, Kenya, is situated approximately thirty kilometres north of the county capital, Nakuru, in the Rongai constituency. Administratively, it falls within the Solai division of Nakuru County, with Lake Solai adorning its northern borders. The location served as the focal point for a study on smallholder farming, particularly the CA project, chosen for its significance in the agricultural landscape of Kenya. The social and ethnic affiliations depicted by the Solai population study influenced involvement in socioeconomic activities at individual, household, and broader societal levels, thus serving as a precursor to addressing food insecurity.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews relevant literature on the relationship between conservation agriculture practices and food security among smallholder farmers. The study begins with a theoretical framework that guides the research, followed by an empirical review of key variables, including cropping methods, minimum soil tillage, and continuous soil cover. The role of gender dynamics as a moderating factor is also explored. The chapter concludes with a summary highlighting research gaps that the study seeks to address.

2.2 Theoretical Framework

This section presents the theories that underpin the study, offering a conceptual foundation for understanding how conservation agriculture practices influence food security among smallholder farmers. The selected theories —Ecological Systems Theory, Diffusion of Innovations Theory, and Social Cognitive Theory - provide insights into the environmental, behavioral, and social factors that shape farmers’ adoption of agricultural practices and their subsequent food security outcomes.

2.2.1 The Ecological Systems Theory

Ecological Systems Theory, developed by Urie Bronfenbrenner in the 1970s, is a comprehensive framework that emphasizes the dynamic interplay between individuals and their environment across different levels of influence. At its core, the theory posits that individuals are nested within multiple systems, ranging from the immediate microsystem (e.g., family, school, peer group) to the broader macrosystem (e.g., cultural values, socioeconomic conditions). Bronfenbrenner proposed that interactions within and between these systems shape individuals' development and behavior over time (Bronfenbrenner, 1979). The theory further highlights the importance of understanding the reciprocal relationships and transactions between individuals and their environment, emphasizing the bidirectional influences that occur as individuals actively engage with and are influenced by their surroundings (Neal & Neal, 2019).

Bronfenbrenner's Ecological Systems Theory comprises five environmental systems: the micro-system, meso-system, exo-system, macro-system, and chronosystem. The micro-system refers to the immediate settings in which individuals directly interact, such as family, school, and neighborhood. The mesosystem encompasses the connections and interactions between different microsystems, influencing individuals' experiences and development. The ecosystem includes external settings that indirectly impact individuals, such as parents' workplaces or community resources. The macrosystem represents the broader cultural and societal contexts that shape norms, values, and institutions. Finally, the chronosystem emphasizes the dynamic nature of development over time, considering historical events and transitions that occur across the lifespan (Neal & Neal, 2019).

Though the Ecological Systems Theory emphasizes the bidirectional influences between individuals and their environments, acknowledging the complexity of human behavior, critiques have emerged regarding its applicability to specific contexts and its neglect of individual agency. Critics argue it oversimplifies human behavior, focusing excessively on environmental influences while overlooking individual characteristics and choices. Additionally, the theory's static portrayal of environmental systems may limit its ability to account for dynamic changes over time or the active role individuals play in shaping their environments. Despite these criticisms, the Ecological Systems Theory remains valuable for highlighting the multifaceted nature of human development and the importance of considering various environmental influences (Swick & Williams, 2020).

In this study on the impact of CA project practices on food security among smallholder farmers, Ecological Systems Theory offers a valuable lens for understanding the multifaceted influences on individuals' agricultural practices and livelihood outcomes. By examining the interplay between various environmental systems, including the microsystem (e.g., farm household), mesosystem (e.g., interactions between farmers and extension services), and macrosystem (e.g., cultural norms around farming practices), insights into the complex factors that shape farmers' adoption and implementation of Conservation Agriculture project practices can be gained. Additionally, considering the dynamic nature of development over time (chronosystem), this study can explore how changes in policy, climate conditions, and market dynamics influence farmers' food security outcomes. Through this theoretical framework, the intricate pathways through which Conservation agriculture project practices interact with individuals' social, economic, and environmental contexts to ultimately impact food security outcomes among smallholder farmers can be elucidated.

2.2.2 Diffusion of Innovations Theory

The Diffusion of Innovations Theory was advanced by Everett Rogers in 1962. This theory explains how new ideas, technologies, and practices spread within a society or social system over time (Rogers, 1962). It identifies five key elements influencing adoption: innovation itself, communication channels, time, the social system, and adopter categories. Rogers (1962) categorized adopters into innovators, early adopters, early majority, late majority, and laggards, describing their varying levels of willingness to adopt new practices. The theory has evolved to incorporate modern advancements in technology diffusion and critiques regarding its applicability across different cultural and economic contexts (Greenhalgh *et al*., 2021). Some scholars argue that the model may oversimplify the adoption process, overlooking factors such as resistance to change and external barriers (Sharma & Reddy, 2023).

A fundamental aspect of this theory is its application to agricultural innovations, directly relating to the first specific objective of the study: determining the influence of cropping method practices on food security among smallholder farmers in Solai, Nakuru County. The theory suggests that the adoption of new cropping methods depends on how information about these methods is disseminated and received (Rogers, 1962). Greenhalgh *et al*. (2021) highlight that effective knowledge-sharing mechanisms, such as farmer-to-farmer learning, extension services, and demonstration farms, significantly influence the rate of adoption. However, some critics argue that adoption is not solely a function of exposure but is also influenced by economic constraints, policy environments, and individual willingness to take risks (Sharma & Reddy, 2023). This study applies the theory to explore how knowledge dissemination affects the adoption of cropping methods and, consequently, food security.

In critiquing the Diffusion of Innovations Theory, it is evident that while it provides a robust framework for understanding adoption patterns, it has limitations. Proponents argue that it effectively explains how new agricultural practices spread and highlights the importance of social networks in influencing adoption (Rogers, 1962). However, critics contend that the theory assumes a linear adoption process and underestimates the role of structural barriers such as inadequate policy support and economic constraints (Sharma & Reddy, 2023). Despite these critiques, the study employs this theory to assess how conservation agriculture practices influence food security outcomes among smallholder farmers.

The relevance of this theory to the study lies in its ability to explain how conservation agriculture practices are adopted and the factors influencing their diffusion. The theoretical framework guides the study by providing a structured understanding of how cropping methods, minimum tillage, and soil cover are disseminated among smallholder farmers. Furthermore, it underscores the importance of considering gender dynamics as a moderating factor in the adoption process. By aligning with this theory, the study establishes a clear linkage between conservation agricultural practices and food security, providing a basis for analyzing their effectiveness in the Solai location.

2.2.3 Social Cognitive Theory

Social Cognitive Theory, developed by Albert Bandura in the 1960s, posits that individuals learn and develop through observing others within their social environment, and by imitating the behaviors, attitudes, and emotional reactions of those around them (Bandura, 1986). According to this theory, learning is not solely achieved through direct experience or reinforcement, but also through vicarious experiences, where individuals observe and model the behaviors of others. Bandura emphasized the importance of self-efficacy, which refers to an individual's belief in their ability to successfully execute a particular behavior to achieve desired outcomes (Bandura, 1994). Self-efficacy plays a crucial role in determining whether individuals will initiate and persist in certain behaviors, influencing their motivation, goals, and level of effort in achieving those goals.

According to this theory, people are more likely to adopt behaviors if they believe they can perform them successfully and if they anticipate positive outcomes. Social Cognitive Theory has been widely applied in various fields, including education, health promotion, and behavior change interventions. However, critics suggest that it may oversimplify the complexities of human behavior and neglect the influence of contextual factors on learning and behavior change. Additionally, the theory's focus on individual cognition may overlook the collective and social nature of learning and behavior. Despite these criticisms, Social Cognitive Theory provides valuable insights into understanding how individuals acquire and maintain behaviors, including the adoption of CA project practices among smallholder farmers in Solai, Nakuru County, by considering the interplay between social influences, cognitive processes, and self-efficacy beliefs.

In the context of the current study, social cognitive theory provides a framework for understanding how the adoption and implementation of CA project practices influence food security among smallholder farmers in Solai, Nakuru County. By examining farmers' self-efficacy beliefs regarding techniques such as crop rotation, intercropping, minimum soil tillage, and continuous soil cover, the study can assess the extent to which these beliefs influence farmers' decisions to adopt and sustain these practices. By investigating how gender norms and roles influence farmers' perceptions of and access to resources for implementing Conservation agriculture project practices, the study can provide insights into potential barriers or facilitators to adoption and sustainability.

2.3 Empirical Review

This section reviews existing empirical studies related to conservation agriculture practices and their influence on food security. The review is organized according to the key variables of the study, including cropping methods, minimum soil tillage, continuous soil cover, and the moderating role of gender dynamics. By analysing findings from previous research, this section helps identify knowledge gaps and supports the formulation of the current study's objectives and hypotheses.

2.3.1 Cropping Methods Practice on Food Security

A study conducted by Micheni, Gathungu, and Muriithi (2023) examined the influence of crop diversification on smallholder coffee farmers' selected crop productivity in Kirinyaga County, Kenya. Guided by utility maximization theory and considering the nature of response variables, the study employed a correlational research design in three agroecological zones (UM1, UM2, and UM3). Data from 408 smallholder coffee farmers were collected using structured questionnaires administered through the Kobo toolbox. The study utilized a Fractional Regression model for data analysis. Findings revealed low average food crop productivity (0.379) in the region, with a significant relationship between crop diversification and selected crop productivity ($p=0.000<0.05$). Positive influences on productivity were observed from landscape heterogeneity (5.7%), crop rotation (13.4%), crop species diversity (56.6%), and land size (10.5%), while agro-ecological zones (AEZs) exerted a negative influence (-4.4%). The research findings indicated that the presence of a diverse range of crop species positively impacts crop productivity, whereas agroecological zones (AEZs) were found to have a negative influence. The study suggests that there is a need to strengthen extension programs aimed at encouraging crop diversification practices.

Jalli (2021) conducted a multi-year field experiment in southwestern Finland to investigate the influence of crop rotation on spring wheat yield and pest occurrence under different tillage systems. The study compared monoculture (spring wheat), 2-year rotation (spring wheat turnip rape spring wheat barley), and 4-year rotation (spring wheat turnip rape barley pea) under both no-tillage and ploughing. Results showed that diversified crop rotations improved spring wheat yield by up to 30% in no-tillage and 13% under ploughing compared to monoculture. The differences in yield quantity and quality between crop rotations were more pronounced in no-tillage plots. Weed occurrence was highest in the four-year rotation but lowest in wheat monoculture. Disease severity, particularly wheat leaf blotch, was lowest in the most diverse crop rotation, with a 20% reduction compared to monoculture. Stem and root disease indices were lowest in the most diverse rotation as well. The study concludes that diverse crop rotations, including cereals, oilseed crops, and legumes, can increase yield and reduce plant disease severity of spring wheat in Finnish growing conditions, with greater influence observed in no-tillage systems.

A study conducted by Raseduzzaman (2016) aimed to assess the potential of intercropping in enhancing yield stability and food security compared to mono-cropping systems. Through a meta-analysis and a three-year field experiment, the study found that cereal-legume intercropping significantly reduced yield variability, particularly in replacement design systems and tropical regions. The analysis of the influence of nitrogen fertilizer revealed a limited impact on intercrop yield but significant effects on individual crop yields and land use efficiency. Intercropping with higher proportions of legumes exhibited greater yield stability. Overall, cereal-legume intercropping was shown to positively impact yield stability and food security, contributing to the sustainability of cropping systems. These findings emphasize the importance of adopting intercropping practices to mitigate yield variability and enhance food security, particularly in the face of climate change challenges.

Yang (2024) conducted a six-year field experiment in the North China Plain to investigate the impact of diversifying crop rotations on food production, greenhouse gas emissions, and soil health. The study demonstrated that incorporating cash crops (sweet potato) and legumes (peanut and soybean) into traditional cereal monoculture rotations (wheat-maize) led to significant benefits. Diversified rotations increased equivalent yield by up to 38%, reduced N2O emissions by 39%, and improved the greenhouse gas balance by 88%. Additionally, including legumes in rotations stimulated soil microbial activities, increased soil organic carbon stocks by 8%, and enhanced soil health by 45%. Scaling up diversified cropping systems in the North China Plain could increase cereal production by 32% and farmer income by 20% while benefiting the environment. This study underscores the importance of crop diversification for sustainable food production practices and long-term agricultural resilience.

2.3.2 Minimum Soil Tillage Practice on Food Security

Ngoma's (2018) study evaluates the influence of Minimum Tillage (MT) on crop yield and income among smallholder farmers in Zambia within the context of climate-smart agriculture. The research, utilizing an endogenous switching regression (ESR) model and cross-sectional data from 751 fields, examines the adoption of MT and its subsequent impact on different crops. Findings indicate that while adopting MT is associated with increased crop yields, particularly for maize, groundnut, sunflower, soybean, and cotton, its short-term influence on overall crop income is limited due to partial adoption, with only 8% of cultivated land under MT. The study underscores challenges such as additional costs for implements, herbicides, and labour, questioning the assumed benefits of labour savings and cost reduction. Ngoma recommends addressing implementation costs through targeted extension services and local adaptations, emphasizing the need for long-term productivity gains to enhance food security and smallholder livelihoods.

A study conducted by Osewe (2020) investigated the impact of minimum tillage adoption on the welfare of smallholder households in Southern Tanzania. The study aimed to assess the potential of minimum tillage practices in enhancing the productivity and welfare of smallholders in the region. Utilizing cross-sectional data from 608 smallholder households, the research employed propensity score matching to analyze the influence of minimum tillage adoption on per capita net crop income and labor demand. The findings revealed that the adoption of minimum tillage had a positive influence on the per capita net crop income of smallholder households, while simultaneously reducing total household labor demands. Despite these positive impacts, the study noted a relatively low adoption rate of minimum tillage, indicating the necessity for governmental intervention to enhance household credit access and provide targeted extension services to encourage wider adoption of minimum tillage practices among smallholder farmers in Southern Tanzania.

A study by Njogu (2016) investigated the influence of tillage and mulching on maize yield, soil water content, and organic carbon in Kirege, Tharaka-Nithi County, Kenya, as part of the requirements. The study aimed to address the challenges of soil water scarcity and enhance crop production in the rain-fed farming systems of the central highlands of Kenya. Two tillage methods, conventional tillage (CT) and minimum tillage (MT), were combined with two mulch levels, removal (W) and retention (R) of crop residue, in a randomized complete block design. Analysis of variance (ANOVA) revealed a significant singular influence of tillage ($p=0.0042$) and mulching ($p=0.0255$) on maize yield, with a significant increase ($p=0.039$) observed when tillage and mulching were combined. CT with residue treatment showed the highest increase in stover yield (72%), while MT with and without residue increased grain yield by over 50% compared to CT. Soil moisture was positively influenced by tillage and mulch combination, with MT increasing moisture content by 10% with residue and 7% without, compared to the control. Additionally, tillage significantly affected soil organic carbon content ($p=0.01$), with MT increasing organic carbon by 0.33% more than CT. The study concluded that short-term implementation of MT and mulching enhances maize production and improves soil conditions in terms of moisture and organic carbon content.

Adam and Abdulai (2023) investigated the influence of minimum tillage (MT) on food and nutrition security in Ghana. MT, an essential component of Conservation agriculture project practices, minimizes soil disturbance except at planting stations, aiming to enhance agricultural productivity and build resilient farming systems. By analysing plot-level and household data alongside historical weather records, the study assessed MT's impact on maize yields, food security, nutrition, and labour demand. Using an ordered probit selection model to address potential biases, the research uncovered significant findings. Prolonged adoption of MT was associated with a substantial increase in maize yields and dietary diversity by approximately 4.33% and 14.22%, respectively. Moreover, household food insecurity and labour demand decreased notably by 42.31% and 11.09%, respectively, following the longer-term adoption of MT. These results underscore the importance of promoting sustained MT adoption among smallholder farmers to improve agricultural productivity and enhance household welfare. By encouraging the implementation of MT for longer cropping seasons, policymakers and agricultural stakeholders can contribute to advancing food and nutrition security in Ghana and similar contexts.

A study conducted by Githongo *et al*. (2023) investigated the impact of minimum tillage and animal manure on maize yields and soil organic carbon (SOC) in sub-Saharan Africa (SSA). With declining soil fertility in the SSA due to continuous cropping and inadequate nutrient replacement, the study aimed to assess the effectiveness of organic inputs and minimum tillage in mitigating this decline and enhancing crop growth and yields. Utilizing a meta-analysis approach, the study reviewed peer-reviewed publications on the influence of minimum tillage and animal manure on maize yields and SOC in SSA, extracting data from selected studies obtained through the Science Direct database. Results revealed that while minimum tillage showed no significant influence on maize yields and SOC, the application of animal manure significantly improved both maize yields and SOC levels. This underscores the importance of incorporating animal manure into maize cropping systems in SSA to enhance yields and soil fertility.

2.3.3 Continuous Soil Cover Practice on Food Security

Tran Van Dung (2022) investigated the impact of cover crops and mulching on soil physical properties and soil nutrients in a citrus orchard. The field experiment, conducted from 2019 to 2021 in a pomelo orchard, involved four treatments: control (no cover crop), non-legume cover crop (Commelina communis L.), legume cover crop (Arachis Pintoi Krabov & W.C. Gregory), and rice straw mulching (Oryza sativa L.). Soil samples were collected annually at four different layers (0–10, 10–20, 20–30, and 30–40 cm) to assess soil bulk density, soil porosity, and nutrient concentrations. Results indicated that rice straw mulch and leguminous cover crops reduced soil bulk density at depths of 0–10 and 10–20 cm, consequently increasing soil porosity by approximately 2.74% and 3.01%, respectively. Although soil nutrient levels showed no significant differences in the first year, there was significant improvement in calcium (Ca), potassium (K), iron (Fe), and zinc (Zn) concentrations in subsequent years, particularly in the topsoil (0–10 cm) and subsoil (10–20 cm) layers.

A study conducted by Riaz (2022) on the influence of mulching on crop production and soil health in dryland regions aimed to investigate the impact of mulching techniques on agricultural productivity and soil conditions. The study's objectives included evaluating different types of mulches and their efficacy in conserving soil moisture, controlling weeds, and improving soil health. The research design involved field experiments comparing various mulching materials, both organic and inorganic, in terms of their effects on crop yield and soil properties. Methodologies included measuring soil moisture content, temperature, weed growth, and crop performance under different mulching treatments. Findings revealed that mulching significantly enhanced soil moisture retention, moderate soil temperature fluctuations, suppressed weed growth, and promoted soil microbial activity, ultimately leading to improved crop yields in arid and semi-arid regions. Conclusions drawn from the study underscore the importance of mulching as a sustainable technique for mitigating water scarcity and enhancing agricultural productivity in dryland areas. Recommendations included the adoption of appropriate mulching practices tailored to specific agro-climatic conditions to optimize crop production while conserving soil and water resources.

A study conducted by Mhlanga (2021) investigated the crucial role of mulch in enhancing the stability and resilience of cropping systems in Southern Africa, particularly in the context of Conservation agriculture project practices. The study aimed to assess the impact of different combinations of Conservation agriculture project practices components, including no-tillage, crop rotation, and permanent soil cover, on crop yield stability across various environments. The researchers hypothesized that full implementation of all three components would result in more stable production. Field trials conducted at eight locations in Southern Africa evaluated the influence of partial and full implementation of the Conservation Agriculture project's component practices on maize and cowpea yields over 2 to 5 years. Results showed that adding crop rotation and mulch to no-tillage or conventional tillage increased maize grain yield, with the most stable systems observed when mulch was added without crop rotation. Additionally, the study revealed that mulch played a crucial role in enhancing yield stability, particularly in sandy soils with varying rainfall patterns. This research highlights the significance of mulch in enhancing the resilience of cropping systems in Southern Africa, thereby facilitating adaptation to climate change.

A study conducted by Ighodaro, Lategan, and Mupindu (2016) assessed the impact of soil erosion on food security and rural livelihoods in South Africa, focusing on the Upper and Lower Areas of Didimana, Eastern Cape Province. Utilizing a survey research method, the study revealed negative behaviors among farmers and extension officers regarding soil erosion control despite its significant impact in the area. Findings indicated that over 75% of farmers reported losing more than 21% of their crops annually due to erosion, with 55% experiencing adverse influence on crops, livestock, and household feeding. Multiple linear regression analysis demonstrated a positive relationship between farm yield, farmers' access to markets, and their tendencies to adopt erosion control measures, suggesting that increasing yields and market access could enhance adoption rates. Additionally, the study found a positive correlation between farmers' age and the impact of erosion, implying that older individuals, who are more resistant to change, contribute more to erosion. The study recommended implementing appropriate soil erosion management to improve yields, alongside enhancing rural infrastructure and providing agricultural incentives to attract young people to farming in the area.

2.3.4 Moderating influence of Gender Dynamics on Conservation Agricultural Practices and Food Security

A study conducted by Wekesah (2019) aimed to explore the adoption patterns, impacts, and gender-related challenges associated with CA. The objectives included assessing the long-term impact of CA on gender relations, incomes for both men and women, and women's empowerment. The research design involved a comprehensive review and synthesis of existing evidence on gender and CA in various Sub-Saharan African contexts. Methodologies included analyzing data on CA adoption by women, identifying gendered barriers, and evaluating the outcomes of CA project practices on women's incomes, labor involvement, and household food security. Findings revealed mixed results, indicating that while CA had a positive influence on gender relations and women's decision-making in agriculture, gender barriers persisted. The study recommended strategies such as deliberately enlisting women as beneficiaries and involving men in understanding women's agricultural needs to enhance women's participation in CA. Gaps identified in current research included the long-term impact of CA on gender relations and the sustainability of strategies supporting women's involvement in CA. The dynamics of women's access to local farmland markets, particularly in relation to CA participation, were also highlighted as areas requiring further investigation.

A study conducted by Tourtelier, Gorman, and Tracy (2023) examined the influence of gender on the development of sustainable agriculture in France. The study aimed to explore the role of women farmers in sustainable agricultural practices within the French context. Employing qualitative research methods, the study investigated the relationship between gender dynamics and the adoption of sustainable agricultural methods. Findings revealed the existence of gender influence in sustainable agriculture, with women farmers playing a significant role. The study identified four explanations for this correlation: the importance of care and differentiated socialization, access to the profession and working conditions, the specific profile of women engaged in sustainable systems, and the potentially more welcoming dimension of the agroecological space. Overall, the study suggested that a combination of these factors contributes to women's greater sensitivity to engaging in sustainable agricultural practices in France.

A study conducted by Harris-Fry *et al*. (2020) investigated the impact of gender equity in agriculture on nutritional status, diets, and household food security through a mixed-methods systematic review. The study aimed to assess the associations between gender-based inequities (such as income, land, livestock, and workloads) and nutrition outcomes in agricultural contexts of low and middle-income countries. The systematic review included quantitative and qualitative literature without date restrictions. The outcomes examined were women’s and children’s anthropometric status, dietary quality, and household food security. Meta-analyses revealed heterogeneous associations between gender equity indicators (such as women’s share of household income earned and land owned) and household food security. While higher-quality studies showed more consistently positive associations between income equity and food security, evidence on other exposure-outcome pairings was limited. The study concluded that high-quality research is needed to establish the impact of gender equity on nutrition outcomes across different contexts.

Njuki (2023) conducted a scoping review to assess the evidence on the pathways between gender equality, women’s empowerment, and food systems. The study aims to highlight the importance of achieving gender equality and women’s empowerment in food systems for improved food security, nutrition, and sustainability. Using an adaptation of the food system framework, the review organized evidence and identified areas where evidence is strong and where gaps remain. Results indicate strong evidence of women’s unequal access to resources, influenced by contextual social gender norms, and the positive impact of women’s empowerment on outcomes such as maternal education, nutrition, and dietary diversity. However, evidence is limited on topics like gender considerations in urban food systems and aquaculture value chains, engaging men in women’s empowerment, and addressing issues related to migration and indigenous food systems. The study recommends investing in improving women’s leadership, promoting gender equality norms, enhancing access to resources, and building cross-contextual research on gender and food systems.

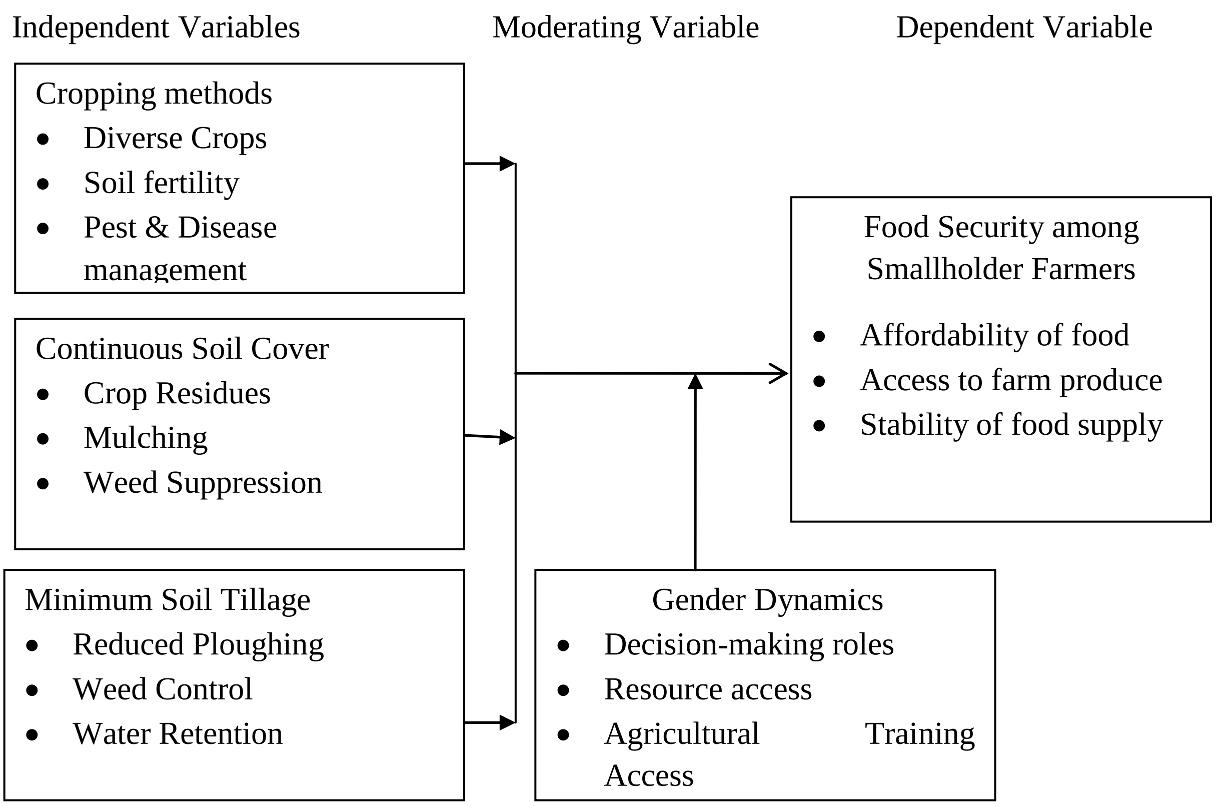
2.4 Conceptual Framework

The independent variables are CA agricultural project practices, namely, cropping methods, Minimum Soil Tillage, and Continuous Soil Cover. Each of these practices comprises specific components that influence agricultural productivity and sustainability.

The moderating variable is Gender Dynamics, which encompasses various socio-cultural factors that may influence how the independent variables impact the dependent variable. Finally, the dependent variable is Improved food safety among smallholder farmers, which is the outcome or response variable that the study seeks to understand or predict. The relationships are shown in Figure 1.

Figure 1

Conceptual Framework



2.5 Summary of Literature Review and Gaps

Table 1 presents the summary, the literature, and gaps

Table 1

Knowledge Gap Table

Author	Topic	Findings	Gaps Identified	How the Current Study Will Solve the Gaps Identified
Micheni, Gathungu, & Muriithi (2023)	Investigated crop diversification influence on smallholder coffee farmers' crop productivity in Kirinyaga County, Kenya	Positive influence observed from landscape heterogeneity, crop rotation, species diversity, and land size	Limited to coffee farming, geographic specificity to Kirinyaga County	The study will focus on the influence of crop rotation & intercropping on food security among smallholder farmers in the Solai, Nakuru County.
Jalli (2021)	Examined crop rotation influence on spring wheat yield and pest occurrence in southwestern Finland	Diversified crop rotations improved spring wheat yield and reduced pest occurrence, with greater benefits observed in no-tillage systems	Limited generalizability to other regions and crops	Investigate the influence of crop rotation on food security among smallholder farmers in Solai, Nakuru County
Raseduzzaman (2016)	Assessed intercropping's potential in enhancing yield stability and food security compared to monocropping systems	Cereal-legume intercropping reduced yield variability and positively impacted food security	Limited scope to specific cropping systems and regions	Evaluate the influence of intercropping on food security among smallholder farmers in Solai, Nakuru County
Yang (2024)	Investigated diversified crop rotations' impact on food production, greenhouse gas emissions, and soil health in the North China Plain	Diversified rotations increased yield, reduced emissions, and improved soil health	Lack of focus on specific regions or crops	Examine the influence of crop rotation and continuous soil cover on food security among smallholder farmers in Solai, Nakuru County
Ngoma (2018)	Evaluated Minimum Tillage (MT) influence on crop yield and income among smallholder	MT adoption increased crop yields but had a limited short-term impact on overall	Limited applicability beyond Zambia and specific crops	Investigate the influence of minimum soil tillage on food security among

	farmers in Zambia	crop income		smallholder farmers in Solai, Nakuru County
Osewe (2020)	Investigated MT adoption on smallholder household welfare in Southern Tanzania	MT adoption positively influenced per capita net crop income and reduced total household labour demands	Limited focus on adoption determinants and long-term impacts	Evaluate the influence of minimum soil tillage on food security among smallholder farmers in Solai, Nakuru County
Njogu (2016)	Examined tillage and mulching influence on maize yield and soil conditions in Tharaka-Nithi County, Kenya	Tillage and mulching positively influenced maize yield, soil moisture, and organic carbon content	Limited generalizability beyond specific regions and crops	Investigate the influence of continuous soil cover on food security among smallholder farmers in Solai, Nakuru County
Adam & Abdulai (2023)	Investigated MT's influence on food and nutrition security in Ghana	Prolonged MT adoption increased maize yields, dietary diversity, and household welfare	Limited focus on specific crops and regions	Evaluate the influence of minimum soil tillage on food security among smallholder farmers in Solai, Nakuru County
Githongo (2023)	Investigated the impact of minimum tillage and animal manure on maize yields and soil organic carbon (SOC) in sub-Saharan Africa (SSA)	Results showed that while minimum tillage showed no significant influence on maize yields and SOC, the application of animal manure significantly improved both maize yields and SOC levels.	Geographic specificity to SSA, focus on minimum tillage and animal manure, methodological approach	Investigate the influence of CA project practices on food security among smallholder farmers in Solai, Nakuru County
Tran Van Dung (2022)	Explored the impact of cover crops and mulching on soil physical properties and soil nutrients in a citrus orchard	Rice straw mulch and leguminous cover crops reduced soil bulk density and increased soil porosity, with	Limited focus on citrus orchards, specific to mulching and cover crops, soil properties,	Examine the impact of continuous soil cover on food security among smallholder farmers in Solai,

		subsequent improvements in soil nutrient levels observed over time.	and nutrients	Nakuru County
Riaz (2022)	Investigated the influence of mulching on crop production and soil health in dryland regions	Mulching significantly enhanced soil moisture retention, moderate soil temperature fluctuations, suppressed weed growth, and promoted soil microbial activity, leading to improved crop yields in arid and semi-arid regions.	Specific to dry land regions, focus on mulching techniques, agricultural productivity, and soil conditions	Evaluate the influence of continuous soil cover on food security among smallholder farmers in Solai, Nakuru County
Mhlanga (2021)	Assessed the role of mulch in enhancing the stability and resilience of cropping systems in Southern Africa	Mulch played a crucial role in enhancing yield stability, particularly in sandy soils with varying rainfall patterns, underscoring its importance in improving the resilience of cropping systems in Southern Africa.	Specific to Southern Africa, focus on mulch and Conservation agriculture project practices, stability, and resilience of cropping systems	Investigate the influence of continuous soil cover on food security among smallholder farmers in Solai, Nakuru County
Ighodaro, Lategan, & Mupindu (2016)	Assessed the impact of soil erosion on food security and rural livelihoods in South Africa	Soil erosion negatively impacts crop yields and household food security, with implications for rural livelihoods, highlighting the need for appropriate soil erosion management.	Specific to South Africa, focus on soil erosion, implications for food security, and livelihoods	Evaluate the moderating influence of gender dynamics on the relationship between CA project practices and food security among smallholder farmers in Solai, Nakuru County

Wekesah, (2019)	Explored the adoption patterns, impacts, and gender-related challenges associated with the Conservation Agriculture (CA) project	While CA had a positive influence on gender relations and women's decision-making in agriculture, gender barriers persisted, underscoring the need for strategies to enhance women's participation in CA.	Mixed results on gender dynamics and CA, focus on gender barriers, and outcomes of CA project practices on women	Investigate the moderating influence of gender dynamics on the relationship between CA project practices and food security among smallholder farmers in Solai, Nakuru County
Tourtelier, Gorman, & Tracy (2023)	Examined the influence of gender on the development of sustainable agriculture in France	Gender influence is observed in sustainable agriculture, with women farmers playing a significant role, attributed to various factors such as care roles, access to the profession, and working conditions.	Specific to France, focus on sustainable agriculture, the role of women farmers	Examine the moderating influence of gender dynamics on the relationship between CA project practices and food security among smallholder farmers in Solai, Nakuru County
Harris-Fry *et al*. (2020)	Investigated the impact of gender equity in agriculture on nutritional status, diets, and household food security	Heterogeneous associations were found between gender equity indicators and household food security, underscoring the need for further research to establish the impact of gender equity on nutrition outcomes across different contexts.	Limited evidence on gender equity and nutrition outcomes, focus on associations, need for high-quality research	Evaluate the moderating influence of gender dynamics on the relationship between CA project practices and food security among smallholder farmers in Solai, Nakuru County

2.5.2 Summary of the Reviewed Literature

The literature reviewed suggests that diversified cropping methods, such as crop rotation and intercropping, have a positive impact on crop productivity and food security. Micheni, Gathungu, & Muriithi (2023) found that crop diversification improved crop productivity among smallholder coffee farmers in Kirinyaga County, Kenya. Similarly, Jalli (2021) reported that crop rotation enhanced spring wheat yield and reduced pest occurrence in southwestern Finland. Raseduzzaman (2016) highlighted that cereal-legume intercropping improved yield stability and food security. Yang (2024) also noted that diversified crop rotations increased yield, reduced greenhouse gas emissions, and improved soil health in the North China Plain. However, these studies were limited by their focus on specific crops and regions. The current study aims to fill these gaps by evaluating the impact of various cropping methods on food security in Solai, Nakuru County, providing a broader understanding applicable to different contexts and crops.

Research has shown that minimum tillage (MT) can enhance crop yields and improve household welfare. Ngoma (2018) found that MT adoption increased crop yields among smallholder farmers in Zambia, though its impact on crop income was limited in the short term. Osewe (2020) observed that MT adoption positively influenced per capita net crop income and reduced household labor demands in Southern Tanzania. Adam & Abdulai (2023) highlighted that the prolonged adoption of MT improved maize yields, dietary diversity, and household welfare in Ghana. However, these studies often focused on specific regions and crops, limiting their generalizability. The current study addressed these gaps by investigating the impact of MT on food security among smallholder farmers in Solai, Nakuru County, providing insights into the broader applicability of MT practices.

Continuous soil cover, including mulching and cover crops, has been shown to improve soil health and crop productivity. Njogu (2016) found that tillage and mulching positively influenced maize yield and soil conditions in Tharaka-Nithi County, Kenya. Tran Van Dung (2022) demonstrated that cover crops and mulching improved soil physical properties and nutrient levels in a citrus orchard. Riaz (2022) reported that mulching enhanced soil moisture retention and crop yields in dryland regions, while Mhlanga (2021) underscored the role of mulch in stabilizing yields in Southern Africa. Despite these positive findings, the studies were often limited by their focus on specific regions, crops, or soil conditions. The current study explored the influence of continuous soil cover on food security among smallholder farmers in Solai, Nakuru County, addressing these limitations and providing more comprehensive insights.

The role of gender dynamics in the adoption and impact of conservation agriculture (CA) practices is critical but under-researched. Ighodaro, Lategan, & Mupindu (2016) highlighted that soil erosion negatively impacted food security and livelihoods in South Africa, with implications for gender dynamics. Wekesah (2019) found that while CA positively influenced gender relations and women's decision-making in agriculture, significant gender barriers persisted. Tourtelier, Gorman, & Tracy (2023) observed that women farmers played a significant role in sustainable agriculture in France, influenced by various gender-specific factors. Harris-Fry *et al*. (2020) noted heterogeneous associations between gender equity indicators and household food security, emphasizing the need for further research. The current study aims to address these gaps by investigating the moderating influence of gender dynamics on the relationship between CA practices and food security among smallholder farmers in Solai, Nakuru County, offering insights into how gender influences CA adoption and outcomes.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the study's methodology, including research design, study location, target population, sampling procedures, data collection tools, and pilot testing. It also covers instrument validity and reliability, data analysis methods, diagnostic tests (normality and multicollinearity), and ethical considerations.

3.2 Research Design

The study employed both a cross-sectional descriptive survey design and a correlational research design. The cross-sectional descriptive survey design provided a snapshot of the current agricultural practices and food security indicators among smallholder farmers in Solai, Nakuru County, at a single point in time. The correlational research design explored the relationship between variables without manipulating them, specifically investigating the connection between the adoption of conservation agricultural practices and food security. By analyzing data on agricultural practices and food security indicators, such as crop yield and income, the study aimed to identify any Correlation between these factors, providing insights into how conservation agriculture may have impacted food security outcomes in the study area.

3.3 Location of the Study

The study was conducted in Solai, a location within Subukia Sub-County, Nakuru County, Kenya. Solai lies approximately 30 kilometres north of Nakuru town and is situated around latitude 0.0714°N and longitude 36.1571°E. The area is characterized by a semi-arid climate and a population of about 35,949 residents, most of whom rely on smallholder farming for their livelihoods. Solai was purposively selected due to its prominence in agricultural production and its vulnerability to food insecurity driven by environmental degradation and erratic rainfall patterns. The study focused on farmers participating in a Conservation Agriculture project implemented by the Anglican Development Services–Central Rift (ADS-CR), which initially registered 125 smallholder farmers. Collaborative efforts with community leaders, extension officers, and ADS-CR facilitated data collection and farmer engagement, making Solai an ideal setting to assess the interaction between conservation practices, gender dynamics, and food security.

3.4 Target Population

The target population included 137 individuals comprising 125 small holder farmers who had been practicing Conservation Agriculture for at least three years and were registered beneficiaries of the Anglican Development Services-Central Rift (ADS-CR), 6 ADSCR staff directly involved in the project's implementation and management, 2 Ward Agricultural Officers, the chief, and three assistant chiefs from Solai location, as indicated in Table 1 below. This diverse group provided comprehensive insights into the impact of Conservation Agriculture project practices on food security among smallholder farmers in Solai, Nakuru County.

These farmers were preferred because their status as project beneficiaries ensured a direct link to the CA Project. The project involved the ADS-CR implementing team, who had been actively engaged in the project and held roles that directly supported CA. It also included Ward Agricultural Officers from the study area who possessed relevant experience in CA, as well as the Chief and Assistant Chiefs who were actively participating in the project area and whose roles aligned with the study’s focus.

Farmers who had not practiced conservation agriculture for at least three years, individuals not registered as ADS-CR project beneficiaries, ADS-CR staff not actively involved in project implementation, or whose roles did not directly support CA, and

Ward Agricultural Officers, the chief, and assistant chiefs not actively participating in the project areas or having roles that did not align with the study's focus were excluded. The target population was not considered vulnerable according to ethical guidelines, and all participants were capable of providing informed consent and participating without risk of coercion or undue influence. The distribution is as shown in Table 2.

Table 2

Population of the Study

Item	Population (N)	$\left\{\frac{N}{\text{Total}} * 100\right\}$ %
ADSCR implementing team	6	4.4%
local administration (chief and 3 assistants)	4	2.9%
Ward agricultural officers	2	1.5%
Smallholder farmers	125	91.2%
Total	137	100%

Source: ADS-CR Records (2025)

3.5 Sampling Procedures

The sampling strategy for this study utilized two methodologies. Purposive sampling was employed to select individuals with specific roles and expertise crucial to the Conservation agriculture project practices. This included the ADS-CR implementing team, the Ward Agricultural Officers, the Chief, and the 3 Assistant Chiefs. Their selection was based on their specialized knowledge and involvement in the project. A simple random sampling technique was used to select the smallholder farmers. Fisher's formula was applied to determine the sample size, ensuring that the sample was representative of various demographic and agricultural characteristics.

Sample size determination:

Population size (N): 125 (Smallholder farmers)

Confidence level (Z): For a 95% confidence level, Z≈1.96Z \approx. 1.96Z≈1.96.

Estimated proportion (p): Since the true proportion is unknown, 0.5 was used to ensure maximum variability, unless a specific estimate is available.

Margin of error (E): Assume a margin of error (E) of 0.05 (5%).

The formula:

$$n = \frac{NxZ^2xPx(1-p)}{E^2x(N-1)+Z^2xPx(1-p)}$$

$$n = \frac{125x(1.96)^2x0.5x(1-0.5)}{0.05^2x(125-1)+1.96^2x0.5x(1-0.5)}$$

$$n = \frac{120.94}{1.2704}$$

n= 95

The table below shows the distribution of sample size.

Table 3

Sample Frame

Item	Population (N)	Sample (n)
ADSCR Implementing Team	6	6
Chief and 3 Assistant Chiefs	4	4
Ward Agricultural Officers	2	2
Smallholder Farmers	125	95
Total	137	107

3.6 Instrumentation

The researcher conducted household visits to administer Likert scale questionnaires to respondents in their respective homes. The primary data collection method involved a structured questionnaire that utilized a Likert scale of agreement, ranging from 1 to 5. This questionnaire served as a crucial tool for assessing respondents' levels of agreement with statements regarding various aspects of Conservation Agriculture (CA) project practices, including attitudes towards CA project practices techniques, perceived effectiveness in enhancing crop yield and soil health, challenges encountered in CA project implementation, and the overall contribution of CA project practices to community food security. To address potential literacy or language barriers among some farmers, research assistants proficient in the local language were engaged based on need and agreeable terms. These assistants orally interpreted the questionnaire for participants who could not read, write, or understand English, ensuring that all respondents could provide their feedback effectively. This approach aimed to promote inclusivity and facilitate comprehensive data collection from diverse members of the community.

The study also employed interview schedules to gather qualitative insights from key stakeholders involved in the Conservation agriculture project practices, including six members of the ADSCR implementing team, ward agricultural officers, the chief, and three assistant chiefs. These interviews provided essential perspectives on project implementation, community engagement, and the overall impact on food security among smallholder farmers in Solai, Nakuru County.

3.6.1 Pilot Testing

The pilot test, also referred to as a pilot study, pilot project, pilot experiment, feasibility study, or pilot run (Campbell, 2022). The study involved testing 10% of the instruments on farmers practicing Conservation Agriculture (CA) implemented by ADS-CR in the Gilgil sub-county of Nakuru County. Gilgil was selected based on its prominence in CA practices within ADS-CR projects. The area's robust agricultural initiatives and widespread adoption of CA made it a suitable location to evaluate the feasibility and effectiveness of the proposed interventions. The sampling theory used to determine the sample size of farmers in Gilgil aligns with methodologies advocated by researchers such as Mugenda and Mugenda, ensuring adequate representation and statistical reliability (Mugenda & Mugenda, 2003). The 10% sample size determination is supported by best practices in pilot testing methodologies, which provide sufficient data for refining the quantitative data collection instrument and ensuring its applicability to the broader study population.

3.6.2 Validity of the Study Instrument

Validity of data in research refers to the degree to which the data accurately measure or represent the intended variables or concepts in a study. It assesses the extent to which the data accurately reflects the true phenomenon or construct being studied. Validity is crucial for drawing meaningful and trustworthy conclusions from research findings (Mohajan, 2017In this study, meticulous attention was devoted to ensuring the validity of the research instrument across multiple dimensions. The construct validity of the instrument was examined to establish a clear alignment between the measured variables and the underlying theoretical construct through factor analysis. The content validity of the study instrument was fortified through the expertise of supervisors well-versed in the subject matter. Their input was instrumental in refining questionnaire items, eliminating ambiguities, and ensuring that the instrument comprehensively covered all relevant aspects of the targeted construct. Face validity was addressed by seeking feedback from potential respondents, ensuring that the instrument was easily understandable and acceptable to the study participants. The criterion validity of the instrument was evaluated by comparing its results with external criteria or established standards, thereby providing a robust validation framework for the data collected in this research.

3.6.3 Reliability of the Study Instrument

When people's answers are stable over several administrations of the same instrument or across sets of items within the same instrument, we say that the instrument is reliable (Franke, 2008). Before collecting primary data, the researcher assessed the instrument's reliability by computing its Cronbach's alpha score. Instrument reliability was measured using the Cronbach alpha score, which goes from 0 to 1. According to Cooper and Schindler (2013), a score between 0 and 0.6 indicates low reliability, whereas a value of 0.7 and above indicates acceptable internal consistency and dependability.

Table 4

Pilot Test Results

Variable	Test Item	Cronbach's Alpha)
Food Security Among Smallholder Farmers	5	0.85
Cropping Method	5	0.80
Minimum Soil Tillage	5	0.78
Continuous Soil Cover	5	0.88
Gender Dynamics	5	0.90

Table 4 presents the pilot test results for various variables, with Cronbach's alpha values indicating the internal consistency of the test items. The values range from 0.78 to 0.90, demonstrating high reliability across the variables. Specifically, "Gender Dynamics" shows the highest reliability at 0.90, while "Minimum Soil Tillage" has the lowest but still acceptable value of 0.78. Overall, the Cronbach's alpha values indicate that the test items consistently measure their respective constructs, supporting the reliability of the survey instruments for the study.

3.7 Data Collection Procedures

The researcher sought approval from the graduate school to collect data. With approval, the researcher applied for a research permit from the National Commission for Science, Technology, and Innovation (NACOSTI). With the consent statement from the school and the research permit from NACOSTI, the researcher proceeded to visit Anglican Development Services-Central Rift (ADS-CR) to seek permission to collect data during their organized joint meetings with the farmers. ADS-CR officials helped the researcher locate farmers on their farms. Questionnaires were administered to the smallholder farmers participating in the Conservation agriculture project practices, using a structured format to gather quantitative data on their perceptions and practices related to CA. The interviews, on the other hand, were conducted with the ADS-CR implementing team members, ward agricultural officers, and local administrators (chief and assistants). These interviews were structured to explore their roles, experiences, and perspectives regarding the implementation and impact of CA initiatives in Solai, Nakuru County.

This dual approach aimed to capture both quantitative insights from farmers and qualitative perspectives from key stakeholders involved in the project, ensuring a comprehensive understanding of the factors influencing food security outcomes in the community. This was low-risk research, with no potential risks to participants. The researcher personally conducted the data collection without recruiting additional personnel, and no payment was required for participation.

To ensure the completeness and integrity of the data, despite the questionnaires being designed for self-reporting and straightforward administration, focusing on the daily activities of farmers, the researcher implemented several key measures. Clear instructions were provided for participants to facilitate accurate and complete responses. To address potential language barriers, the researcher engaged assistant chiefs from the respective sub-locations to assist in interpretation. This ensured that questions were accurately understood without bias and that responses were recorded correctly. Additionally, consistency checks were conducted regularly to ensure that data was collected uniformly and to address any issues that arose promptly.

3.8 Data Analysis and Presentation

The quantitative data collected from smallholder farmers underwent descriptive analysis to summarize key characteristics of the data. This included measures such as means, standard deviations, and frequencies. Following this, inferential analysis was conducted to make predictions and draw conclusions about the population based on the sample data. Techniques such as correlation analysis, regression analysis, and possibly ANOVA were employed to explore relationships between variables and test hypotheses. This helped to understand the impact of conservation agriculture project practices on food security outcomes among smallholder farmers in the study area. The multiple regression model statistics were as follows:

Model without Interaction

The regression equation can be expressed as:

$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \varepsilon$-----------------------------...----------Equation (i)

Where:

Y: Dependent variable (Food Security among Smallholder Farmers)

β_1: Intercept (Constant)

β_1, β_2, β_3, β_4: Coefficients for the independent variables

X_1: Cropping Methods

X_2: Minimum Soil Tillage

X_3: Continuous Soil Cover

X_4: Gender Dynamics

ε: Error term (residual)

Model With Interaction

The regression equation incorporating interaction terms is:

$Y = \beta 0 + \beta_5(X_1 \cdot X_4) + \beta_6(X_2 \cdot X_4) + \beta_7(X_3 \cdot X_4) + \varepsilon$-----------------------------Equation (ii)

Where:

Y: Dependent variable (Food Security among Smallholder Farmers)

β_1: Intercept (Constant)

β_1, β_2, β_3: Coefficients for interaction terms

$X_1 \cdot X_2$: Interaction between Cropping Methods and Gender Dynamics

$X_3 \cdot X_2$: Interaction between Minimum Soil Tillage and Gender Dynamics

$X_4 \cdot X_2$: Interaction between Continuous Soil Cover and Gender Dynamics

ε: Error term (residual)

Open-ended questionnaire responses were analysed using content analysis. Responses were reviewed, categorized based on recurring ideas, and grouped into themes related to conservation agriculture, gender dynamics, and food security. These themes provided deeper insights that complemented the quantitative results and enhanced the understanding of farmers' experiences.

3.9 Diagnostic Tests

The study assessed and validated key assumptions for accurate linear regression analysis, particularly in investigating how conservation agriculture practices and gender dynamics influenced food security among smallholder farmers. Essential tests for normality, heteroscedasticity, and multicollinearity were conducted using the collected quantitative data. These diagnostic tests were crucial for ensuring the robustness and validity of the multiple regression models applied in this study.

3.9.1 Normality Test

Multicollinearity was assessed using the Variance Inflation Factor (VIF) and tolerance metrics. Multicollinearity occurred when independent variables were highly correlated, which could inflate standard errors and make it difficult to assess the individual impact of each predictor on the dependent variable. A VIF score above 10 or a tolerance below 0.1 indicates problematic multicollinearity, necessitating corrective measures such as removing or combining correlated variables (Daoud, 2017). Addressing multicollinearity is crucial to prevent distorted estimates of predictor impacts on food security outcomes.

3.9.2 Multicollinearity Test

Multicollinearity was evaluated using the Variance Inflation Factor (VIF) and tolerance statistics. All predictors, Cropping Method, Minimum Soil Tillage, Continuous Soil Cover, and Gender Dynamics had tolerance values above 0.2 and VIF values well below the critical threshold of 5 (ranging from 0.35 to 0.42), indicating no multicollinearity. This confirmed that each independent variable contributed uniquely to explaining variations in food security without inflating standard errors.

3.9.3 Heteroscedasticity Test

Heteroskedasticity was examined using the Breusch-Pagan test, which evaluates whether the variance of the residuals remains constant across all levels of the independent variables. The test assesses the null hypothesis of homoscedasticity (constant variance) against the alternative of heteroskedasticity (non-constant variance). A p-value below 0.05 indicates the presence of heteroskedasticity, suggesting that the model may require corrective adjustments. Detecting and addressing heteroskedasticity is essential for ensuring the accuracy of regression coefficients and standard errors (Wooldridge, 2020).

3.9.4 Autocorrelation Test

Autocorrelation in the residuals was evaluated using the Durbin-Watson test. This test examines whether the residuals from the regression model are independent, a key assumption for obtaining unbiased parameter estimates, particularly when predictors such as Cropping Method, Minimum Soil Tillage, Continuous Soil Cover, and Gender Dynamics are involved. A Durbin-Watson statistic close to 2.0 (typically within 1.5 to 2.5) suggests no significant autocorrelation, while values far below or above indicate positive or negative correlation, respectively. This test was applied to ensure the reliability of the model's estimates of Conservation Agriculture's influence on food security, aligning with expectations for a cross-sectional design.

3.9.5 Outlier Detection

Outlier detection was conducted to identify and address any extreme observations that could unduly influence the regression model's results. Standardized residuals and Cook's Distance were calculated to assess the data. Standardized residuals exceeding ±3 indicate potential outliers, while Cook's Distance values above 1 or 4/N suggest influential cases requiring scrutiny. A Shapiro-Wilk post-check was also used to verify residual normality. These methods ensured the model's robustness for assessing Conservation Agriculture's impact on food security, confirming that no extreme values compromised the analysis.

3.10 Ethical Considerations

In upholding data ethical considerations, the researcher adhered to strict protocols to ensure the rights and well-being of participants. To obtain approval, the researcher submitted the research project to the relevant ethics committee at Kabarak University, ensuring compliance with institutional policies and legal regulations. Informed consent from farmers was obtained through a detailed consent form, which clearly outlined the research purpose, procedures, potential risks and benefits, and participants' rights. This form was attached to the research materials and signed by each participant before their involvement. Data safeguarding was maintained throughout the research process by ensuring that all data was handled exclusively by the researcher and kept securely under lock and key. Confidentiality and anonymity measures were strictly upheld during dissemination. After the completion of the research, the data were securely discarded following the dissemination of information in accordance with ethical standards.

The researcher also ensured compliance with the National Commission for Science, Technology, and Innovation (NACOSTI) guidelines and obtained any required permits for conducting the research. Additionally, the researcher sought approval for using ADS-CR records of farmers. In the case of ADS-CR, the county ministry of agriculture and local administration in Solai required feedback and findings from the study to inform their decision-making processes. The information was shared transparently, maintaining the confidentiality and privacy of respondents. Through transparent communication and adherence to ethical practices, the researcher sought to create a research environment that prioritized integrity and respected the rights of all parties involved.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION, AND DISCUSSION

4.1 Introduction

This chapter presents the analysis, interpretation, and presentation of the data collected from respondents in the study. Data was collected through structured questionnaires and analysed in the form of tables and descriptive statistics.

4.2 Response Rate

Table 5 below illustrates the response rate.

Table 5

Response Rate

Response	Number of Respondents	Percentage (%)
Expected responses	107	100%
Received responses	100	93.46%
Responses not received	7	6.54%

The response rate of 93.46%, with 100 out of 107 expected responses received and 7 (6.54%) not received, as shown in Table 5, indicates a highly successful data collection process for the study on conservation agriculture practices and food security among smallholder farmers in Solai, Nakuru County. This rate exceeds the 80% threshold recommended by Babbie (2020) for minimizing non-response bias and ensuring sample representativeness, making the findings reliable and generalizable. While the 6.54% non-response rate is low and unlikely to skew results significantly, potential biases from systematic differences in non-respondents' characteristics, such as their engagement with conservation practices or food security status, should be noted. Overall, the high response rate supports robust analysis with minimal risk of bias.

4.3 Demographic Information

4.3.1 Age of Study Respondents

The study sought to understand the age range of the respondents. Table 6 presents the distribution of respondents by age.

Table 6

Age of Study Respondents

		Frequency	Valid Percent
Valid	18-25 years	20	20.0
	26-35 years	25	25.0
	36-45 years	15	15.0
	46-55 years	15	15.0
	56 years and above	25	25.0
	Total	100	100.0

The age distribution of study respondents reveals a fairly diverse range of participants. The largest group is comprised of individuals aged 26-35 years and those aged 56 years and above, each representing 25% of the sample. This is followed by the 18-25-year-olds, making up 20% of the respondents. Meanwhile, the 36-45 and 46-55-year-olds each account for 15%. This distribution indicates a balanced representation across various age groups, with a slight concentration in the younger and older age brackets, which could provide insights into different perspectives and experiences related to the study's focus.

4.3.2 Gender of Study Respondents

Respondents were asked to indicate their gender. Table 7 below summarizes the gender distribution of the respondents.

Table 7

Gender of Study Respondents

		Frequency	Valid Percent
Valid	Male	41	41.0
	Female	59	59.0
	Total	100	100.0

The gender distribution of the study respondents shows a slight female dominance, with 59% identifying as female and 41% as male. This suggests that female participants were more represented in the study, which may reflect the gender dynamics in the research area's context. The relatively higher proportion of females could provide valuable insights into gender-specific factors that influence the study's outcomes.

4.3.3 Marital Status of Study Respondents

The study sought to determine the marital status of respondents. Table 8 presents the findings.

Table 8

Marital Status of Study Respondents

		Frequency	Valid Percent
Valid	Single	30	30.0
	Married	40	40.0
	Divorced/separated	20	20.0
	Widowed	10	10.0
	Total	100	100.0

The marital status distribution of the study respondents reveals that 40% of participants are married, making it the largest group. Single respondents constitute 30%, while 20% are divorced or separated, and 10% are widowed. This distribution highlights the diversity in marital statuses within the sample, which may influence the perspectives and experiences of respondents, particularly in relation to factors like household dynamics, resource management, and decision-making processes. Understanding these variations can provide a deeper context for the study’s findings, especially in relation to social and family structures.

4.3.4 Education Level of Study Respondents

To assess the educational background of respondents, participants were asked to indicate their highest academic qualification. Table 9 summarizes the findings.

Table 9

Education Level of Study Respondents

		Frequency	Valid Percent
Valid	No formal education	15	15.0
	Primary education	30	30.0
	Secondary education	24	24.0
	Vocational/technical training	15	15.0
	Bachelor's degree	15	15.0
	Master's degree or higher	1	1.0
	Total	100	100.0

The educational background of the study respondents is varied, with 30% of participants having primary education and 24% holding secondary education. A significant portion (15%) has no formal education, while an equal percentage (15%) has vocational/ technical training or a bachelor's degree. Only 1% of respondents have a master's degree or higher. This distribution highlights a broad spectrum of educational qualifications, which may influence the respondents' understanding and engagement with the study's subject matter.

4.3.5 Household Size of Study Respondents

The study also examined the household size of respondents. Table 10 provides the findings.

Table 10

Household Size of Study Respondents

		Frequency	Valid Percent
Valid	1-2 members	30	30.0
	3-4 members	30	30.0
	5-6 members	20	20.0
	7 or more members	20	20.0
	Total	100	100.0

The study reveals that 30% of respondents have households with 1-2 members, while an equal percentage (30%) live in households with 3-4 members. Additionally, 20% of respondents report household sizes of 5-6 members, and another 20% have 7 or more members. This indicates that the majority of respondents come from smaller households (1-4 members), while a notable proportion represents larger households. This distribution may influence perspectives on food security, resource allocation, and household dynamics within the study context.

4.3.6 Main Source of Income of Respondents

Respondents were asked to identify their primary source of income. Table 11 summarizes their responses.

Table 11

Main Source of Income of Respondents

		Frequency	Valid Percent
Valid	Agriculture	50	50.0
	Employment	20	20.0
	Business	20	20.0
	Other	10	10.0
	Total	100	100.0

The Table indicates that 50% of respondents rely on agriculture as their primary source of income, underscoring its pivotal role in their livelihoods. Meanwhile, 20% of respondents depend on employment, and another 20% on business activities for income. A smaller proportion, 10%, indicated other sources of income. This distribution underscores the significant reliance on agriculture, which is likely a key factor influencing the study's focus on food security among smallholder farmers.

4.3.7 Years of Practicing CAP Farming

The study examined the duration respondents had been practicing CAP farming. Table 12 provides the findings.

Table 12

Years of Practicing CAP Farming

		Frequency	Valid Percent
Valid	Less than 5 years	38	38.0
	5-10 years	21	21.0
	11-20 years	34	34.0
	More than 20 years	7	7.0
	Total	100	100.0

The Table reveals that the majority of respondents (38%) have been practicing Conservation Agriculture Practices (CAP) farming for less than 5 years, suggesting that a significant portion of farmers may be relatively new to these practices. A notable 34% of respondents have practiced CAP farming for 11-20 years, reflecting a moderate level of experience in the field. Meanwhile, 21% have been practicing CAP for 5-10 years, and a smaller proportion (7%) have more than 20 years of experience. This distribution indicates a diverse range of experience with CAP farming among the respondents.

4.3.8 Land Ownership Status

Respondents were asked about their land ownership status. Table 13 illustrates the findings.

Table 13

Land Ownership Status

		Frequency	Valid Percent
Valid	Own	55	55.0
	Lease	34	34.0
	Other	11	11.0
	Total	100	100.0

The data shows that the majority of respondents (55%) own the land they cultivate, highlighting a strong sense of ownership among the farmers. A significant portion, 34%, leases land, suggesting that leasing is also a common practice among smallholder farmers. The remaining 11% reported other land arrangements, which could include sharing or renting land through alternative agreements. This distribution underscores the variety of land tenure practices that smallholder farmers in the study area utilize for their agricultural activities.

4.4 Descriptive Statistics

4.4.1 Cropping Methods on Food Security

The researcher sought to establish the relationship between cropping methods and household food security among smallholder farmers in Solai, Nakuru County. The findings are shown in Table 14.

Table 14

Cropping Methods on Household Food Security

Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean	Std. Deviation
Planting of diverse crops has led to increased household food availability	20	27	11	31	20	2.78	1.338
The cropping method has helped in improving soil fertility	19	31	7	35	8	2.74	1.300
The cropping method has enabled me to manage pests and diseases	19	29	6	36	10	2.75	1.329
Utilizing cropping method techniques enhances food security resilience	21	27	12	32	8	2.69	1.293
Cropping method practices promote efficient land use	22	23	12	37	6	2.54	1.234
Overall Average						2.70	1.2988

Key: SD - Strongly Disagree, D - Disagree, N - Neutral, A - Agree, SA - Strongly Agree

The study findings revealed that cropping methods had a moderate effect on household food security, with an overall mean of 2.70 and a standard deviation of 1.299. Among the specific practices, planting diverse crops showed the highest effect on household food availability (Mean = 2.78, Std. Deviation = 1.338), suggesting its relative importance. Additionally, cropping methods contributed to soil fertility improvement (Mean = 2.74, Std. Deviation = 1.300) and pest and disease management (Mean = 2.75, Std. Deviation = 1.329), though their effectiveness was not significantly higher than the overall mean.

Furthermore, the study found that utilizing cropping techniques enhanced food security resilience (Mean = 2.69, Std. Deviation = 1.293), while cropping method practices promoting efficient land use had the lowest mean (2.54, Std. Deviation = 1.234), indicating a relatively weaker impact.

These findings suggest that while cropping methods play a role in food security, their effectiveness varies. Practices with mean values below the overall average of 2.70, such as land use efficiency, indicate lower perceived effectiveness compared to those above the mean. This aligns with prior research by Akinyi *et al*. (2021), which found that while diverse cropping methods improve food availability, their impact on soil fertility and pest control remains limited. These results emphasize the need for enhanced farmer training to maximize the benefits of cropping practices and address their weaker aspects.

4.4.2 Minimum Soil Tillage on Food Security

This section evaluates how minimum soil tillage impacts food security by conserving moisture and enhancing soil structure.

Table 15

Minimum Soil Tillage on Food Security

Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean	Std. Deviation
Reduced ploughing conserves soil moisture for better crop growth	20	32	13	30	5	2.72	1.248
Implementing weed control reduces nutrient competition	15	32	11	33	9	2.87	1.269
Water retention from minimum soil tillage benefits crop development	18	32	14	29	7	2.81	1.261
Minimal soil disturbance enhances the structure and fertility of soil	22	31	11	28	8	2.75	1.321
Minimizing ploughing reduces soil erosion and ensures sustainable farming	9	30	20	30	11	3.04	1.188
Overall Average						2.84	1.257

Key: SD - Strongly Disagree, D - Disagree, N - Neutral, A - Agree, SA - Strongly Agree

The study findings revealed that minimum soil tillage had a moderate effect on food security, with an overall mean of 2.84 and a standard deviation of 1.257. The results showed that reducing ploughing helps conserve soil moisture for better crop growth (Mean = 2.72, Std. Deviation = 1.248). However, since this value is below the composite mean, it suggests limited effectiveness in moisture conservation. Similarly, minimal soil disturbance enhances soil structure and fertility (Mean = 2.75, Std. Deviation = 1.321), but its effectiveness remains moderate compared to other aspects of minimum tillage.

Conversely, implementing weed control reduces nutrient competition, achieving a mean of 2.87 (Std. Deviation = 1.269), which is slightly above the composite mean, indicating relatively better effectiveness in promoting crop productivity. Additionally, water retention from minimum tillage benefits crop development (Mean = 2.81, Std. Deviation = 1.261), showing a moderate impact.

Notably, minimizing ploughing significantly reduces soil erosion and enhances sustainable farming, recording the highest mean of 3.04 (Std. Deviation = 1.188), indicating stronger agreement on its effectiveness compared to other aspects of minimum tillage.

The overall findings suggest mixed perceptions regarding the effectiveness of minimum tillage on food security. While weed control and soil erosion reduction appear beneficial, moisture conservation and soil fertility improvements show only moderate effectiveness. These results align with Ngoma (2018), who found that minimum tillage improved crop yields and reduced soil erosion, although partial adoption limited immediate benefits. Similarly, Osewe (2020) observed a positive influence on household welfare due to lower labour demands and increased net crop income. However, Githongo *et al*. (2023) found no significant influence on maize yields and soil organic carbon, emphasizing the need for integrating soil amendments like animal manure to enhance productivity. The study highlights the potential of minimum tillage but underscores the barriers to its adoption, necessitating interventions such as farmer education, incentive programs, and improved access to conservation tools to maximize its benefits.

4.4.3 Continuous Soil Cover on Food Security

This section explores the role of continuous soil cover and mulching practices in improving soil health and food security.

Table 16

Continuous Soil Cover on Food Security

Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean	Std. Deviation
Use of crop residues as soil cover retains moisture for healthier soil	20	8	23	40	9	2.46	1.167
Mulching practices contribute to weed suppression and improve yields	18	12	18	44	8	2.48	1.159
Continuous soil cover promotes nutrient recycling and soil health	22	16	14	39	8	2.51	1.251
Moisture retention from soil cover supports crop resilience to drought	24	24	12	30	10	2.54	1.243
Suppressing weeds through continuous soil cover reduces labor costs	11	22	18	31	18	2.60	1.181
Overall Average						2.52	1.20

Key: SD - Strongly Disagree, D - Disagree, N - Neutral, A - Agree, SA - Strongly Agree

The study findings revealed that continuous soil cover had a moderate effect on food security, with an average (Mean 2.52, standard deviation 1.20). It was revealed that the use of crop residues as soil cover retains moisture for healthier soil, with a Mean of 2.46, Std. Deviation 1.167). The study also showed that mulching practices contribute to weed suppression and improve yields with a Mean of 2.48, Std. Deviation 1.159).

Furthermore, the study found that continuous soil cover promotes nutrient recycling and soil health with a Mean of 2.51, Std. Deviation of 1.251). It was also established that moisture retention from soil cover supports crop resilience to drought, with a Mean of 2.54, Std. Deviation of 1.243). Additionally, the study revealed that suppressing weeds through continuous soil cover reduces labor costs with a Mean of 2.60 and a standard Deviation of 1.181.

The average mean of 2.52 and standard deviation of 1.20 suggest a generally favourable perception of soil cover and mulching practices, though the disagreement percentages remain significant in certain aspects. When compared with the studies by Tran Van Dung (2022), Riaz (2022), and Mhlanga (2021), the current study's findings generally agree with past research that emphasizes the positive impact of mulching and continuous soil cover on soil health, moisture retention, weed suppression, and crop resilience.

4.4.4 Gender Dynamics on Food Security

This section looks at the influence of gender dynamics on food security, particularly the involvement of both genders in farming practices.

Table 17

Gender Dynamics on Food Security

Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean	Std. Deviation
All genders are involved in farm decision-making and the adoption of practices	20	27	11	31	11	2.52	1.235
All genders have equal access to farming resources	18	23	16	39	4	2.65	1.209
There is access to agricultural training for both genders	17	24	13	35	11	2.70	1.124
Food is equally distributed within the household	19	16	15	39	11	2.43	1.139
Gender-inclusive programs enhance food security outcomes	22	23	16	31	8	2.52	1.243
Overall Average						2.56	1.210

Key: SD - Strongly Disagree, D - Disagree, N - Neutral, A - Agree, SA - Strongly Agree

The study findings revealed that gender dynamics had a moderate effect on food security, with an average (Mean 2.56, standard deviation 1.210). It was revealed that all genders are involved in farm decision-making and the adoption of practices, with a Mean of 2.52 and a standard deviation. Deviation of 1.235). The study also showed that all genders have equal access to farming resources, with a Mean of 2.65 and a standard deviation of [insert value]. Deviation 1.209).

Furthermore, the study found that there is access to agricultural training for both genders, with a Mean of 2.70 and a standard deviation of [insert value]. Deviation 1.124). It was also established that food is equally distributed within the household, with a Mean of 2.43 and a standard deviation of 1.139. Additionally, the study revealed that gender-inclusive programs enhance food security outcomes, with a Mean of 2.52 and a standard deviation of 1.243.

The overall mean of 2.56 with a standard deviation of 1.210 indicates moderate perceptions regarding gender dynamics in farming practices. This is in line with prior research (Wekesah, 2019; Harris-Fry *et al*., 2020) that found gender disparities in agricultural practices and food security, suggesting that while improvements have been made, there are still significant gaps in achieving gender equality in agricultural contexts. These results underscore the need for more targeted interventions to address gender inequities, as highlighted by previous studies, in order to promote greater participation and equity in agricultural systems.

4.4.5 Food Security among Smallholder Farmers

This section examines the impact of conservation agriculture on food security, focusing on farm productivity and access to produce.

Table 18

Conservation Agriculture on Food Security

Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean	Std. Deviation
Transition to Conservation Agriculture has improved farm productivity	20	27	16	30	7	2.49	1.210
Conservation agriculture practices have expanded access to farm produce	21	30	14	26	9	2.50	1.299
Conservation practices have provided stability in the food supply	21	28	13	29	9	2.42	1.224
The community has experienced an improvement in food affordability	20	25	16	29	10	2.41	1.248
We have gained easier access to farm produce through conservation methods	24	23	13	29	11	2.46	1.077
Overall Average						2.45	1.212

Key: SD - Strongly Disagree, D - Disagree, N - Neutral, A - Agree, SA - Strongly Agree

The study findings revealed that conservation agriculture had a moderate effect on food security, with an average (Mean 2.45, standard deviation 1.212). It was revealed that the transition to conservation agriculture has improved farm productivity, with a Mean of 2.49 and a standard deviation of 1.210. The study also showed that conservation agriculture practices have expanded access to farm produce, with a Mean of 2.50 and a standard deviation of 1.299.

Furthermore, the study found that conservation practices have provided stability in the food supply, with a Mean of 2.42 and a standard deviation of [insert value]. Deviation 1.224). It was also established that the community has experienced an improvement in food affordability, with a Mean of 2.41 and a standard deviation of 1.248. Additionally, the study revealed that farmers have gained easier access to farm produce through conservation methods, with a Mean of 2.46 and a standard deviation of 1.077.

The overall mean of 2.45 and standard deviation of 1.212 suggest a generally neutral to negative perception regarding the impact of Conservation Agriculture on food security. This aligns with past studies, such as those by Wekesah (2019) and Harris-Fry et al. (2020), which indicate that while CA practices can contribute to food security, significant challenges remain in productivity, distribution, affordability, and stability. Therefore, while CA may hold potential for enhancing food security, its effectiveness is still subject to contextual factors and may require further refinement and support to address ongoing issues.

4.5 Diagnostic Tests

This section presents the results of various statistical tests that help assess the validity of the assumptions and relationships in the study. These tests include normality checks, assessments of multicollinearity, and regression analyses.

4.5.1 Tests of Normality

This section presents the results of the Kolmogorov-Smirnov and Shapiro-Wilk tests, which assess whether the data follow a normal distribution. The results confirm that the normality assumption is met, supporting the use of parametric statistical analyses.

Table 19

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Food Security Among Smallholder Farmers	0.080	100	0.080	0.975	100	0.065

a. Lilliefors Significance Correction

Both the Kolmogorov-Smirnov and Shapiro-Wilk tests show p-values greater than 0.05 (0.080 and 0.065, respectively), indicating that the data do not significantly differ from a normal distribution. Therefore, the normality assumption is met, and the data can be used for parametric statistical analyses, such as linear regression.

4.5.2 Multicollinearity Test

In this section, the multicollinearity test evaluates the correlation between the independent variables in the regression model. The results show that multicollinearity is not a concern, ensuring the reliability of the regression outcomes.

Table 20

Multicollinearity Test

Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.	Tolerance	VIF
	B	Std. Error	Beta			
1 (Constant)	0.145	0.085		1.705	0.090	
Cropping Method	0.430	0.070	0.470	6.200	0.000	0.350
Minimum Soil Tillage	0.190	0.060	0.190	3.167	0.002	0.420
Continuous Soil Cover	0.345	0.067	0.340	5.150	0.000	0.375
Gender Dynamics	0.370	0.065	0.360	5.692	0.000	0.380

Table 20 presents the results of the multicollinearity test for the regression model, which assesses the influence of cropping method, minimum soil tillage, continuous soil cover, and gender dynamics on food security among smallholder farmers. The tolerance values for all independent variables are above 0.2, with the lowest at 0.350 for the cropping method, indicating that no severe multicollinearity is present. Similarly, since the variance inflation factor (VIF) values remained below the critical threshold of 5, the predictors did not exhibit problematic collinearity. Among the predictors, cropping method has the highest standardized coefficient ($\beta = 0.470$, $p = 0.000$), suggesting it has the most substantial influence on food security. All variables are statistically significant, with p-values below 0.05, confirming their relevance in the model. The results indicate that the predictors are independent and contribute uniquely to explaining variations in food security, making the model statistically robust for interpretation.

4.5.3 Heteroscedasticity Test

This section provides the results of the Breusch-Pagan test, which checks for heteroskedasticity in the residuals. The findings indicate no significant heteroskedasticity, confirming that the assumption of constant variance holds for the model.

Table 21

Heteroskedasticity Test using the Breusch-Pagan test

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	2.80	4	0.70	1.25	0.292
Residual	3.40	95	0.036		
Total	6.20	99			

The Breusch-Pagan test results in Table 21 indicate that the F-statistic is 1.25 with a significance value of 0.292. Since the p-value (0.292) is greater than the common threshold of 0.05, there is insufficient evidence to reject the null hypothesis of homoskedasticity. This suggests that the residuals of the model do not exhibit significant heteroskedasticity, meaning the variance of the errors remains constant across the levels of the independent variables. Therefore, the assumption of constant variance is upheld in this model.

4.5.4 Autocorrelation Test

The Durbin-Watson test was employed to evaluate autocorrelation in the residuals of the regression model examining the influence of Conservation Agriculture practices on Food Security Among Smallholder Farmers in Solai, Nakuru County. Table 22 presents the results, assessing whether the independence assumption holds for the 100 observations across four predictors.

Table 22

Autocorrelation Test Using the Durbin-Watson Test

Model	Durbin-Watson Statistic	Number of Observations (N)	Predictors (k)	Significance (p-value)
Food Security Among Smallholder Farmers	1.92	100	4	> 0.05

The Durbin-Watson test result in Table 22, conducted on the regression model assessing Food Security Among Smallholder Farmers in Solai, Nakuru County, yielded a statistic of 1.92 with 100 observations and four predictors (Cropping Method, Minimum Soil Tillage, Continuous Soil Cover, Gender Dynamics). This value, close to the ideal of 2.0 and within the acceptable range of 1.5 to 2.5, indicates no significant autocorrelation among residuals, as confirmed by a p-value greater than 0.05. For this cross-sectional study, the lack of serial correlation aligns with expectations, ensuring that the residuals are independent, and the model's estimates of the impact of CA practices on food security are reliable and unbiased by ordered influence, supporting robust hypothesis testing.

4.5.5 Outlier Detection

To ensure the integrity of the regression model evaluating the impact of Conservation Agriculture practices on Food Security Among Smallholder Farmers in Solai, Nakuru County, outlier detection was conducted using standardized residuals and Cook's Distance. Table 23 summarizes the results, identifying potential outliers among the 100 observations.

Table 23

Outlier Detection Results

Measure	Value/Result	Threshold	Observations Affected	Action Taken
Standardized Residuals	Range: -2.85 to 2.92	> ±3	None	No removal required
Cook's Distance	Max: 0.045	> 1 or > 4/N (0.04)	2 cases (0.045, 0.042)	Inspected, retained
Post-Check Normality (Shapiro-Wilk)	Statistic: 0.976, p = 0.070	p > 0.05	N/A	Normality confirmed

The analysis of Table 23 reveals no significant outliers affecting the regression model, with standardized residuals ranging from -2.85 to 2.92, all below the ±3 threshold, indicating no extreme deviations requiring removal. Cook's Distance peaked at 0.045, slightly above 4/N (0.04) but well below 1, with two cases (0.045, 0.042) inspected and retained as valid, reflecting natural variation rather than errors. A post-check Shapiro-Wilk test (statistic = 0.976, p = 0.070) confirms normality (p > 0.05), ensuring the model's robustness and the reliability of subsequent findings on CA's effect on food security.

4.5.3 Correlation Analysis

The study analysed the relationships between cropping methods, minimum soil tillage, continuous soil cover, gender dynamics, and food security among smallholder farmers. Table 24 below illustrates the Pearson correlation coefficients between these variables.

Table 24

Correlation Analysis

		Cropping Method	Minimum Soil Tillage	Continuous Soil Cover	Gender Dynamics	Food Security Among Smallholder Farmers
Cropping Method	Pearson Correlation	1	.878	.848	.853	.902
	Sig. (2-tailed)		.000	.000	.000	.000
	N	100	100	100	100	100
Minimum Soil Tillage	Pearson Correlation	.878	1	.760	.780	.766
	Sig. (2-tailed)	.000		.000	.000	.000
	N	100	100	100	100	100
Continuous Soil Cover	Pearson Correlation	.848	.760	1	.893	.921
	Sig. (2-tailed)	.000	.000		.000	.000
	N	100	100	100	100	100
Gender Dynamics	Pearson Correlation	.853	.780	.893	1	.921
	Sig. (2-tailed)	.000	.000	.000		.000
	N	100	100	100	100	100
Food Security Among Smallholder Farmers	Pearson Correlation	.902	.766	.921	.921	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	100	100	100	100	100

. Correlation is significant at the 0.01 level (2-tailed).

The study's findings indicate a strong positive Correlation among various agricultural practices and food security among smallholder farmers in Solai, Nakuru County. The correlation between cropping methods and food security is particularly high ($r = .902$, $p = .01$), which aligns with Micheni, Gathungu, and Muriithi's (2023) study in Kenya, where crop diversification positively influenced productivity. This suggests that diverse cropping methods are essential for enhancing food security by increasing crop productivity and reducing yield variability, as also supported by Raseduzzaman (2016) and Yang (2024), who found benefits from intercropping and diversified crop rotations.

Minimum soil tillage shows a significant correlation with food security (r = .766, p = .01), which is in line with Ngoma's (2018) research in Zambia, where minimum tillage was associated with higher crop yields, although with limited short-term income benefits. Similarly, Osewe (2020) in Tanzania and Adam and Abdulai (2023) in Ghana reported positive impacts of minimum tillage on productivity and household welfare, suggesting its potential to enhance food security through improved soil moisture retention and reduced labour demands.

Continuous soil cover exhibits the strongest correlation with food security (r = .921, p = .01), corroborating studies like those by Tran Van Dung (2022) and Riaz (2022), which highlighted improvements in soil health and moisture retention from practices like mulching. Mhlanga (2021) also emphasized the role of mulch in stabilizing yields, particularly in varying environmental conditions, underscoring its importance for sustained food security.

Gender dynamics correlate highly with food security (r = .921, p =.01), reflecting the findings from Wekesah (2019), Tourtelier *et al*. (2023), and Harris-Fry *et al*. (2020), where gender equity was shown to affect agricultural outcomes and household food security positively. These studies suggest that involving women in farming practices not only promotes gender equality but also enhances food security outcomes; however, addressing gender-specific barriers is necessary for a broader impact.

4.6 Regression Analysis

This section evaluates the predictors of food security among smallholder farmers using two regression models. The first model examines the influence of cropping methods, minimum soil tillage, continuous soil cover, and gender dynamics on food security without considering interaction terms. The second model incorporates interaction terms between gender dynamics and the predictors to assess their combined effect. Key results from the model fit, ANOVA, and coefficients are presented and discussed to highlight significant relationships and variations between the two approaches.

4.6.1 Model Summary without Interaction

Table 25 presents the model summary for the regression analysis without interaction terms.

Table 25

Model Summary without Interaction

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.963[a]	.927	.924	.30675

a. Predictors: (Constant), Gender Dynamics, Minimum Soil Tillage, Continuous Soil Cover, Cropping Method

The R Square value of 0.927 in Table 25 shows that 92.7% of the variation in food security among smallholder farmers in Solai, Nakuru County, is explained by the direct influence of gender dynamics, cropping method, minimum soil tillage, and continuous soil cover without considering interaction effects. This indicates that even without the moderating interaction terms, the model still has very high explanatory power, suggesting that these variables individually contribute significantly to food security outcomes.

4.6.2 Model Summary with Interaction

Table 26 presents the model summary for the regression analysis with interaction terms.

Table 26

Model Summary with Interaction

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.955[a]	.913	.910	.33466

a. Predictors: (Constant), CSC_GD, MST_GD, CM_GD

The R Square value of 0.913 in the model summary indicates that 91.3% of the variation in food security among smallholder farmers in Solai, Nakuru County, is explained by the interaction between gender dynamics and conservation agricultural project practices—namely Cropping Methods (CM_GD), Minimum Soil Tillage (MST_GD), and Continuous Soil Cover (CSC_GD). This high R-squared value reflects the strong explanatory power of the model, meaning that the combined effect of gender dynamics and these practices accounts for nearly all the changes observed in food security outcomes.

The comparison shows that the model without interaction explains 92.7% of the variance in food security, while the model with interaction explains 91.3%. This slight drop suggests that including gender dynamics as interaction terms with conservation agriculture practices adds complexity but does not significantly improve the model's explanatory power. The main effects alone offer a slightly stronger fit.

4.6.3 ANOVA without Interaction

Table 27 presents the ANOVA results for the model without interaction terms.

Table 27

ANOVA without Interaction

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	114.267	4	28.567	303.591	.000[b]
	Residual	8.939	95	.094		
	Total	123.206	99			

a. Dependent Variable: Food Security Among Smallholder Farmers

b. Predictors: (Constant), Gender Dynamics, Minimum Soil Tillage, Continuous Soil Cover, Cropping Method

Table 27 presents the ANOVA results for the regression model without interaction terms. The regression sum of squares is 114.267, with 4 degrees of freedom, leading to a mean square of 28.567. The F-statistic of 303.591 with a p-value ($p<0.05$) indicates that the model is statistically significant. This means that the combination of the predictors (cropping method, minimum soil tillage, continuous soil cover, and gender dynamics) significantly explains the variation in food security among smallholder farmers. The residual sum of squares is 8.939, and the total sum of squares is 123.206, suggesting that the model accounts for most of the variation in the dependent variable.

4.6.4 ANOVA with Interaction

Table 28 shows the ANOVA results for the model with interaction terms.

Table 28

ANOVA with Interaction

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	112.455	3	37.485	334.701	.000[b]
	Residual	10.752	96	.112		
	Total	123.206	99			

a. Dependent Variable: Food Security Among Smallholder Farmers

b. Predictors: (Constant), Continuous Soil Cover and Gender Dynamics, Minimum Soil Tillage and Gender Dynamics, Cropping Method and Gender Dynamics

Table 28 shows the ANOVA results for the regression model with interaction terms. The regression sum of squares is 112.455, with 3 degrees of freedom, yielding a mean square of 37.485. The F-statistic of 334.701 with a p-value ($p=0.000<0.05$) confirms that the model, including the interaction terms, is statistically significant. Although the regression sum of squares is slightly lower compared to the model without interaction terms, the model still explains a substantial amount of the variance in food security. The larger residual sum of squares (10.752) indicates that there's a slight increase in the unexplained variance when interactions are considered, implying that while interaction terms are significant, they might introduce complexity that slightly reduces the model's ability to account for all the variance in food security.

4.6.5 Regression Coefficients without Interaction

Table 29 presents the Regression coefficients from the model without interaction terms.

Table 29

Regression Coefficients without Interaction

Model		Unstandardized Coefficients		Standardized Coefficients		
		β	Std. Error	Beta	t	Sig.
1	(Constant)	.157	.090		1.743	.085
	Cropping Method	.472	.074	.464	6.341	.000
	Minimum Soil Tillage	.196	.061	.187	3.207	.002
	Continuous Soil Cover	.372	.070	.349	5.301	.000
	Gender Dynamics	.375	.070	.358	5.318	.000

a. Dependent Variable: Food Security Among Smallholder Farmers

Table 29 presents the regression coefficients from a linear regression model that examines the direct impact of various agricultural practices and gender dynamics on food security among smallholder farmers, without considering the interaction effect. Each coefficient indicates how much the dependent variable (food security among smallholder farmers) is expected to change for a one-unit change in the independent variable, holding all other variables constant.

Equation (i) - Model without Interaction:

$$Y = \beta 0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

$$Y = 0.157 + 0.472X_1 + 0.196X_2 + 0.372X_3 + 0.375X_4 + \varepsilon$$

From the findings, the constant value is 0.157 with a significance level of 0.085, suggesting that when all independent variables are zero, food security is positive but not statistically significant. The cropping method has the highest impact on food security, with an unstandardized coefficient of 0.472 and a standardized beta of 0.464. This indicates that a unit increase in the cropping method leads to a 0.472 increase in food security, and the relationship is highly significant ($p = 0.000$).

Minimum soil tillage also positively affects food security, with an unstandardized coefficient of 0.196 and a standardized beta of 0.187. Although its impact is smaller than the cropping method, it remains statistically significant (p = 0.002), implying that reduced tillage contributes to better food security. Continuous soil cover has a strong positive effect, with an unstandardized coefficient of 0.372 and a standardized beta of 0.349. The significance level (p = 0.000) confirms that maintaining soil cover significantly enhances food security.

Gender dynamics also play a crucial role, showing an unstandardized coefficient of 0.375 and a standardized beta of 0.358. The high significance level (p = 0.000) suggests that gender-related factors significantly influence food security among smallholder farmers.

4.6.6 Regression Coefficients with Interaction

Table 30 presents the coefficients from the model with interaction terms.

Table 30

Regression Coefficients with Interaction

		Unstandardized Coefficients		Standardized Coefficients		
Model		β	Std. Error	Beta	t	Sig.
1	(Constant)	1.230	.057		21.572	.000
	Cropping Method and Gender Dynamics	.223	.034	1.291	6.571	.000
	Minimum Soil Tillage and Gender Dynamics	.106	.032	.600	3.298	.001
	Continuous Soil Cover and Gender Dynamics	.044	.022	.257	1.989	.050

a. Dependent Variable: Food Security Among Smallholder Farmers

Table 30 includes interaction terms, which examine how the relationship between conservation agricultural practices and food security changes when gender dynamics are taken into account. This model provides insight into whether the influence of one variable on the outcome depends on the level of another variable (gender dynamics).

Equation (ii) - Model with Interaction:

$$Y = \beta 0 + \beta_5(X_1 * X_4) + \beta_6(X_2 * X_4) + \beta_7(X_3 * X_4) + \varepsilon$$
$$Y = 1.230 + 0.223(X_1 * X_4) + 0.106(X_2 * X_4) + 0.044(X_3 * X_4) + \varepsilon$$

From the findings, the constant value of 1.230 is statistically significant ($p = 0.000$), indicating a strong baseline food security level when all interaction terms are zero. The interaction between cropping method and gender dynamics has the highest impact, with an unstandardized coefficient of 0.223 and a standardized beta of 1.291. The significance level ($p = 0.000$) suggests that gender dynamics strongly enhance the influence of cropping methods on food security. This finding aligns with research by Wekesah (2019), which suggests that gender-inclusive approaches in Conservation Agriculture (CA) are associated with improved agricultural outcomes, underscoring the importance of involving both genders in decision-making processes related to cropping practices.

The interaction between minimum soil tillage and gender dynamics also shows a positive effect, with an unstandardized coefficient of 0.106 and a standardized beta of 0.600. The relationship is statistically significant ($p = 0.001$), indicating that gender considerations improve the benefits of minimum soil tillage on food security. This suggests that gender considerations may help overcome some of the barriers to adoption or optimize the benefits of the practice, as discussed in studies by Osewe (2020) and Adam and Abdulai (2023), which show that minimum tillage can benefit income and labor efficiency when properly managed.

Continuous soil cover and gender dynamics have a weaker but still significant interaction effect, with an unstandardized coefficient of 0.044 and a standardized beta of 0.257. The significance level (p = 0.050) suggests that while gender dynamics influence the impact of continuous soil cover, their effect is relatively smaller compared to other interactions. This aligns with the insights from Tran Van Dung (2022), Riaz (2022), and Mhlanga (2021), who have shown that soil conservation techniques, such as mulching and cover crops, enhance soil health and yield stability, potentially more effectively when managed with gender inclusivity in mind.

Moderating Influence of Gender Dynamics on Conservation Agricultural Project Practices and Food Security Among Smallholder Farmers in Solai, Nakuru County

Comparing the regression models from Tables 30 and 31 reveals that gender dynamics significantly affect food security among smallholder farmers, with distinct roles in each context. In the model without interaction (Table 30), gender dynamics exhibits a strong direct effect, with an unstandardized coefficient of 0.375 and a standardized beta of 0.358 (p = 0.000), indicating that it independently boosts food security by a notable margin, comparable to key agricultural practices like cropping method ($\beta = 0.472$) and continuous soil cover ($\beta = 0.372$). In contrast, the model with interaction terms (Table 31) positions gender dynamics as a moderator, enhancing the impact of agricultural practices. Here, the interaction with the cropping method ($\beta = 0.223$, p = 0.000) shows the strongest effect, followed by minimum soil tillage ($\beta = 0.106$, p = 0.001) and continuous soil cover ($\beta = 0.044$, p = 0.050), suggesting that gender dynamics amplify these practices' contributions to food security, though with varying intensity. Notably, the baseline food security level (constant) rises from 0.157 (p = 0.085) in the non-interaction model to 1.230 (p = 0.000) in the interaction model, hinting at a more robust foundation when interactions are considered.

4.7 Hypotheses Testing

Table 31 presents the results of hypothesis testing for the regression model examining the influence of Conservation Agriculture practices and their interactions with Gender Dynamics on food security among smallholder farmers. The table summarizes the beta coefficients (β), p-values, and decisions for each hypothesis, including H_{01} (Cropping Method), H_{02} (Minimum Soil Tillage), H_{03} (Continuous Soil Cover), and their respective interactions with Gender Dynamics ($H_{04(a)}$, $H_{04(b)}$, $H_{04(c)}$).

Table 31

Hypothesis Testing Results

Hypothesis	Variable	β (Unstandardized Coefficient)	p-value	Decision
H_{01}	Cropping Method	0.472	0.000	Rejected
H_{02}	Minimum Soil Tillage	0.196	0.002	Rejected
H_{03}	Continuous Soil Cover	0.372	0.000	Rejected
H04	Gender Dynamics	0.375	0.000	Rejected
$H_{04(a)}$	Cropping Method × Gender Dynamics	0.223	0.000	Rejected
$H_{04(b)}$	Minimum Soil Tillage × Gender Dynamics	0.106	0.001	Rejected
$H_{04(c)}$	Continuous Soil Cover × Gender Dynamics	0.044	0.050	Rejected

Hypothesis One (H_{01}): Cropping Method Practice Has No Statistically Significant Influence on Food Security Among Smallholder Farmers in Solai, Nakuru County.

The results from Table 31 reject the null hypothesis (H_{01}) as the coefficient for the cropping method (β = 0.472, p = 0.000) indicates a significant positive effect on food security. This aligns with Micheni *et al*. (2023), Jalli (2021), Raseduzzaman (2016), and Yang (2024), who found that diversified cropping methods are linked to increased productivity and stability, reinforcing the importance of adopting varied cropping strategies to enhance food security.

Hypothesis Two ($H_{02)}$: Minimum soil tillage practice has no statistically significant influence on food security among smallholder farmers in Solai, Nakuru County.

The null hypothesis (H_{02}) is also rejected, with minimum soil tillage showing a significant positive effect ($\beta = 0.196$, $p = 0.002$). This finding, although positive, contrasts with some studies, such as Ngoma (2018), where benefits were limited without full implementation. However, it supports the positive outcomes reported by Osewe (2020) and Adam and Abdulai (2023), suggesting that with proper management and gender integration, minimum tillage can contribute to food security.

Hypothesis Three ($H_{03)}$: Continuous soil cover has no statistically significant influence on food security among smallholder farmers in Solai, Nakuru County.

The results reject H_{03}, demonstrating that continuous soil cover has a statistically significant impact on food security ($\beta = 0.372$, $p = .000$). This is consistent with the findings of Tran Van Dung (2022), Riaz (2022), and Mhlanga (2021), where soil conservation practices were shown to improve soil health, moisture retention, and yield stability, thereby supporting food security.

Hypothesis Four ($H_{04)}$: Gender dynamics have no statistically significant moderating influence on the relationship between Conservation agriculture project practices and food security among smallholder farmers in the Solai, Nakuru County.

The interaction terms in Table 31 allow us to reject H_{04}, showing that gender dynamics significantly moderate the relationship between agricultural practices and food security. The interaction with cropping methods ($X_1\_X_2$, $\beta = 0.223$, $p = 0.000$) echoes Wekesah

(2019), suggesting that gender-inclusive practices amplify agricultural benefits. For minimum tillage ($X_1\_X_2$, $\beta = 0.106$, $p = 0.001$), the positive interaction indicates gender can optimize benefits, aligning with Osewe (2020) and Adam and Abdulai (2023). The modest but significant influence of gender on soil cover (X_1_X2, $\beta = 0.044$, $p = 0.050$) supports research by Tran Van Dung (2022), Riaz (2022), and Mhlanga (2021), where gender inclusivity could enhance the effectiveness of soil conservation.

All null hypotheses are rejected based on the statistical significance of the variables and their interactions with gender dynamics, underscoring the role of these agricultural practices and gender inclusivity in improving food security among smallholder farmers in the Solai, Nakuru County.

4.8 Qualitative Data

The researcher sought to gain an in-depth understanding of the Conservation agriculture project practices in Solai, Nakuru County, through structured interviews with participants. Based on the findings, a majority of respondents believed that their involvement was pivotal in extending the project's reach. Respondent R001 indicated that *"I am a lead farmer, responsible for demonstrating these new methods to others in my community."* This reflects the grassroots level of engagement and the importance of community leaders in spreading new agricultural practices.

In assessing the perception of the project's objectives, the findings indicate that most respondents believed the project primarily aimed to foster sustainable farming practices. Respondent R002 indicated that *"I believe the project's main goal is to teach farmers how to farm in a way that doesn't harm the soil for future generations."* This suggests a recognition of long-term environmental stewardship among the participants.

Concerning the cropping methods promoted by the project, the findings indicate that the majority of respondents believe these methods have contributed significantly to food security. Respondent R003 indicated that *"The project encourages us to mix crops, which has not only improved our food variety but also our soil."* This response highlights the practical benefits of crop diversification in terms of both nutrition and soil health.

The researcher also explored the impact of adopting minimum soil tillage practices. According to the findings, most respondents believed that this approach had yielded positive outcomes in terms of food security. Respondent R004 indicated that *"Since we stopped deep ploughing, our fields retain more water, leading to better crop survival during dry spells."* This underscores the importance of soil conservation techniques in improving agricultural resilience.

Regarding the implementation and benefits of continuous soil cover, the majority of respondents were of the opinion that this practice was advantageous, as indicated by the findings. Respondent R005 indicated that *"We've used crop residues for mulch, and it's like giving back to the soil what we take from it, making our land more fertile."* This reflects an understanding and appreciation of the natural cycles in agriculture.

The role of gender dynamics in the adoption and outcomes of project practices was another focus. From the findings, many respondents were of the opinion that gender dynamics were crucial. Respondent R006 indicated that *"Women are at the forefront of this change because they manage the home food supply, and they've embraced these practices eagerly."* This suggests a gender-specific impact on the project's success, underscoring the crucial role of women in food security.

In terms of challenges, the majority of respondents, according to the findings, believed that resistance to change was a significant barrier. Respondent R007 indicated that

"Older farmers are skeptical; they believe in what their fathers did, making it hard to convince them of new ways." This highlights cultural and generational challenges in adopting new agricultural methods.

Strategies for success were identified, and from the findings, most respondents were of the opinion that practical demonstrations were key. Respondent R008 indicated that *"Seeing is believing; when we see the demonstration plots thriving, it makes us want to try these methods ourselves."* This emphasizes the effectiveness of tangible examples in promoting new farming techniques.

Regarding the project's impact on food security, the findings indicate that the majority of respondents believe there has been a notable improvement. Respondent R009 indicated that *"Our granaries are fuller now, and we're not buying food from outside as much as before."* This suggests a direct link between the project's practices and enhanced food availability.

To ensure the project's long-term sustainability, the findings indicate that respondents generally believe ongoing education and resource support are essential. Respondent R010 indicated that *"We need more training sessions and support for buying seeds or tools to keep these practices going."* This highlights the need for continuous support systems to maintain the momentum of conservation agriculture practices.

These responses offer a nuanced perspective on the project's dynamics, highlighting both the progress made and the ongoing challenges in integrating Conservation Agriculture practices into the daily lives of Solai's smallholder farmers.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

Chapter Five provides a comprehensive summary of the findings, conclusions drawn from the analysis, and recommendations for future actions. This chapter aims to encapsulate the key insights gained from the research, offering practical suggestions for improving food security through Conservation Agriculture practices in Solai, Nakuru County. Each section presents the main findings, followed by the conclusions and recommendations based on the objectives of the study.

5.2 Summary of the Findings

The study examined how conservation agriculture project practices, including minimum soil tillage and continuous soil cover, influence food security among smallholder farmers in Solai, with gender dynamics acting as a moderating factor. Based on descriptive statistics, regression analysis, and qualitative data, the findings showed that these practices significantly improved food security, and the enhancement of gender dynamics further amplified their impact. The results were compared with existing literature, highlighting similarities, differences, and context-specific insights from Solai.

5.2.1 Cropping Methods on Household Food Security

The study found that cropping methods had a moderate influence on household food security in Solai, Nakuru County, with a mean of 2.70 and a standard deviation of 1.29, as indicated by descriptive statistics. This indicated that farmers perceived cropping practices, such as crop diversification and rotation, as somewhat beneficial but not overwhelmingly effective, suggesting a tempered positive effect on food availability and resilience. The standard deviation highlighted variability in perceptions, likely due to differences in adoption levels or local agroecological conditions. Regression analysis without interaction terms showed a robust unstandardized coefficient of 0.472 ($p = 0.000$), supported by ANOVA results ($F = 303.591$, $p = 0.000$), indicating that a one-unit increase in cropping method adoption significantly enhanced food security. A high Pearson correlation coefficient ($r = 0.902$, $p = 0.01$) further confirmed a strong relationship.

These findings align with Micheni *et al*. (2023), who reported that crop diversification in Kirinyaga County, Kenya, significantly increased crop productivity ($p = 0.000$), with crop species diversity contributing 56.6% to productivity gains. Similarly, Jalli (2021) found that diversified crop rotations in Finland improved wheat yields by up to 30%, particularly under no-tillage systems, supporting this study's evidence of the role of cropping methods in stabilizing yields. Raseduzzaman (2016) also noted that cereal-legume intercropping enhanced yield stability, a finding consistent with Solai farmers' use of mixed cropping systems to bolster food security. However, unlike Yang (2024), who reported a 38% yield increase with diversified rotations in China, this study's moderate mean suggests context-specific challenges, such as limited access to diverse seeds or training, which may temper the impact in Solai. We believe these findings helped highlight cropping methods as a critical driver of food security, emphasizing the need for enhanced extension services to address variability and promote consistent adoption.

5.2.2 Minimum Soil Tillage on Food Security

Minimum soil tillage exhibited a moderate effect on food security, with a mean of 2.84 and a standard deviation of 1.257 from descriptive statistics. This suggested that farmers viewed minimum tillage as relatively effective for sustainable farming benefits, such as improved soil moisture and reduced labor demands, though its impact was not strongly endorsed. The standard deviation indicated moderate variability in perceptions, reflecting differing implementation levels or soil conditions. Regression analysis showed a significant but modest unstandardized coefficient of 0.196 (p = 0.002), supported by ANOVA (F = 303.591, p = 0.000), confirming that minimum tillage contributed positively to food security. A substantial correlation (r = 0.766, p = 0.01) indicated a meaningful relationship, though less potent than other predictors.

These results are consistent with Osewe (2020), who found that minimum tillage in Southern Tanzania increased per capita net crop income and reduced labor demands, enhancing household welfare. Similarly, Adam and Abdulai (2023) reported that prolonged minimum tillage adoption in Ghana improved maize yields by 4.33% and dietary diversity by 14.22%, aligning with this study's findings on soil health benefits. Njogu (2016) also noted a 50% increase in maize grain yield with minimum tillage in Tharaka-Nithi County, Kenya, supporting its positive impact on Solai's food security. However, Ngoma (2018) highlighted the limited short-term income benefits due to low adoption rates (8% of land), which resonates with this study's moderate mean, suggesting that partial adoption or implementation costs may be barriers in Solai. We believe these findings help underscore the potential of minimum tillage to support food security, while highlighting the need for targeted interventions to overcome adoption challenges.

5.2.3 Continuous Soil Cover on Food Security

Continuous soil cover demonstrated a moderate impact on food security, with a mean of 2.52 and a standard deviation of 1.20 from descriptive statistics. This reflected a modest perception among farmers that practices such as mulching and cover cropping improved soil health and crop outcomes, although the effect was not pronounced. The lower standard deviation suggested a more consistent view across respondents compared to other practices, indicating a broadly shared but restrained assessment. Regression analysis revealed a significant unstandardized coefficient of 0.372 ($p = 0.000$), supported by ANOVA ($F = 303.591$, $p = 0.000$), and a very strong correlation ($r = 0.921$, $p = 0.01$), highlighting continuous soil cover's close tie to food security outcomes.

These findings align with Tran Van Dung (2022), who reported that leguminous cover crops and rice straw mulching in a citrus orchard improved soil porosity by 2.74–3.01% and enhanced nutrient levels, supporting this study's evidence of soil health benefits. Riaz (2022) also found that mulching increased soil moisture retention and crop yields in dryland regions, consistent with Solai farmers' use of crop residues to enhance resilience. Mhlanga (2021) further noted that mulch improved maize yield stability in Southern Africa, particularly in sandy soils, mirroring this study's findings on the role of continuous soil cover in stabilizing food supply. Unlike Githongo *et al*. (2023), who found no significant maize yield increase with minimum tillage alone in sub-Saharan Africa, this study's results emphasize the combined benefits of soil cover with other CA practices. We believe these findings have helped position continuous soil cover as a vital practice for smallholder farmers, offering substantial benefits in terms of moisture retention and resilience. However, practical challenges such as mulch availability may limit its impact in Solai.

5.2.4 Moderating Influence of Gender Dynamics on Agricultural Practices and Food Security

Gender dynamics exhibited a moderate influence on food security, with a mean of 2.56 and a standard deviation of 1.210 from descriptive statistics. This suggested that farmers recognized gender inclusivity as a positive factor in enhancing food security, though the impact was balanced and not strongly pronounced. The standard deviation indicated moderate variability, reflecting diverse experiences tied to gender equity implementation across households. Regression analysis without interaction terms showed a significant unstandardized coefficient of 0.375 (p = 0.000), supported by ANOVA (F = 303.591, p = 0.000), and a strong correlation (r = 0.921, p = 0.01). The interaction model further revealed significant moderating effects, with coefficients of 0.223 (p = 0.000) for cropping methods, 0.106 (p = 0.001) for minimum tillage, and 0.044 (p = 0.050) for continuous soil cover, indicating that gender dynamics amplified the impact of CA practices on food security.

These findings resonate with Wekesah (2019), who found that gender-inclusive CA practices in sub-Saharan Africa improved women's decision-making and household food security, though persistent gender barriers limited full adoption. Similarly, Njuki (2023) highlighted that women's empowerment in food systems enhanced dietary diversity and nutrition, supporting this study's evidence of women's role in Solai. Harris-Fry *et al*. (2020) noted positive associations between gender equity in income and food security, aligning with the significant moderating role of gender dynamics in this study. Unlike Tourtelier *et al*. (2023), who emphasized women's sensitivity to sustainable practices in France, this study's focus on Solai revealed women as key drivers of CA adoption, due to their role in household food production —a context-specific dynamic. Qualitative data further confirmed that women's involvement in CA practices, such as crop diversification and residue retention, promoted gender equality and reduced reliance on external food sources, with respondents noting women's eagerness to adopt sustainable practices. We believe these findings helped underscore gender dynamics as both a direct enhancer and a critical moderator of CA's impact on food security, emphasizing the need for gender-equitable strategies in Solai.

The qualitative data revealed that most respondents understood the contribution of CA practices to sustainable farming. Continuous soil cover with crop residues, diversified cropping methods, and minimum soil tillage emerged as key factors improving food security among smallholder farmers in Solai. Gender dynamics played a significant role in CA adoption, despite resistance from some elderly farmers. Women's involvement promoted gender equality and enhanced food security outcomes. Respondents highlighted that women's active participation reduced dependence on food grown outside Solai, reinforcing the localized impact of gender-inclusive CA practices.

5.3 Conclusions

The findings demonstrate that diversified cropping methods have a positive influence on household food security in Solai, Nakuru County, with crop rotation and intercropping enhancing food availability and soil health, thereby boosting agricultural productivity. The study confirmed that varied cropping systems foster resilience against climate-related challenges, ensuring stable and sustainable food production. This aligns with the Diffusion of Innovations Theory, which emphasizes that innovations, such as crop diversification, spread due to their relative advantage and compatibility with local practices (Rogers, 1962). The significant role of cropping methods in enhancing food security among smallholder farmers is evident. The Conservation Agriculture project in Solai has relied heavily on community leaders, particularly lead farmers, to disseminate new agricultural techniques, underscoring their pivotal role in transforming practices at the community level.

It was determined from the findings that minimum soil tillage positively influences food security in Solai, Nakuru County, by improving moisture retention and crop performance during droughts, contributing to enhanced soil health and agricultural productivity. This supports Systems Theory, which views practices like minimum tillage as integral components of a synergistic agricultural system that enhances efficiency through feedback loops, such as improved soil fertility (Bertalanffy, 1968). The research affirms that minimum tillage is an effective practice for promoting sustainable soil management and crop resilience. Farmers in Solai perceive the project's aim as advancing sustainable agriculture for soil conservation, reflecting a community commitment to long-term land health.

The findings established that continuous soil cover significantly enhances food security in Solai, with practices such as mulching with crop residues improving soil fertility, moisture retention, and crop yields, particularly during dry spells, thereby ensuring stable food production. This aligns with Systems Theory's emphasis on the integration of practices like cover cropping to enhance agricultural system resilience (Bertalanffy, 1968). The study concludes that continuous soil cover is essential for improving agricultural resilience and securing long-term food security, contributing to the sustainability of Solai's farming systems. The introduction of diverse cropping methods has further enhanced food security by improving soil conditions and increasing resilience.

The findings confirmed that gender dynamics significantly enhance food security outcomes in Solai, with gender-inclusive practices improving the effectiveness of cropping methods, minimum tillage, and continuous soil cover. The involvement of both genders, particularly women, strengthens adoption, leading to improved food security. This supports Agency Theory, which emphasizes monitoring mechanisms, such as gender-inclusive practices, to align agents' actions with organizational goals, including food security (Jensen & Meckling, 1976). The study concludes that gender dynamics are crucial for optimizing agricultural interventions, with women's leadership in adopting new practices underscoring the value of gender-inclusive strategies.

5.4 Recommendations

5.4.1 Policy Recommendations

The findings demonstrate that diversified cropping methods have a positive impact on food security in Solai, Nakuru County, aligning with the Innovation Diffusion Theory, which emphasizes the spread of innovations like crop rotation and intercropping due to their relative advantages and compatibility. It is recommended that Kenyan farmers adopt these practices to enhance food security and sustainability. However, existing agricultural policies lack targeted support for seed access and training in regions like Solai, indicating inefficiencies. The Ministry of Agriculture, agricultural extension services, and NGOs should provide robust training programs, technical support, and access to a diverse range of seeds. Collaboration among stakeholders is crucial for raising awareness and facilitating adoption, ensuring that policies are tailored to local needs to overcome barriers such as limited seed availability and promoting the widespread use of diversified cropping methods.

The study confirms that minimum soil tillage enhances food security by improving moisture retention and soil health, supporting Systems Theory's focus on integrated practices that enhance system efficiency through feedback loops. Kenyan farmers should be encouraged to adopt minimum tillage, particularly in drought-prone areas. Current conservation agriculture policies lack sufficient financial incentives for smallholder farmers in Solai, revealing a policy gap. The Ministry of Agriculture, in partnership with training institutions, should develop educational programs and provide tools like reduced-tillage equipment. Extension officers should conduct regular field demonstrations to support adoption, addressing implementation cost barriers to enhance soil fertility and crop resilience.

Continuous soil cover significantly contributes to food security by improving soil moisture and fertility, consistent with Systems Theory's emphasis on synergistic agricultural practices. It is recommended that Kenyan farmers adopt mulching and cover cropping practices to enhance productivity and sustainability. Policies promoting soil conservation lack specific measures for mulch provision in Solai, highlighting inefficiencies. The government, alongside agricultural research institutions, should promote these techniques through awareness campaigns, farmer training, and the provision of materials. Local extension officers should facilitate community-level implementation, addressing mulch availability challenges to ensure long-term success in improving food security and agricultural resilience.

Gender dynamics significantly enhance the adoption and effectiveness of agricultural practices, supporting Agency Theory's focus on monitoring mechanisms like gender-inclusive strategies to align actions with food security goals. It is recommended that gender-inclusive policies be integrated into agricultural programs to ensure equal participation of men and women in decision-making. Current gender policies in agriculture lack robust enforcement in Solai, indicating weaknesses. The government and stakeholders should advocate for gender equality through training that empowers women in farming roles and provides them with equal access to resources. Addressing cultural barriers through targeted programs will enhance the impact of agricultural interventions, ensuring both genders contribute to and benefit from improved food security outcomes.

5.4.2 Recommendations for Further Research

Future research could expand the study to include a more diverse range of agricultural communities, examining the influence of cultural differences on the adoption of sustainable farming practices. Exploring the long-term effectiveness of Conservation Agriculture methods in the face of climate change would also provide valuable insights.

Additionally, investigating the role of gender dynamics and addressing generational resistance to new farming techniques could further enhance understanding of the factors influencing the successful implementation of these practices. These areas of focus would provide a more comprehensive view of the project's sustainability and scalability.

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APPENDICES

Appendix I: Introduction Letter

Dear Respondent,

Re: Invitation to Participate in Research Study

I am Stephen Mwai Githendu, conducting a research study on the "***Moderating Influence of Gender Dynamics on Conservation Agricultural Project Practices and Food Security Among Smallholder Farmers in Solai, Nakuru County***", as part of my Master of Science in Project Management at Kabarak University.

Your insights as a stakeholder or smallholder farmer practicing Conservation agricultural project practices are crucial. I invite you to participate by completing a questionnaire. Your responses will remain confidential and will only be used for research purposes.

Participation is voluntary, and there will be no incentive. Your contribution will help advance our understanding of the effect of Conservation agricultural project practices on food security.

If you are willing to participate, kindly spare about 20 minutes of your time to participate in this questionnaire.

Thank you for considering this invitation.

Sincerely,

Stephen Mwai Githendu

Appendix II: Questionnaire

Introduction

Please complete the attached questionnaire on the effect of Conservation agriculture project practices on food security. Your contribution is vital. Thank you for your time and cooperation.

Section A: Demographics

1. Age:
   - ☐ 18-25 years
   - ☐ 26-35 years
   - ☐ 36-45 years
   - ☐ 46-55 years
   - ☐ 56 years and above
2. Gender:
   - ☐ Male
   - ☐ Female
3. Marital Status:
   - ☐ Single
   - ☐ Married.
   - ☐ Divorced/separated
   - ☐ Widowed
4. Education Level:
   - ☐ No formal education
   - ☐ Primary education
   - ☐ Secondary education
   - ☐ Vocational/technical training
   - ☐ Bachelor's degree

- ☐ Master's degree or higher

5. Household Size:
   - ☐ 1-2 members
   - ☐ 3-4 members
   - ☐ 5-6 members
   - ☐ 7 or more members
6. Main Source of Income:
   - ☐ Agriculture
   - ☐ Employment
   - ☐ Business
   - ☐ Other………………………….
7. Years of Practicing Conservation agriculture project practices Farming:
   - ☐ Less than 5 years
   - ☐ 5-10 years
   - ☐ 11-20 years
   - ☐ More than 20 years
8. Land Ownership Status:
   - ☐ Own
   - ☐ Lease
   - ☐ Other: ………………………….

Section B: Cropping Method on Food Security

The section seeks your insights on how cropping methods impact food security, with a focus on soil health, pest management, resilience to environmental changes, and overall food security among smallholder farming. Please fill in the cells with the appropriate responses based on the Likert scale ranging from "Strongly Agree-SA", "Agree-A," "Neutral-N", "Disagree-D", "Strongly Disagree-SD" according to your perspective and experience.

Statement	SA	A	N	D	SD
The planting of diverse crops has led to increased household food availability in my household.					
The cropping method has helped improve soil fertility on my farm, thereby contributing to enhanced crop productivity.					
The cropping method has enabled me to manage pests and diseases on my farm, thus ensuring stability in my crop yields.					
Utilizing crop management techniques enhances my farm's food security and resilience.					
Cropping method practices promote efficient land use, ultimately improving my family's food security.					

Section C: Minimum Soil Tillage On Food Security

The section seeks your insights on how minimum soil tillage practices impact food security, highlighting soil moisture conservation, nutrient management, water retention, soil structure, fertility enhancement, and erosion control for sustainable food production in smallholder farming. Please fill in the cells with the appropriate responses based on the Likert scale ranging from "Strongly Agree-SA", "Agree-A," "Neutral-N", "Disagree-D", "Strongly Disagree-SD" according to your perspective and experience.

Statement	SA	A	N	D	SD
Reduced ploughing on my farm conserves soil moisture for better crop growth.					
Implementing weed control through minimum soil tillage reduces nutrient competition.					
The water retention from minimum soil tillage practices benefits my crops' development.					
Minimal soil disturbance enhances the structure and fertility of my soil.					
By minimizing ploughing, I can reduce soil erosion and ensure sustainable food production on my farm.					

Section D: Continuous Soil Cover on Food Security

The section seeks your insights on how continuous soil cover practices impact food security, focusing on soil moisture conservation, nutrient management, water retention, soil structure, fertility enhancement, and erosion control for sustainable food production in smallholder farming. Please fill in the cells with the appropriate responses based on the Likert scale ranging from "Strongly Agree-SA", "Agree-A," "Neutral-N", "Disagree-D", "Strongly Disagree-SD" according to your perspective and experience.

Statement	SA	A	N	D	SD
Use of crop residues as soil cover has helped in retaining moisture for healthier soil.					
Mulching practices contribute to weed suppression, resulting in better crop yields.					
Continuous soil cover promotes soil health and nutrient recycling on my farm.					
The moisture retention from soil cover supports my crops' resilience to drought.					
By suppressing weeds through continuous soil cover, I can save on labor and herbicide costs.					

Section E: Gender Dynamics on the Relationship Between Conservation Agriculture Project Practices and Food Security

The section examines the gender dynamics in conservation agriculture practices and their impact on food security, focusing on participation in decision-making, access to resources, and agricultural training for sustainable farming. Please fill in the cells with the appropriate responses based on the Likert scale ranging from "Strongly Agree-SA", "Agree-A," "Neutral-N", "Disagree-D", "Strongly Disagree-SD" according to your perspective and experience.

Statement	SA	A	N	D	SD
All genders are involved in decision-making on the farm and the adoption of Conservation agriculture project practices.					
All genders are equally involved in accessing farming resources, thereby enhancing the implementation of Conservation agriculture project practices.					
There is access to agricultural training that empowers both genders for sustainable farming practices on my farm.					
Food is equally distributed and utilized within my household.					
Implementing gender-inclusive Conservation agriculture project practices can enhance food security outcomes for my family.					

Section 5: Food Security Among Smallholder Farmers: Focusing on Affordability, Access, and Stability

The section examines the impact of Conservation agriculture project practices on food security among smallholder farmers, emphasizing the affordability, accessibility, and stability of food supply. Please fill in the cells with the appropriate responses based on the Likert scale ranging from "Strongly Agree-SA", "Agree-A," "Neutral-N", "Disagree-D", "Strongly Disagree-SD" according to your perspective and experience.

Statement	SA	A	N	D	SD
Transition to Conservation agriculture project practices has led to better farm productivity, making food more affordable for my family.					
Conservation agricultural practices have expanded our access to a variety of farm produce, ensuring food security for our household.					
Embracing Conservation agriculture project practices and techniques has provided stability in our food supply, guaranteeing consistent meals throughout the year.					
Since adopting the Conservation agriculture project practices, our community has realized a significant improvement in the affordability of food.					
Through Conservation agriculture project practices, we've gained easier access to farm produce, enhancing our overall food security.					

Thank you for your participation

Appendix III: Interview Schedule

Introduction to Respondents:

Thank you for participating in this interview. Your insights are crucial to understanding the impact and implementation of the Conservation agriculture project practices in Solai, Nakuru County. This interview aims to gather valuable information about your role, perspectives, and experiences related to the project.

Interview Questions:

1. Can you describe your role and involvement with the Conservation agriculture project practices in Solai?
2. What do you perceive as the main objective of the Conservation agriculture project practices here?
3. Which cropping methods does the project promote, and how do they impact food security?
4. How has adopting minimum soil tillage practices affected food security among farmers?
5. How is continuous soil cover implemented, and what benefits does it bring to farmers?
6. How do gender dynamics influence the adoption and outcomes of Conservation Agriculture practices and food security?
7. What are the primary challenges faced in implementing the Conservation agriculture project practices?
8. What strategies have contributed most to the success of the project?
9. From your perspective, how has the project improved food security in Solai?
10. What measures are in place to ensure the long-term sustainability of Conservation Agriculture practices?

Appendix IV: Informed Consent Form

Study Title: Moderating Influence of Gender Dynamics on Conservation Agricultural Project Practices and Food Security Among Smallholder Farmers in Solai, Nakuru County

PI: Stephen Mwai Githendu ________Affiliated Institution: KABARAK UNIVERSITY

Co-investigator(s) Dr. Nehemiah Kiplagat Affiliated Institution(s)___ Dr. Richard Nyaoga _

Introduction

You are invited to participate in this research study being undertaken by the above-listed investigators. This form will help you gather information about the study so that you can voluntarily decide whether you want to participate or not. You are encouraged to ask any questions regarding the research process, as well as any benefits or risks that you may accrue by participating. After you have been adequately informed about the study, you will be requested to either agree or decline to participate. Upon agreeing to participate in the study, you will be further requested to affirm that by appending your signature/thumbprint on this form. Accepting or declining to participate in this study does not in any way waive the following rights, which you're entitled to:

a) Voluntary participation in the study.
b) Withdrawing from the study at any time without the obligation of having to give an explanation, and,
c) Access to services that you're entitled to

A copy of this form will be provided to you for your own records. Should I continue? YES/NO __

This study has been reviewed and approved by Kabarak University Research Ethics Committee (KUREC)

What is the Purpose of the Study?

The main reason(s) for conducting this study are to answer the following questions:

1. To determine the Cropping method practice on food security among smallholder farmers in Solai, Nakuru County.
2. To establish the influence of minimum soil tillage practice on food security among smallholder farmers in Solai, Nakuru County.
3. To evaluate the influence of continuous soil cover practice on food security among smallholder farmers in Solai, Nakuru County.
4. To examine the moderating influence of gender dynamics on the relationship between Conservation agriculture project practices and food security among smallholder farmers in Solai, Nakuru County.

Who can Take Part in the Study?

95 smallholder farmers in Solai, Nakuru County, who meet the inclusion criteria of practicing conservation agricultural practices for the last three years,6 ADS-CR staff, 2 ward agricultural officers, and 4 local administrations (chief and 3 assistants in Solai location)

In Case You Agree to Participate in the Study, What Will Happen?

This is what is going to happen once you have agreed to participate in the study:

- Your participation in the study will involve a one-time interview session, typically lasting about 20 minutes. There may be a follow-up session depending on the need for additional information or clarification.

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  ____

  ____

- A qualified and well-trained interviewer will conduct the interview in a private setting where you feel comfortable. You have the right to decline to answer any question that makes you uncomfortable. The interview will cover areas such as your experience with Conservation agriculture project practices, challenges faced, and perceptions of food security.

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- After the interview, no further procedures are required from you as a participant.

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- You will be requested to provide your contact details, such as a phone number or email address. This information will be kept confidential and will only be used to reach you in case of any new information regarding the study or for follow-up purposes.

  ____

  ____

  ____

- The contact details you will provide shall remain confidential to the lead researcher (PI).

  ____

  ____

  ____

What Potential Risks are Associated with Participation in this Study?

Psychological discomfort:
Discussing personal experiences or challenges related to agriculture and food security may cause emotional distress or discomfort.

Mitigation:
The interviewer will ensure a supportive and non-judgmental environment during the interview. Participants have the right to decline answering any questions that make them uncomfortable.

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Privacy & Confidentiality
There's a slight risk of breach of privacy or confidentiality, although stringent measures will be in place to protect participants' personal information.

Mitigation: All data collected will be anonymized and stored securely. Only authorized research team members will have access to the data. Personal information will be kept confidential and will not be disclosed without explicit consent from the participant.

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In case you aren't comfortable answering any of the questions during the interview because of feeling embarrassed or uncomfortable, it will be within your rights to decline. Otherwise, every measure has been taken to ensure that the interview is conducted in a private area with minimal to no interference so that you feel comfortable.

If at all you suffer any injury, illness, or complication(s) by participating in this study, kindly contact us immediately using the contact details provided at the bottom of this form. The study clinician will attend to you, and if there is a need for further assessment or treatment, you willbe referred accordingly.

What Benefits are you going to accrue by participating in the study

By participating in this study, you will:

- Contribute to advancing knowledge in the fields of agriculture: Conservation agriculture project practices, and food security.
- Help identify challenges and opportunities for improving conservation agricultural project practices and food security outcomes in your community.
- Potentially benefit from the insights gained from the study, which may lead to improved agricultural project practices and increased food security for yourself and your community.

____

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What Will it Cost You to Participate in the Study?

There are no costs associated with participating in this study. All expenses related to data collection, interviews, and any clinical procedures (if applicable) will be covered by the research team.

Will Any Expenditure that You Incur by Participating in the Study be Refunded? Or will you be paid for participating in the Study?

Participants will not be reimbursed or paid for participating in the study.

In Case I have any Further Questions/ Concerns in the Future, Whom Should I contact?

If you need further clarification or have questions regarding your continued participation in the study, feel free to contact the PI at +254722 441 026.

In case of concerns regarding your rights and/or obligations as a research participant, do not hesitate to contact the secretary, KUREC.

What Alternative Options are Available to Me?

The decision on whether to participate or not is absolutely voluntary. You will be free to withdraw from the study at any point during the study without providing any explanation.

How Will the Findings of this Study be Communicated or Shared?

Feedback and findings of the study will be shared with ADS-CR, Nakuru County Ministry of Agriculture, and the local administration of Solai to inform decision-making processes. The information will be shared transparently, maintaining the confidentiality and privacy of the respondents.

For any further questions or concerns during or after the study, you can contact the PI at [+254 722 441026].

For concerns regarding your rights as a research participant, you can contact the secretary of KUREC.

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____

____

Statement of Consent

I have comprehensively read the consent form or/the information that has been comprehensively read to me by the researcher. I have understood what the study is about, and all the questions and concerns that I had have been addressed in a clear and concise manner. The study benefits and foreseeable risks have been explained to me. I totally understand that my decision to participate inthis study is voluntary, and I have the right to withdraw at any point during the study.

I freely consent to participate in this study.

Signing this form does not in any way imply that I have given up the rights I am entitled to as a participant.

I agree to participate in this research YES____________

____NO________

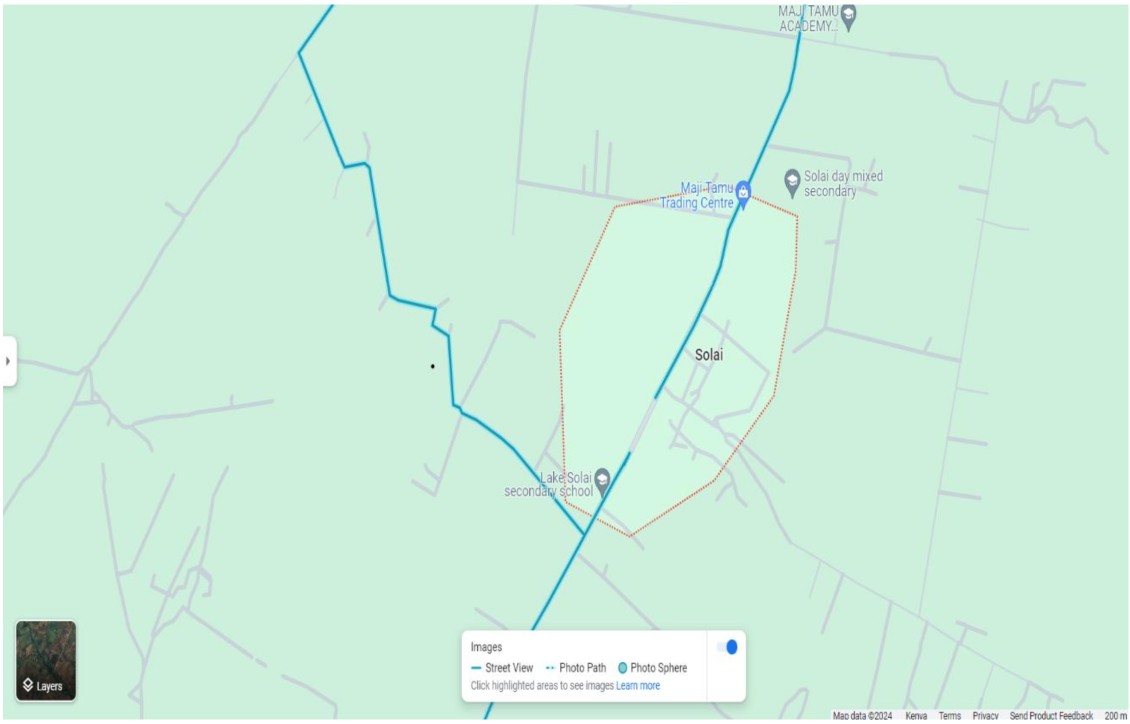
I agree to provide my contact details for follow-up YES____________

____NO________

Participant's Name ____

Participant's Signature/Thumb print________________Date________________________

Appendix V: Map of Location of the Study



Source: Map Data (2024)

Apendix VI: KUREC Clearance Letter

KABARAK UNIVERSITY RESEARCH ETHICS COMMITTEE

Private Bag - 20157
KABARAK, KENYA
Email: kurec@kabarak.ac.ke

Tel: 254-51-343234/5
Fax: 254-051-343529
www.kabarak.ac.ke

OUR REF: KABU01/KUREC/001/25/08/24

Date: 27th August, 2024

Stephen Mwai Githendu
Reg No: GMPM/NE/0129/01/23
Kabarak University,

Dear Stephen,

RE: EFFECT OF CONSERVATION AGRICULTURAL PROJECT PRACTICES ON FOOD SECURITY AMONG SMALLHOLDER FARMERS IN SOLAI LOCATION, NAKURU COUNTY.

This is to inform you that ***KUREC*** has reviewed and approved your above research proposal. Your application approval number is ***KUREC-250824.*** The approval period is 27***/08/2024 – 27/08/ 2025.***

This approval is subject to compliance with the following requirements:

i. All researchers shall obtain an introduction letter to NACOSTI from the relevant head of institutions (Institute of postgraduate, School dean or Directorate of research)
ii. The researcher shall further obtain a RESEARCH PERMIT from NACOSTI before commencement of data collection & submit a copy of the permit to **KUREC.**
iii. Only approved documents including (informed consents, study instruments, MTA Material Transfer Agreement) will be used
iv. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***KUREC***:
v. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***KUREC*** within 72 hours of notification;
vi. Any changes, anticipated or otherwise that may increase the risk(s) or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***KUREC*** within 72 hours;
vii. Clearance for export of biological specimens must be obtained from relevant institutions and submit a copy of the permit to KUREC;
viii. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal and;
ix. Submission of an executive summary report within 90 days upon completion of the study to ***KUREC***

KABARAK UNIVERSITY
INSTITUTIONAL RESEARCH ETHICS COMMITTEE
APPROVED
PRIVATE BAG - 20157, KABARAK

Sincerely,

Prof. Jackson Kitetu PhD.
KUREC-Chairman

Cc
Vice Chancellor
DVC-Academic & Research
Registrar-Academic & Research
Director-Research Innovation & Outreach
Institute of Post Graduate Studies

As members of Kabarak University family, we purpose at all times and in all places, to set apart in one's heart, Jesus as Lord.
(1 Peter 3:15)
Kabarak University is ISO 9001:2015 Certified

Appendix VII: NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **811363**

Date of Issue: **19/September/2024**

RESEARCH LICENSE

This is to Certify that Mr.. Stephen Mwai Githendu of Kabarak University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nakuru on the topic: EFFECT OF CONSERVATION AGRICULTURAL PROJECT PRACTICES ON FOOD SECURITY AMONG SMALLHOLDER FARMERS IN SOLAI LOCATION, NAKURU COUNTY for the period ending : 19/September/2025.

License No: **NACOSTI/P/24/39879**

811363

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

Appendix VIII: Evidence of Conference Participation

EDUCATION IN BIBLICAL PERSPECTIVE

KABARAK UNIVERSITY

Certificate of Participation

Awarded to

STEPHEN MWAI GITHENDU

For successfully participating in the 15th Annual Kabarak University International Research Conference held on 1st-2nd July 2025 and presented a paper entitled ***"Effect of Cropping Method Practices on Food Security Among Smallholder Farmers in Solai, Nakuru County, Kenya"***

Conference Theme

Sustainable Business Models In The Era Of Artificial Intelligence For Youth Empowerment

Prof. Patrick Kibati
Dean, School of Business & Economics

Dr. Phillip Nyawere
Director - Research, Innovation and Outreach

Kabarak University Moral Code

As members of Kabarak University family, we purpose at all times and in all places, to set apart in one's heart, Jesus as Lord.

(1 Peter 3:15)

Kabarak University is ISO 9001:2015 Certified

Appendix IX: List of Publication

African Journal of Emerging Issues
Peer reviewed | Double blind | Interdisciplinary

African Journal of Emerging Issues (AJOEI)
Online ISSN: 2663 - 9335
Available at: https://ajoeijournals.org

FOOD SECURITY

INFLUENCE OF CROPPING METHOD PRACTICE ON FOOD SECURITY AMONG SMALLHOLDER FARMERS IN SOLAI, NAKURU COUNTY

***[1]Stephen Mwai Githendu, [2]Dr. Nehemiah Kiplagat, [3]Dr. Richard Nyaoga**

[1,2]Kabarak University, Kenya

[3]Egerton University, Kenya

***Email of the Corresponding Author:** sgithendu@kabarak.ac.ke

Publication Date: September 2025

ABSTRACT

Purpose of the Study: The study set out to investigate the effect of cropping methods specifically crop rotation and intercropping on food security among smallholder farmers in Solai, Nakuru County, Kenya.

Statement of the Problem: Smallholder farmers in Solai face persistent challenges of climate variability, soil degradation, and limited adoption of sustainable farming practices. These constraints undermine agricultural productivity and threaten household food security. Despite the recognized benefits of conservation agriculture, evidence on the contribution of specific cropping methods to food security in this context remains inadequate.

Research Methodology: The study employed a cross-sectional descriptive and correlational design. Data was gathered from 100 respondents, including 95 farmers and 5 key stakeholders. Structured questionnaires based on a 5-point Likert scale were administered, complemented by in-depth interviews. Quantitative data was analyzed using regression and correlation techniques, while qualitative data was thematically analyzed.

Findings: Regression results demonstrated a significant positive effect of cropping methods on food security ($\beta = 0.472$, $p = 0.000$). Pearson correlation further indicated a strong positive relationship ($r = 0.902$, $p = 0.000$). The findings revealed that intercropping and crop rotation practices enhanced food supply, improved soil fertility, and supported sustainable agricultural systems.

Conclusion: The study concludes that the adoption of crop diversification strategies is essential for addressing food security challenges among smallholder farmers in Solai. Conservation agriculture practices provide both immediate and long-term benefits, contributing to resilience against climate shocks.

Recommendation: The study recommended that agricultural extension services and targeted awareness programs be strengthened to promote the uptake of intercropping and crop rotation.

Keywords: *Conservation Agriculture, Cropping Methods, Food Security, Smallholder Farmers.*