SOCIO-ECONOMIC FACTORS INFLUENCING ADOPTION OF SUSTAINABLE SUGARCANE FARMING PRACTICES AMONG SMALLHOLDER FARMERS IN KAKAMEGA NORTH SUB-COUNTY, KENYA

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A Thesis submitted to the School of Agriculture & Veterinary Sciences and Technology in partial fulfillment of the requirement for the Degree of Master of Science in Agricultural Education and Extension of Masinde Muliro University of Science & Technology.

NOVEMBER, 2025

DECLARATION

This thesis is my original work prepared with no other than the indicated sources and support and has not been presented elsewhere for a degree or any other award.

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CERTIFICATION

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DEDICATION

To my late dad, Humphrey Nyongesa, mother Florence Mwangala, husband Timona Sunguti, daughter Eliana Blessings, and siblings Chillian, Ebby, Mary, Joy, Quirine and Edwin.

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I express my gratitude to God for his protection throughout my studies. My sincere appreciation goes to my mother, Florence Mwangala for her financial support and continuous encouragement in my studies. I acknowledge the rest of my family members for their invaluable emotional, spiritual, and moral support during this research journey. I extend my profound appreciation to my esteemed supervisors, Prof. Alice Chesambu Ndiema and Prof. Levi Shadeya Akundabweni for their valuable guidance and mentorship throughout the research. Their expertise was instrumental in refining the report to its current state. I also acknowledge the support and contribution of the academic staff at Masinde Muliro University Dk. Ondulo Jasper for guidance in data analysis and Prof. Wamocho Leonard for his continuous encouragement throughout the study. More gratitude also goes to Mr. Simiyu at the Ministry of Agriculture Kakamega North sub-county for making the data collection process more efficient.

ABSTRACT

One of the major agricultural activities of the country is sugarcane production, although the productivity of sugarcane is low relative to the potential. Despite the fact that sustainable practices encourage production, smallholder farmers do not implement it due to a number of reasons. The research project was intended to explore the socio-economic issues that affect the adoption of the sustainable sugarcane farming culture among smallholders in Kakamega North sub-county. The objectives were specific and were as follows to evaluate the current rate of adoption of sustainable sugarcane farming practices, establish the relationship that exists between socioeconomic factors and the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers, and explore the role of farmer groups in adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers. The study involved all the seven wards in Kakamega North sub-county in which the population of sugarcane smallholder farmers was 65,323 and a sample size of 394. The study employed the cross-sectional survey design. Sampling proportion was done to provide sufficient ward representation. A questionnaire that is structured was used to gather data by the questionnaire to the sampled farmers. The study results thereof included the following; 84 percent of them practiced mulching, 93 percent did not do soil testing, and 100 percent did not practice integrated harvesting methods. Gender, the level of farming experience, and income were found to have significant ($p \leqslant 0.05$) association with adoption of mulching practices. On the same note, integration of the practices of weeding was significantly related ($p \leqslant 0.05$) to gender and education level, level of income, membership to farmer groups and access to extension services. Moreover, extension services, soils testing practice, and income level were highly associated with the adoption of the practice of soil testing. To sum up, the research paper underscores that gender, farm experience, education level, income level, farm groups and extension services are important factors in determining the sustainable farming practices adoption of sugarcane smallholder farmers. As a means of increasing the uptake of such practices, a need is presently that policymakers, agricultural extension officers and farmer organizations should focus on certain interventions that are to be packaged and lobbied effectively to enable them to take care of these critical issues and hence, create a more sustainable sugarcane production practice. Further studies are needed in future to examine long-term effects of such socio-economic factors on sustainability and address novel strategies in an effort to eliminate obstacles to the introduction of sustainable practices.

TABLE OF CONTENTS

CONTENTS **PAGE**

PLAGIARISM STATEMENT ii

COPYRIGHT PAGE iv

DEDICATION v

ACKNOWLEDGEMENTS vi

ABSTRACT vii

TABLE OF CONTENTS viii

LIST OF TABLES xii

LIST OF FIGURES xv

LIST OF APPENDICES xvi

ABBREVIATIONS AND ACRONYMS xvii

OPERATIONAL DEFINITION OF TERMS xviii

CHAPTER ONE 1

INTRODUCTION 1

1.0.Overview 1

1.1.Background to the study 1

1.2.Statement of the problem 5

1.3.General objective 5

1.4.Specific Objectives 6

1.6.Hypothesis 6

1.7. Significance of the study 7

1.8. Justification of the study 7

1.9. Limitations of the study 8

1.10. Assumptions of the study 8

CHAPTER TWO 10

LITERATURE REVIEW 10

2.0. Overview. 10

2.1. Technology adoption. 10
2.2. Technology Transfer and Adoption Problems. 12
2.3. Sustainable Sugarcane Farming Practices. 14
2.3.1. Mulching. 14
2.3.2. Soil Nutrient Management: Soil testing. 15
2.3.3. Integrated Harvesting Methods. 16
2.3.4. Integrated Weed Management Practices. 18
2.4.0 Socio-economic factors influencing the adoption of sustainable sugarcane farming practices. 19
2.4.1. Gender. 19
2.4.2. Age. 21
2.4.3. Education level. 23
2.4.4. Land ownership. 24
2.4.5. Farming experience. 25
2.4.6. Market Access. 26
2.4.7. Extension services. 27
2.4.8 Farmer Groups. 28
2.4.9. Income level. 29
2.5. Theoretical framework. 30
2.7. Literature Review Summary 34
CHAPTER THREE 35
RESEARCH METHODOLOGY 35
3.0. Overview. 35
3.1. Research design. 35
3.2. Description of study location. 35
3.3. Target population. 36
3.4. Sampling procedure. 36
3.5. Sample size. 37

3.6. Data collection procedure and instruments. 38
3.7. Pre-testing of data collection instrument. 39
3.8. Data analysis and presentation. 39
3.9. Reliability and Validity. 43
3.10. Ethical considerations during data collection. 43
CHAPTER FOUR 44
RESULTS AND DISCUSSION 44
4.1. Overview. 44
4.2.0. Adoption status of sustainable sugarcane farming practices by sugarcane smallholder farmers. 44
4.2.1. Adoption status of Soil Nutrient Management practice; Soil testing by sugarcane smallholder farmers. 44
4.2.2. Adoption status of Integrated Weeding Practices by sugarcane smallholder farmers. 46
4.2.3. Adoption status of mulching as a practice by sugarcane smallholder farmers. 48
4.2.4. Adoption status of integrated sugarcane harvesting methods by sugarcane smallholder farmers. 49
4.3.0. Relationship among various socio-economic factors influencing adoption of sustainable sugarcane farming practices. 51
4.3.1. Age and Market Access Crosstabulation. 51
4.3.2. Age and Farmer Group Membership Crosstabulation. 53
4.3.3. Age and Access to Extension Services Crosstabulation. 54
4.3.4. Education Level and Access to Extension Services Crosstabulation. 55
4.3.5. Education Level and Market Access Crosstabulation. 57
4.3.6. Education Level and Farmer Group Membership Crosstabulation. 59
4.3.7. Gender and Access to Extension Services Crosstabulation. 60
4.3.8. Gender and Market Access Crosstabulation. 62
4.3.9. Gender and Farmer Group Membership Crosstabulation. 63
4.3.10. Income Level and Access to Extension Services Crosstabulation. 65

4.3.11. Income Level and Market Access Crosstabulation. 66
4.3.12. Income Level and Farmer Group Membership Crosstabulation. 68
4.3.13. Farming Experience and Access to Extension Services Crosstabulation. 70
4.3.14. Farming Experience and Market Access Crosstabulation. 72
4.3.15. Farming Experience and Farmer Group Membership Crosstabulation. 74
4.3.16. Land Type and Access to Extension Services Crosstabulation. 75
4.3.17. Land Type and Market Access Crosstabulation. 77
4.4.0. Adoption of Sustainable Sugarcane Practices by Socio-economic Characteristics of Smallholder Farmers. 79
4.4.2. Adoption by Age. 82
4.4.3. Adoption by Gender. 82
4.4.4. Adoption by Education Level. 83
4.4.5. Adoption by Farming Experience. 83
4.4.6. Adoption by Income Level. 83
4.4.7 Adoption by Land Ownership. 84
4.4.8. Adoption by Farmer Group Membership. 84
4.4.9. Adoption by Market Access. 84
4.4.10. Adoption by Access to Extension Service. 85
4.5.0. Relationship between adoption of the various sustainable sugarcane farming practices and socio-economic characteristics of smallholder sugarcane farmers. 85
4.6.0 Role of Farmer groups in the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers. 91
CHAPTER FIVE 96
CONCLUSIONS AND RECOMMENDATIONS 96
5.1. Overview 96
5.2.0. Conclusions 96
5.3. Recommendations 97
5.4 Suggestions for further studies. 97
REFERENCES 99

APPENDICES 113
APPENDIX 1: MAP OF KAKAMEGA NORTH SUB-COUNTY 113
APPENDIX 2: NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION RESEARCHER'S LICENSE 114
APPENDIX 3: QUESTIONNAIRE FOR INDIVIDUAL SMALLHOLDER SUGARCANE FARMERS 115

LIST OF TABLES

Table 1.1. Sugar production, import, and export trends in Kenya……3

Table 3.1: Sample size across the seven wards in Kakamega North Sub-County…..38

Table 3.2: Reliability analysis result for individual sugarcane smallholder farmers' questionnaire……..40

Table 3.3: Categorization of variables for chi square analysis……..…….42

Table 4.1: Distribution of sugarcane smallholder farmers' reasons for not conducting soil testing. …….……..…..47

Table 4.3.1: Age and Market Access Crosstabulation……...…….…….52

Table 4.3.2: Age and Farmer Group Member Crosstabulation…….……...54

Table 4.3.3: Age and Access to Extension Services Crosstabulation……...55

Table 4.3.4: Education Level and Access to Extension Services Cross tabulation…..56

Table 4.3.5: Education Level and Market Access Crosstabulation……..…….…...58

Table 4.3.6: Education Level and Farmer Group Membership Crosstabulation...…...60

Table 4.3.7: Gender and Access to Extension Services Crosstabulation……..…....61

Table 4.3.8: Gender and Market Access Crosstabulation……..……....63

Table 4.3.9: Gender and Farmer Group Membership Crosstabulation……..65

Table 4.3.10: Income Level and Access to Extension Services Crosstabulation……..…66

Table 4.3.11: Income Level and Market Access Crosstabulation……..…..67

Table 4.3.12: Income Level and Farmer Group Membership Crosstabulation……69

Table 4.3.13: Farming Experience and Access to Extension Services Crosstabulation..71

Table 4.3.14: Farming Experience and Market Access Crosstabulation……....73

Table 4.3.15: Farming Experience and Farmer Group Membership Crosstabulation….75

Table 4.3.16: Land Type and Access to Extension Services Crosstabulation……..…...76

Table 4.3.17: Land Type and Market Access Crosstabulation……78

Table 4.3.18: Land Type and Farmer Group Membership Crosstabulation……79

Table 4.4.1: Adoption of Sustainable Sugarcane Practices by Socio-economic Characteristics of Smallholder Farmer……...……..….81

Table 4.5.1: Relationship between adoption of mulching practice and the socio-economic factors ……..…...….86

Table 4.5.2: Relationship between the adoption of integrated weed management and the socio-economic factors ……...…..88

Table 4.5.3: Relationship between adoption of soil testing and the socio-economic factors…….90

Table 4.6.1: Influence of sugarcane smallholder farmers' membership in farmer group(s) on adoption of soil testing practices in Kakamega North sub-county, Kenya……....91

Table 4.6.2: Influence of farmer group(s) on the adoption of Integrated Weed Management practices in Kakamega North sub-county, Kenya……,,….92

Table 4.6.3: Influence of farmer group(s) on the adoption of mulching practices by smallholder farmers in Kakamega North sub-county, Kenya……...93

Table 4.6.4: Major benefits obtained through membership into farmer group in the adoption of sustainable sugarcane farming practices by smallholder farmers in Kakamega North sub-county, Kenya……94

LIST OF FIGURES

Figure 2.1: Diagrammatic representation of conceptual framework……..….34

Figure 4.1: Distribution of sugarcane smallholder farmers based on adoption of soil testing practice in Kakamega North Sub-County, Kenya……..46

Figure 4.2: Distribution of sugarcane smallholder farmers based on the adoption of weeding practices in Kakamega North Sub-County, Kenya……..…48

Figure 4.3: Distribution of sugarcane smallholder farmers based on adoption of mulching practice in Kakamega North Sub-County, Kenya……..……...49

Figure 4.4: Distribution of sugarcane smallholder farmers based on sugarcane harvesting methods in Kakamega North Sub-County, Kenya……..…51

LIST OF APPENDICES

Appendix 1: Map of Kakamega North Sub-County.

Appendix 2: National Commission for Science, Technology, and Innovation (NACOSTI) Researcher's License.

Appendix 3: Questionnaire of individual smallholder sugarcane farmers.

ABBREVIATIONS AND ACRONYMS

GDP: Gross Domestic Product

IWM: Integrated Weed Management

SSFPs: Sustainable Sugarcane Farming Practices

KSH: Kenyan Shillings

OPERATIONAL DEFINITION OF TERMS

Adoption:	Adoption is a mental process that involves the decision to practice an agricultural innovation, new idea, or improved practice.
Adoption status:	Current state of whether sugarcane farmers are carrying out a practice or not at a specific point in time.
Farmer group:	associations formed either formally or informally to help sugarcane farmers come together to pursue a common goal and interest of improving sugarcane productivity.
Integrated Weed Management:	involves a combination of two or more control methods in all possible ways to manage weeds in a farm.
Market access:	it involves physical, legal, and logistical conditions that either facilitate or hinder the ability of sugarcane smallholder farmers to transport, deliver, and sell their harvested cane to factories.
Cane residue:	the upper portion of harvested cane that is left on the farm when it is transported to the processing pla

Smallholder farmer**:** this is an individual who owns and operates a relatively small piece of land and is dedicated to actively managing the production of sugarcane.

Sustainable practices: agricultural methods and techniques used in sugarcane cultivation that aim to maintain or enhance productivity while minimizing environmental impact, conserving resources, and supporting the long-term viability of farming.

CHAPTER ONE

INTRODUCTION

1.0.Overview

This chapter provides an overview of the background to the study, statement of the problem, general objective, specific objectives, hypothesis, significance of the study, justification of the study, limitations of the study, and assumptions of the study.

1.1. Background to the study.

Sugarcane (*Saccharum officinarum L*) is a tropical and sub-tropical tall perennial grass species primarily cultivated for its sugar-rich stalk. Sugarcane production contributes 86% to the total sugar in the world (Voora *et al*., 2023). It is not only used in the production of sugar but also in the manufacture of ethanol and molasses (Formann *et al*., 2020). Milled cane (bagasse) is used as the by-product to provide energy. The deep-rooted effect of sugarcane on agriculture, economy and renewable energy, makes it an essential basis of our networked world.

Sugarcane is cultivated in numerous regions across the world. The leading countries responsible for more than 70% of the world's sugarcane production include; Brazil, India, mainland China, Pakistan, and Thailand. Brazil is the largest global producer of sugarcane, boasting a significant 40% share of global production (Voor *et al*., 2023). India closely

follows it with a 22% contribution. Mainland China and Thailand contribute 4% and 6% respectively to the world's sugarcane production (Som-Ard *et al*., 2021). Africa as a continent contains a multitude of countries that collectively contribute 5% of the total global sugarcane production (Ambetsa *et al*., 2020). Although many countries in Sub-Saharan Africa produce sugarcane, the following five countries produce over 50%: South Africa (33%), Sudan (9%), Kenya (7%), Swaziland (7%), and Mauritius (7%) (Hess *et al*., 2016; Nanjala *et al*., 2022).

In Kenya, cultivation of sugarcane is primarily done in Nyanza, Western and Coastal parts of the country. The sector enhances the growth of Kenya's economy by providing employment (directly and indirectly) to the population. It accounts for about 16% of the Gross Domestic Product (GDP) of the nation (Khaemba *et al*., 2022). Harvested cane crops are transported to processing plants where they are transformed into sugar and various associated products. Sugarcane smallholder farmers mainly cultivate sugarcane alongside other food crops within their landholdings. The land size for smallholder farmers is 1.5 acres on average (Ndung'u, 2023). Nevertheless, the sector is currently experiencing challenges such as the collapse of certain industries, and low production from cane farms which results in increased imports of sugar products to the country.

Kombo *et al*. (2022) found that there is limited availability of sugarcane for milling due to a continuous decline in sugarcane production. The declining sugarcane production and increased import trend are shown in Table 1.1 on page 3 (NAP, 2024). On average, sugar mills in Kenya are operating at 60% of their installed capacity.

Table 1.1: Sugar production, import, and export trends in Kenya

YEAR	2019	2020	2021	2022	2023
Sugar production (T)	440,935	603,788	700,241	796,554	472,773
Sugar imports(T)	458,631	442,393	426,334	320,708	608,178
Sugar exports(T)	775	375	1196	359	474

Source NAP: 2024

Kakamega County in western Kenya is an important sugarcane producer. It has been a major player in sugarcane production in Kenya because of its special features including its favourable climate, fertile soil and its large sugar factories (West Kenya, Mumias, and Butali). The unpredictability of the sugarcane industries with frequent close-downs and openings was also explained by different factors, one of the main reasons being the lack of sufficient supply of the sugarcane by the farmers. This is because of the instability of these sugar mills and the significant economic losses to the local community and the country.

Kakamega North sub-county consists of the bigger Kakamega County. The main economic activity that is undertaken in the sub-county is agriculture. It entails the cultivation of

different crops including maize, sugarcane, groundnuts, beans and vegetables. Farming of sugarcane in general has a significant role to play in local economy development. The sugarcane farmers in Kakamega North sub-county are approximately 65,323 (Nanjala et al., 2022). West Kenya and Butali Sugar companies are two sugarcanes industries that are found in this sub-county.

As aforementioned, the lack of sufficient sugarcane harvest in the farms, which cannot sustain their operations, is one of the factors that contributed to the collapse and closure of the sugar mills. The inability of sugarcane smallholder farmers to practice sustainable sugarcane farming, including, mulching, soil nutrient management practice; soil testing, Integrated Weed Management, and Integrated harvesting methods, also contributes to poor sugarcane production (Kombo et al., 2022).

The inability of sugarcane smallholder farmers to engage in sustainable sugarcane farming technologies like mulching, soil testing, Integrated Weed Management, and harvesting techniques are among the causes of poor sugarcane production (Kombo et al., 2022). The research studies have shown that sugarcane smallholder farmers in the study area are more concerned with the use of different sustainable sugarcane farming methods (Francis et al., 2020). Thus, this underscored the urgent need to determine the socio-economic variables that determine the adoption of sustainable sugarcane agricultural practices among small

scale farmers within the Kakamega North Sub-County. These factors are critical in addressing the challenges facing sugarcane smallholder farmers in the adoption of sustainable sugarcane farming practices, and therefore, aim at increasing the productivity in the area.

1.2.Statement of the problem.

Despite the developed sugarcane production practices for smallholder farmers to increase production to meet the ever-rising demand for the products, various factors have limited their utilization. Furthermore, a larger percentage of sugarcane farmers operate on small landholdings, which limit their ability to scale up production using conventional methods. Farmers must increase sugarcane production by adopting sustainable sugarcane farming practices at a more intensive rate. Unfortunately, the current state of adoption and the factors limiting the adoption of these practices by the farmers within the study area remain unclear. Therefore, this necessitated the need to investigate the socio-economic factors that influence the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers in the study area.

1.3.General objective.

To contribute to the improvement of livelihoods of small-scale sugarcane farmers through increased sugarcane production by addressing the challenge of adoption of sustainable

sugarcane farming practices among sugarcane smallholder farmers in Kakamega North Sub-County.

1.4. Specific Objectives.

i. To assess the current adoption status of sustainable sugarcane farming practices among sugarcane smallholder farmers in Kakamega North Sub-County.

ii. To determine the relationship between socioeconomic factors and the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers in Kakamega North Sub-County.

iii. To investigate the role of farmer groups in the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers in Kakamega North Sub-County.

1.5. Research Question.

i. What is the current adoption status of sustainable sugarcane farming practices among sugarcane smallholder farmers in Kakamega North Sub-County?

1.6. Hypothesis.

(H_{02}): There is no significant association between socioeconomic factors and the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers in Kakamega North Sub-County.

(H_{03}): Farmer groups do not significantly influence the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers in Kakamega North Sub-County.

1.7. Significance of the study.

The research results will enhance the livelihood of the smallholder sugarcane farmers and the people in general. The findings will also be a valuable tool to policy makers who can make more specific and efficient interventions to assist sugarcane farmers and make informed strategic choices in respect of agricultural activities. Enhancement of the sugarcane smallholder farmers production directly increases the economic welfare of farmers and the economies of regions where they are located. In addition, the increased sugarcane production will decrease the dependency on the imports hence strengthening the national food security and guaranteeing a regular supply of cheap sugar, a crucial part of the diet of many.

1.8. Justification of the study.

The choice of the Kakamega North sub-county as a site of the study was informed by the fact that sugarcane can be grown there. In addition, the primary cash crop that is used in the region is sugarcane (Nanjala et al., 2022). The study took a holistic approach by the virtue of addressing the socio-economic factors affecting the implementation of sustainable

sugarcane farming practices, and this arose because the study based its idea on the fact that the issue of causation in the context of production economics offers the most relevant framework of viable solutions. Lastly, the choice to conduct research about sugarcane crops production was made due to the fact that it is the largest economic activity of the local community providing many socio-economic advantages in the form of employment, income generation, and development of a rural area.

1.9. Limitations of the study.

i. This study was delimited to the Kakamega North sub-county as the primary geographical area of investigation.

ii. The study specifically focused on sugarcane smallholder farmers, with a total population of approximately 65,323 (Nanjala *et al*., 2022). In Kakamega County, smallholders typically have on average 1.5 acres of land (Ndung'u, 2023).

iii. The research study was constrained by the fact that sugarcane smallholder farmers lack the means to directly observe and confirm the true weight of their harvested cane during the weighing process in factories, as they are dependent solely on the information provided in payment receipts, which may not always be precise.

1.10. Assumptions of the study.

i. Gender was not a source of bias or discrimination during data collection, and both male and female sugarcane smallholder farmers in Kakamega North Sub-County had equal and equitable opportunities to participate in the study.

ii. The decision-making process of smallholder farmers was not significantly affected by external biases, pressures, or restrictions that would have undermined rational decision-making.

CHAPTER TWO

LITERATURE REVIEW

2.0. Overview.

This section covers the different essential aspects within the domain of sustainable sugarcane farming practices. They include; technology adoption, technology transfer and problems, the adoption of sustainable sugarcane farming practices, socio-economic factors influencing the adoption of sustainable sugarcane farming practices, and the role of farmer groups in the adoption of sustainable sugarcane farming practices, theoretical framework, and the conceptual framework.

2.1. Technology adoption.

The adoption of technology has generally been characterized as the period in which individuals or groups come to understand, consider, and persistently adopt new practices or innovations (Gardeazabal et al., 2023). In agriculture, adoption extends beyond access to tools or inputs, and involves behavior change, investment decision-making and incorporating innovations into systems of farming. The theoretical perspective of adoption is the Diffusion of Innovation Theory by Rogers (2003), which draws attention to the relative advantage, compatibility, complexity, trialability, and observability, which significantly determine the way and the reasons why farmers embrace or reject innovations.

The implementation of agricultural technologies has also been mentioned as one of the most important factors of agricultural transformation and especially in developing countries (Yokamo et al., 2020). Enhanced production, management of soil fertility, pest and weed control, irrigation, and post-harvest technologies have been demonstrated to positively impact on household livelihood, resilience to climatic stress, and production. Zang et al. (2025) argue that adoption does not only increase the productivity of the farm, it also lessens rural poverty, in the presence of both technologies and context-relevant technologies. According to more recent studies, technology adoption is at the heart of dealing with food insecurity and poverty with smallholder farmers in sub-Saharan Africa since technology can help mitigate risks of production and stabilize the household income of the population (Arstan et el., 2022).

Although these are the advantages, there is still an issue of low adoption. Failure by the farmers to adopt better technologies means that production will be at stalemate, soils will become degraded and the exposure to weeds, pests and diseases will be more frequently experienced. It was noted that poor adoption weakens the synergies among technologies, especially integrated practices, resulting in the traps of poverty (Barbier 2023). Bashiru et al. (2024) made stronger claims much more recently by claiming that despite the potential of smart farming technologies in Africa, their adoption is low because of poor promotional

efforts, infrastructural disconnects, and smallholder capacity. Likewise, Ayim et al. (2020), observed that, irrespective of the presence of digital agricultural innovation, lack of access to information, low digital literacy and insufficient extension services constitute barriers towards successful applications. This implies the idea that technology has the potential to revolutionize the agricultural sector and enhance livelihoods, but in order to do so, it must be adopted and not merely made available, but with conducive institutions, knowledge, and funds.

2.2. Technology Transfer and Adoption Problems.

The focus to close the gap between farmer practice and agricultural research is through technology transfer. It is the complex process of transferring knowledge, ideas, tools, and materials between innovators and users, which is oftentimes across institutional, cultural, or geographic domains (Alkhazaleh et al., 2022). Technology transfer as opposed to a mere linear flow is interactive and sends and receives multiple senders and receivers such as researchers, extension workers, private actors, and farmers themselves (Landini et al., 2025). The significance of technological transfer and adoption cannot be overestimated. Agricultural innovations are directly correlated with a rise in productivity, better resilience to climate fluctuations, and food security (Pardo et al., 2022). Recent reviews emphasize that the use of better agricultural technologies would help reduce poverty by a significant

margin, particularly among smallholder families that rely on agriculture as their main source of survival (Yokamo et al., 2020). Another meta-analysis study conducted by Abay et al. (2023), once again, confirmed that the adoption of technology has a positive impact on the agricultural output, food security, and household income in various African countries.

There are however major issues remaining in the technology change and adoption. The main problem is the divergence between the technologies created in research facilities and the realities of the smallholder farming systems. Expensive, labor-intensive, or unsuitable innovations are also usually met with opposition (Baptista et al., 2025). Adoption is also constrained by financial barriers since the smallholders do not have easy access to credit and cannot afford inputs. Weaknesses in the structure also include lack of good infrastructure, weak policy support, and lack of adequate funding on extension systems, which contribute to the complexity of adoption (Agwu et al., 2023). The cultural norms and the reduction of risks are also contributory factors, as farmers are reluctant to leave the things which they are used to and move to something new.

More current analyses focus on the new challenges of digital innovations in agriculture. Although ICT-based tools provide possibilities of improving extension, market access, and farm management, their use is still low because of low digital literacy, bad connectivity,

and exclusionary practices (Ayim et al., 2020). In this regard, the issue of adoption is not merely technological, but institutional and socio-economic. It is important to fill these gaps thus to make sure that the technology transfer is translated in real use at the farm level.

2.3. Sustainable Sugarcane Farming Practices.

The sustainable farming practices enhance productivity that leads to economic growth, enhancing livelihood of rural people, guaranteeing quality and quantity of products hence making the agricultural sector a whole sustainable (Verma et al., 2019). These problems that the smallholder farmers face in the adoption of sustainable sugarcane farming practices during the cultivation, harvesting and transportation of sugarcane components in the study area has implications on the effectiveness and efficiency of the different parts of the sugarcane value chain.

Sustainable agricultural production practices in sugar cane include; Integrated Weed Management, soil nutrient management, crop rotation, using organic fertilizers, efficient water use, irrigation practices, sustainable pest and disease control, agro forestry integration, mulching, manual and mechanical harvesting, and use of integrated weed management, among others. The research was primarily engaging in the practices that are largely ambiguous with respect to their present adoption level namely: mulching,

integrated weed management, soil testing practices, and integrated sugarcane harvesting practices.

2.3.1. Mulching.

Mulching aids in enhancing the quality of soil as well as overall crop yield. Nxumalo et al. (2017), developed mulching was found to highly enhance the production of sugarcane through ratoons in terms of stalk properties. The findings showed that organic mulch enhances soil structure and soil fertility (Prem et al., 2020). The effect of mulch on soil is dependent on the nature of mulch material, crop cycle and rate of mulch (Iqbal et al., 2020). The use of organic mulch material has an effect on the factors like tillers, stalk length, yield, and chewable stalks. The positive effect of leguminous crops is more evident in the number of establishments and stalk lengths of the ratoon crops, especially when using mulch (Arlauskiene et al., 2020). Research highlights that combination of mulch type, cycle or growth, and rate are very important in defining the effects of mulch on soil and crop growth. The practice of mulching is improved by several factors in the adoption of the practice by smallholder farmers. Fadeyi et al. (2022): Bandi et al. (2022) assumed that one of the reasons why a farmer would adopt a technology is the relative cost of technology, perceived ease of use, and perceived gains of adopting the technology. Minimal information has been given about the adoption rate of mulching practices that are being

practiced by the sugarcane smallholder farmers in the study area hence the need to conduct the research.

2.3.2. Soil Nutrient Management: Soil testing.

The soil testing provides immeasurable details about the nutrient makeup and wellbeing of the soil, helping farmers make prudent decisions to maximize crop output and general farming output. The soil testing serves as a guideline to the farmer on how to plan and analyze fertilizer programs which type of fertilizer to apply and at what rate. It was found that Bhatt (2020) disclosed natural soil fertility condition and use of different fertilizers, both of which have a significant influence on sugarcane productivity. Therefore, nutrient deficiencies in the soils as well as the surplus of major and minor nutrients also affect the production of sugarcane. Overage of nutrients may result into lodging and high susceptibility of insect attacks and environmental complications whereas underage leads to poor sugarcane production. Use of soil testing practices by farmers is not the same. In a study by Sali et al. (2016), it was found out that 76.00 percent of the respondents engaged in low levels of soil testing. Poor understanding of nutrient management was among the biggest reasons, which led to poor adoption of the practice by the respondents (Sali et al., 2016). Also, it was reported that high costs and inaccessibility to soil testing service are among the biggest challenges facing smallholder farmers during crop production (Mugo,

2019). The researchers sought to know the present condition of the use of soil testing as a sustainable sugarcane farming within the area of the study.

2.3.3. Integrated Harvesting Methods.

Harvesting of sugarcane can either be done manually or mechanically. Mechanical harvesting of cane improves efficiency (Ma *et al*., 2014). In cases where sugarcane harvesting is done at a high speed and transportation facilities are readily available, the harvested cane should be promptly delivered to processing plants to ensure freshness and maintain optimal quality. The use of mechanical methods in harvesting maintains uniformity in cutting height from ground level thus able to leave a stump of recommended height for proper resprouting. According to Bernache *et al.* (2020), if sugarcane harvesting is done at an improper height such as too close to the ground, it can lead to damage to the bud region and the growing point of the cane thus leading to poor sugarcane productivity. Urgesa *et al*. (2021), revealed that delayed harvested cane can lead to sucrose losses and deterioration of cane quality, impacting the overall sugar produced by sugarcane industries. Reduced weight of harvested cane as a result of delayed collection can also cause the sugarcane farmers to obtain losses since the payment is based on weight rather than sucrose content (Nanjala, *et al.*, 2022). In a study conducted by Murali *et al*. (2012); Sulaiman *et al.* (2020), mechanical operations proved to be superior to manual operations as reduced

the dependency on labour and enhanced the completion of farm operations in time. Despite mechanical harvesting methods being beneficial it has limitations such as causing soil stress by tyre contact from transshipment vehicles used in mechanized methods (Esteban *et al*., 2024). Manual sugarcane harvesting requires less capital investment since it doesn't involve expensive machinery (Jones *et al.,* 2020). Studies revealed countries such as India, Brazil, and Sudan utilize both manual and mechanical methods in cane harvesting (Ashraf *et al*., 2023). Nanjala *et al.* (2019); Francis *et al*. (2020), revealed no utilization of mechanized sugarcane harvesting methods in the Kakamega North sub-county, Kenya. The study aimed to understand the current adoption status of the sugarcane harvesting methods within the study area.

2.3.4. Integrated Weed Management Practices.

Weeds affect sugarcane production if not properly controlled. Sugarcane's vegetative stage is highly vulnerable to weed competition, which is about 6- 9 weeks from the time of planting (Galon *et al*., 2023). Control of weeds at the early growing stage of sugarcane before the canopy closure of sugarcane is critical to promote high productivity (Rathika *et al*., 2023). There are various weed control methods but the most recommended one is the use of the Integrated Weed Management method (Kaur *et al*., 2024). This involves the coordinated use of a variety of control methods such as cultural, chemical, and even

biological ways to enhance environmental conservation. Rezaie *et al.* (2021) findings revealed that combining mechanized weeding with herbicide use that use would play an effective role in enhancing sugarcane productivity and controlling weeds in sugarcane. Singh *et al*. (2014) revealed that IWM has a significant positive impact on cane yield thus improving cane production. Variations in the adoption of IWM exist based on the findings of various researchers in different study locations. Rajashekar *et al*. (2017 identified lack of extension persuasion, inadequate loan, too difficult to understand, and inadequate knowledge about IWMPs were some of the major constraints to the adoption of the practice by the farmers. Moreover, findings by Coleman *et al*. (2024) indicated significant knowledge gaps related to IWMPs existed among sugarcane growers thus leading to low adoption of the practice. This study aimed to understand the current adoption status of Integrated Weed Management practices within the study area.

2.4.0 Socio-economic factors influencing the adoption of sustainable sugarcane farming practices.

The adoption of sustainable farming practices in agriculture has garnered significant interest among development economists because the majority of the population in less developed countries relies on agricultural production for their livelihoods (Kamara *et al*.,

2019). Improved practices have been somewhat successful, as shown by the rates at which they have been taken up (Redclift, 2023).

2.4.1. Gender.

Gender as a socio-demographic factor of critical importance, has a crucial influence on the adoption patterns. The literature has given certain contradictory views and some studies show that there is more adoption among women whereas others suggest that men adopt more than the women. There are also some results of gender differences decreasing when it comes to innovations, ideas, technologies, and better practices. The results of the study conducted by Koledoye et al. (2013) indicated that there are significant differences ($p>0.01$) between males and females in the adoption of soil management practices with males being the dominant group in the adoption process. Liu *et al*. (2019), reported male, younger farmers and members of agricultural cooperatives were more likely to adopt soil testing practices. A research study by Isah *et al*. (2010), revealed a larger percentage of male (58%) respondents adopt IWM compared to female (42%) respondents. The researcher concluded men were earlier adopters of new technology than women, probably because males tend to carry out agricultural activities that are more labour demanding than females (Isah *et al*., 2010). Moreover, Girei *et al.* (2012); Francis *et al*. (2020), findings also revealed the majority of the sugarcane farmers were males compared to females. The gender differences

in the adoption of practices are shaped by factors such as asset ownership, socialization ability, and labour intensity of the practices. For instance, (Chau *et al*. (2020); Lipovka *et al*. (2021), findings revealed women outperform men in adopting innovations because they tend to spread awareness of a beneficial agricultural practice or innovation very fast due to their high socialization ability. Furthermore, Thuo *et al*. (2014), established there were gender differences in the adoption of improved peanut varieties whereby female-led households were less inclined to embrace upgraded varieties when contrasted with women and men in male-headed households as they may lack assets such as land. Moreover, Gladwin *et al*. (1997), results indicated gender differences in wealth result in women's lowered access to cash and credit, needed in the acquisition of agricultural inputs. If gender-based adoption constraints are dealt with, this can reduce the gender differences in the adoption of practices. For example, Langyintuo (2020), suggested to guarantee a broader and more equitable implementation of agricultural sustainable practices, measures such as; ensuring improved access for women to additional resources, particularly land, and involvement of women during extension service provision need to be considered. However, the implementation of women empowerment programs has encouraged women's involvement in sugarcane production thus reducing gender disparities in the sector (Kikuyu, 2017). This study sought to find out if there exist gender differences in the adoption of

sustainable sugarcane farming practices within the study area and its influence in the adoption of sustainable sugarcane farming practices.

2.4.2. Age.

Age links to the willingness to embrace new agricultural practices. Findings of a research study by Pawar *et al*. (2022) on the socio-economic profile of sugarcane growers revealed the majority (60%) of sugarcane growers were between 31-50 years, 23.33% were between 51 years and above and 16.67% were 18-30 years. Issa *et al*. (2020), identified majority of the sugarcane farmers belonged between 31 and 40 years which is the productive age group. Massresha *et al.* (2021), stated that age influenced the adoption of farming practices that are sustainable with older people adopting more than younger ones due to their resource endowment and experience in farming. Moreover, Kayode *et al*. (2017) findings revealed the use of mulch on farmer plots was positively associated with age whereby an increase in the age of the farmer likely increased the application of mulch, hence while the older farmers adopt mulching, the younger farmers will likely adopt other innovative. Age was non-significantly related to the adoption of soil testing recommendations. Rajashekar *et al.* (2017), study on profile characteristics of respondents practicing Integrated Weed Management Practices in major crops revealed the majority of the farmers belonged to the age group between 38-52 years (middle-aged). Respondents' age had a significant ($p=0.05$)

relationship with their adoption of IWM practice. A study by Isah *et al.* (2010), revealed the majority of farmers adopting IWM belonged to the age category of 31-40 years. Farmers within that age group were considered to be in a productive age category. On the contrary, younger farmers have been stated to often exhibit higher receptivity and openness to innovations due to good risk perception of new ideas and practices (Feder, 1982; El Intidami *et al*., 2021) Younger farmers have more opportunities to access information via several media sources concerning improved technologies. This makes them to be more informed on the existence of new and improved practices thus enhancing their adoption. Elderly individuals, tend to be hesitant in embracing new practices due to their earlier life experiences, societal perspectives, and personal experiences. The elderly rarely adopt new technologies because they claim as people become older, risk aversion rises, leading to reduced interest in long-term farm investments (Adesina *et al*., 1993; Barrera *et al*., 2005; El Intidami *et al*., 2021). They will only adopt a technology due to factors like the comparative cost of technology, perceived simplicity of use, and perceived benefits of adopting the technology (Fadeyi *et al*., 2022: Bandi *et al*., 2022). The inconclusive nature of existing literature regarding the relationship between age and adoption of sustainable sugarcane farming practices called for additional research to provide more definitive insights and contribute to a more unified body of knowledge.

2.4.3. Education level.

In the vast majority of the research, there was a positive correlation between higher levels of education and the application of better farming methods. Massresha, et al. (2021), also, determined education as a launching point in enhancing perception of farmers towards changes thereby lowering resistance to change. The vast majority of smallholder farmers with formal and informal education can gain access, understand, and use the information on innovative techniques and develop the culture of constant and permanent improvement of their agricultural practices (Fadeyi et al., 2022). Results of a study by Rajashekar et al. (2017) indicated that the education level of farmers had a significant correlation with the IWM practice adoption. The education level of the farmers makes them scrutinize the cost and benefits of embracing sustainable practices. Francis et al. (2020), disclosed majority (36.20) of the sugarcane smallholder farmers had secondary school education. Status of education causes farmers to be wary of the analysis of the costs and benefits of accepting new technology. Moreover, educated sugarcane farmers receiving extension services are more likely to adopt sustainable practices of sugarcane cultivation (Shukla et al., 2023). The purpose of the study was to add to the existing literature body by ensuring we have a better understanding of the role that the level of education played in introducing sustainable

sugarcane farming practices and inform additionally on future approaches to the sustainability of agriculture.

2.4.4. Land ownership.

The nature of the land ownership impacts greatly on the mode of farming practices in the farms. Farm owners with long time interest in the farms would invest more in sustainable activities to acquire returns on investment. As an example, Adenuga et al. (2021) found that land owners who have a longer lease period are more ready to engage in practices that will guarantee the long-term sustainability of their land. Conversely, the owners of land whose lease extension is short are always reluctant to explore the long-term sustainable practices in the fear that they would not enjoy the fruits of such investments, particularly when there is a risk of losing the lease. When revealed land title deeds facilitate access to credit by acting as collaterals, Balana et al. (2022) revealed that this aspect is empowered to purchase inputs that are important in embracing better agricultural practices. Moreover, according to the results of the study by Kumari et al. (2016) freehold ownership allowed sugarcane smallholder farmers to possess full rights to use and occupy their land and therefore grow investment and sugarcane production. Leasing farmers are less in charge of land use and management that restricts their choice on the adoption of some practices (Teshome et al., 2016). In order to fill the existing gap in knowledge, the given study was

devoted to the investigation of the correlation between the ownership of the land and the implementation of the more sustainable sugarcane farming techniques in the region under investigation.

2.4.5. Farming experience.

Studies revealed farmers with greater experience in farming are more inclined to adopt improved agricultural practices (Haruna *et al.,* 2023). Experience enhances one's thinking abilities and fosters maturity for making informed decisions. The greater a smallholder farmer's experience in farming, the more aware they are of the necessary technology and its appropriate application. In cases where there is limited farming experience and a lack of information about the technology being adopted, the adoption of new technology was observed to be minimal (Araya & Mohammed 2014; Fadeyi *et al*., 2022). Nevertheless, other studies revealed experienced farmers are resistant to adopting improved agricultural practices since they are usually older and less educated, therefore it is difficult to shift them to new concepts of farming. Rajashekar *et al*. (2017), revealed there was a significant($P<0.05$) relationship between farming experience and adoption of IWM. Moreover, Matsuura (2020), found most of the sugarcane farmers have less farming experience. Farmers with less farming experience are more open to the adoption of new ideas, innovations, practices, and technology and are not rooted in traditional methods (Issa

et al., 2016). This study aimed to understand the association between farming experience and the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers within the study location.

2.4.6. Market Access.

Market access plays an important role in shaping the adoption of sustainable agricultural practices in various ways. Ferris *et al.* (2014), established access to markets that pay premiums for farm products motivated farmers to adopt practices to meet market requirements and gain higher prices for their produce thus obtaining higher income. Magesa *et al.* (2014), revealed stable and reliable markets provide farmers with the confidence to invest in sustainable practices, knowing that they will be able to sell their produce at fair prices. The market also serves as a source of information about market trends, and new technologies encouraging farmers to adopt the improved practices (Chen *et al*., 2025). Markets enable smallholder farmers to access inputs that are necessary for adopting some agricultural sustainable practices. Kumar *et al.* (2020), stated access to the market increases the adoption of improved technologies and practices. A research study by Machimu (2024), identified the majority of sugarcane smallholder farmers were faced with market access challenges thus affecting cane production. Given the importance of market

access in driving the adoption of sustainable agricultural practices, further investigation was warranted to fully understand its influence within the study area.

2.4.7. Extension services.

The extension services make available and encourage the adoption of sustainable farming practices especially when the farmers must change the management practices to enjoy the prize. Research found the positive influence of extension service access on the use of better practices. On the one hand, training and advising farmers will increase their human resources and information availability (Ayenew et al., 2020). Second, it has been best utilized in conjunction with the allocation of inputs and access to farm credit (Langyintuo, 2020). Thirdly, it also spreads existing knowledge to smallholder farmers about the existence, application, and benefits of new agricultural concepts, practices and technologies (Mapiye, et al., 2021). Close interaction of farmers and the extension agents enhances proficiency in application of technologies and innovations. The discovery made by Danso-Abbeam (2022) showed that extension training was a major contributor to the adoption of better farming practices. The purpose of this research study was to know how the extension services affected the adoption of sustainable sugarcane farming practices by the sugarcane smallholder farmers in the study location..

2.4.8 Farmer Groups.

Small-scale farmers face challenges in adopting sustainable agricultural practices in isolation. The absence of a collaborative environment potentially hinders the diffusion of innovations as farmers lack peer support and shared learning experiences in sugarcane cultivation. Farmer groups facilitate resource sharing, dissemination of new ideas, practices and innovation, knowledge exchange, and joint initiatives which improve their bargaining power, ultimately enhancing the farmers' capacity to successfully adopt and absorb effective sugarcane management practices. In a study conducted by Abdul-Rahaman *et al.* (2020), findings revealed that members of groups and participants in collective marketing received higher prices for their produce and also faced lower input costs. Rokhani *et al*. (2021), found out 30.5% of sugarcane farmers were members of farmer groups and 69.4% were not members of the farmers group. Lack of formation of farmer groups is disadvantaging the farmers from maximizing the benefits of adopting sustainable sugarcane farming practices. The study sought to find out the association between farmer groups and the adoption of sustainable sugarcane farming practices within the study location.

2.4.9. Income level.

Income levels also wield a substantial influence on the adoption of sustainable sugarcane farming practices. Income levels are influenced by both on-farm and off-farm income generation sources. In most occasions, farmers possessing both income sources tend to have higher income levels. In developing nations, small-scale farmers with high-income levels overcome credit constraints in adopting sustainable agricultural practices. On the contrary, higher income levels act as a security for farmers to rent/acquire resources on credit thus promoting the adoption of the practices. Singh *et al*. (2019), established that farmers with high incomes have an advantageous position in accessing essential agricultural resources such as labour, capital, and inputs, enabling them to invest more robustly in their operations and adopt efficient farming practices for increased productivity and sustainable growth. Mwavu *et al.* (2018), revealed that 42.1% of sugarcane farmers had low household financial capacity. Muthoni (2011), suggested the need for farmers to diversify sources of income to improve household financial capacity. This necessitated the need to understand the income levels amongst sugarcane smallholder farmers and their influence on the adoption of sustainable sugarcane farming practices within the study area.

2.5. Theoretical framework.

The research adhered to the Diffusion of Innovation Theory, which is the theory of dissemination of innovations created by Everett Rogers in 1962. The theory presented a fruitful perspective of the communication and adoption of new ideas and technologies within a social system through time. The innovation in the current study was the sustainable sugarcane farming methods and the subject under study is the adoption or lack thereof of the methods among the small-holder sugarcane farmers in Kakamega North Sub-County.

The theory assumes the acceptance of innovations to be dependent on a number of interdependent factors. To begin with, the type of the innovation itself is an important factor. This means that sustainable farming practices can have different implications to different farmers based on their perceived benefits, complexity, compatibility to the current practices, trialability, and observability.

Communication is also in the center stage of the diffusion process. The knowledge of sustainable sugarcane farming activities is passed on via different channels such as extension officers, farmer groups, peers, media and even through training. How this information is transmitted and received by the farmers will greatly affect the readiness of the farmers to adopt the practices.

Another significant factor in the diffusion process is time. Adoption does not take place at the same time to every member of a social system. Rather, various individuals pass through a sequence of steps, firstly, acquire knowledge about the innovation, secondly, develop a feeling about the innovation, thirdly, decide whether to adopt the innovation or not, fourthly adopt the innovation, and lastly confirm the decision. Due to the level of availability of information, risk-taking behavior, and other socio-economic factors, farmers implement innovations at various times and with varying rates.

The social structure under which farmers are operating also plays an important role. Adoption behavior can be influenced by norms, peer influence, group membership and institutional support. Then, as an example, farmers who are members of organized farmer groups or cooperatives can be better prone to new practices because of learning through peers and making decisions. On the same note, farmers with close attachments to extension agencies or support institutions might be more likely to be exposed to innovation and technologies.

In addition, the theory divides adopters into five groups depending on the time of adoption, namely, the innovators, early adopters, early majority, late majority and the laggards. The position occupied by farmers in this continuum can be used to understand the differences in adoption behavior and how specific interventions can be used.

The use of the theory of Diffusion of Innovation to this research assisted in explaining the effect of various issues on adoption of sustainable sugarcane farming practices. It offered a systematic means to evaluate the process of farmers becoming aware of these practices, the difficulties they encounter during the process and the contribution of social and institutional networks to the process of diffusion.

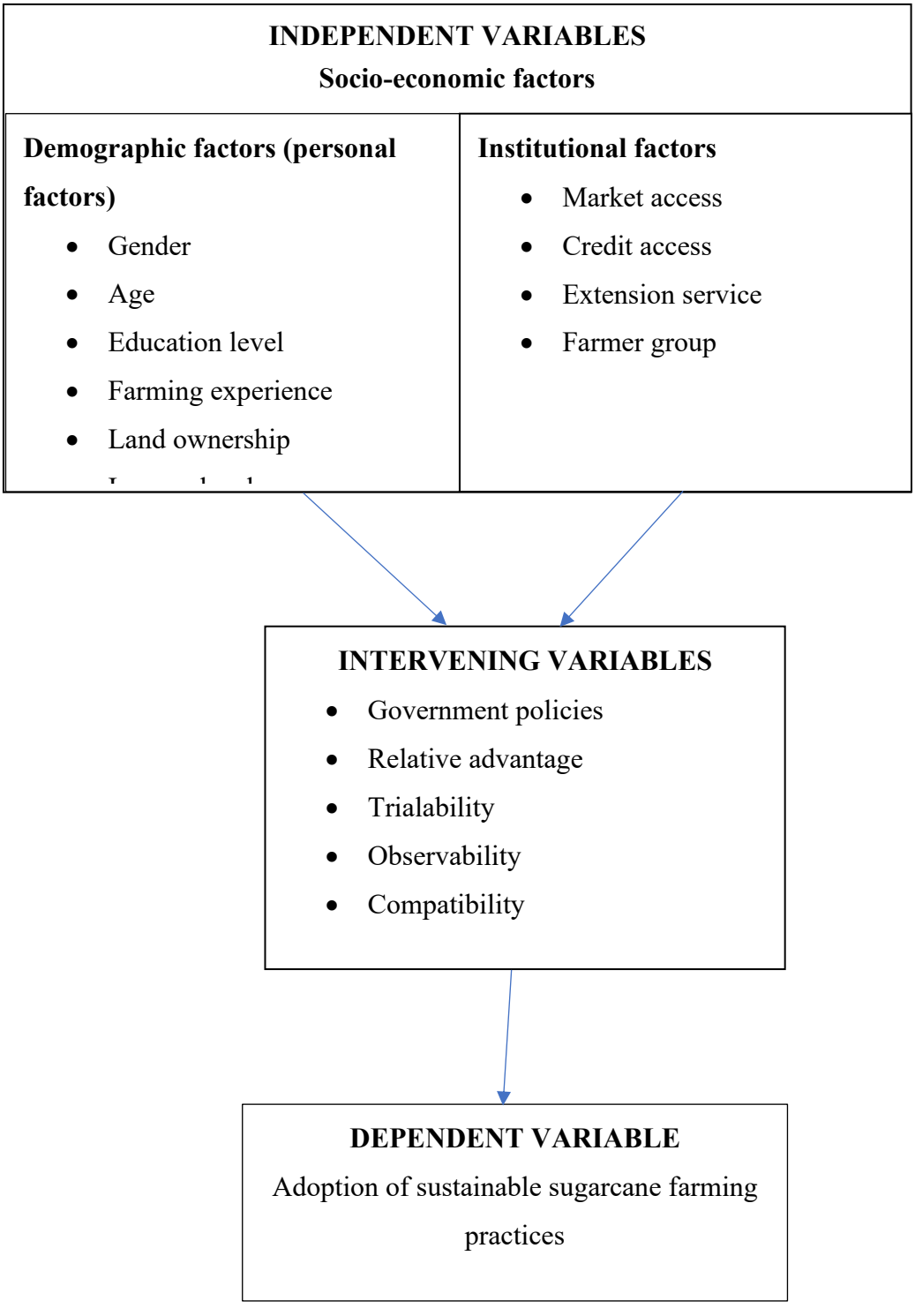
This theoretical framework offered an inclusive perspective of addressing the complexities of factors affecting uptake of sustainable sugarcane farming practices by sugarcane smallholders farmers in Kakamega North Sub-County.

2.6. Conceptual framework.

This theoretical model will be attempting to demonstrate the relationship between the independent variables (personal and institutional factors) and the dependent variable (adoption of sustainable sugarcane farming practices). The dependent variable; adoption of sustainable sugarcane farming practice is the response variable which is affected by other socio-economic factors. Intervening variables are; government policies, relative advantage, trialability, observability and compatibility. The intervening variables indicate how the independent variables affect dependent variables through mediating the cause and effect relationship. All these variables were included in a structure to investigate how the interplay of such effects of socio-economic factors could influence uptake of sustainable

sugarcane farming practices by sugarcane smallholder farmers operating in Kakamega North Sub-County.

Figure 2.1: Diagrammatic representation of the conceptual framework



2.7. Literature Review Summary

There are several influences on the implementation of sustainable farming. The daily practices are critical in maintaining the status quo in adoption of AS-IT-IS, and dynamism in the agricultural system can lead to adoption of AS-IT-SHOULD-BE. The implementation of sustainable sugarcane farming techniques is directly linked to the mentioned factors and the dynamics. The proactive attitude to the introduction of sustainable farming practices is the key element of reaching the required level of introduction. Based on the information given, little information has been availed as regards to socio-economic factors that can guide the adoption of sustainable sugarcane farming practices by smallholder farmers in the study location. Discussing these areas will promote the use of such practices thereby increasing sugarcane production in the study area. Therefore, it was necessary that this compelled the research to be conducted to know the socio-economic issues which affect the application of sustainable sugarcane farming methods among the sugarcane smallholders farmers in the study region.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0. Overview.

The chapter is a detailed description of the research design and the site of study, the target population, the sampling process, the sample size, data collection instruments, pre-testing of data collection instruments, data analysis, reliability, and validity.

3.1. Research design.

A quantitative research method was utilized in the study because analysis of numerical data obtained was to be performed with the use of statistical principles. The research relied on the cross-sectional survey that allowed gathering data about a variety of sugarcane smallholder farmers at a particular moment in time, and it gave a full picture of the current adoption of the sustainable sugarcane farming practices in the study area (Wang et al., 2020). Cross-sectional survey was also used to investigate numerous socio-economic variables at once, hence, to enable the researcher to investigate the relationships between socio-economic variables and the adoption of sustainable sugarcane farming practices.

3.2. Description of study location.

The research site was Kakamega North sub-county that is one of the twelve sub-counties that constitute Kakamega county. The sub-county is at an area of 423.3 kilometers square. It has population of 238,093 people and approximately 51,083 households (Ambetsa, 2020). The region is diverse in terms of topography where it has both fertile plains and low hills. The average temperature of the climate is 20.5 o C and the 1250-1750 milliliters are the average rainfall per year. The rainy seasons are mostly long between March and July and short between September and December. There is a period of short dry spurt in the

months between January and February. This has not been the case in recent years whereby the pattern of rainfall has been affected by the predictability factor due to a number of factors including global warming and other environmental factors. The latitude of the study area is 0^{o} 26' 42.15' N and its longitude is 34^{o} 51' 14.90' E and hence the study area falls under the tropical climate zone. The land is fertile with good climatic conditions that favor different crops such as maize, groundnuts, cassava, sorghum, beans and sweet potatoes. Nevertheless, the main crop is sugarcane which has a major impact on the local economy. There are seven administrative wards in the study area which include Manda-Shivanga, Butali-Chegulo, Shirugu-Mugai, Chemuche, East Kabras, South Kabras and West Kabras.

3.3. Target population.

The target population included 65, 323 small holder sugarcane farmers in the seven wards of Kakamega North sub-county. Such wards are more economically important in the sub-county in terms of sugarcane production.

3.4. Sampling procedure.

The probability sampling technique was employed because it guaranteed equal opportunity of all members of the population to be sampled and take part in the study. There were seven stratia comprised of the seven wards in the sub-county. The number of stratified wards sampled was obtained proportionately. This was to make sure that all stratified wards were proportionately represented as per their population size. In each stratified ward, simple random sampling method was employed to pick the respondents. In order to ease this process, an elaborate sampling frame was built based on the register of sugarcane smallholder farmers acquired on each ward field agent. All the members of the population were assigned their own identifiers and a randomization was used to choose the final

respondents; this was achieved by using random number generator. This was also a way of ensuring that the bias was removed as well as ensuring the chosen sub-set was representative of the greater population which increased the generalization of the research finding to the greater picture being studied.

3.5. Sample size.

The Yamane's formula was used to determine sample size.

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

Where:

n is the required sample size

N is the population size (65,323)

e is the desired margin of error of 0.05

$$n = \frac{65323}{1 + 65323\ (0.05)2}$$

n = 394

The sample size for each ward across the sub-county is shown in Table 3.1.

Table 3.1. Sample size across the seven wards in Kakamega North Sub-County.

Strata	Farmer population	Sample size
West Kabras	7928	48
Chemuche	8581	52
East Kabras	7929	48
Butali-Chegulo	9889	60
Manda Shivanga	10542	63
Shirugu Mugai	8605	52
South Kabras	11849	71
TOTAL	**65,323**	**394**

Source: KNBS (2019)

3.6. Data collection procedure and instruments.

The primary data was gathered through a structured questionnaire that was visited at the household level on the sugarcane smallholder farmers in the Kakamega North sub-county. Data collection was made possible through structured questionnaires which would allow the researcher to collect information on a larger sample in a limited time. Structured questions also made sure that the data obtained was pertinent to the research goals since there were no irrelevant responses. The analyzed and interpreted data were collected by a questionnaire. The instruments collected information in detail in relation to the adoption of the sustainable sugarcane cultivation practices and several socio-economic factors that contributed to the adoption. The research instruments were pre-tested before the data

collection and clear instructions given to the participants to ensure that there was consistency in answers and accuracy. Ethical data collection was done and the privacy and confidentiality of the participants were taken into consideration. They were informed and then participated in the study.

3.7. Pre-testing of data collection instrument.

Pre-testing involved 20 sugarcane smallholder farmers Lugari sub-county. Lugari sub-county was selected because it had similar characteristics to the actual study location. Cronbach's alpha value of 0.72 was obtained, which indicated that the research instruments were valid and reliable.

Table 3.2: Reliability analysis result for individual sugarcane smallholder farmers' questionnaire

Cronbach's Alpha	No. of Items
0.720	14

3.8. Data analysis and presentation.

Descriptive and inferential statistics were employed for data analysis. Descriptive statistics involves calculating percentages and frequencies. The inferential analysis involved conducting chi-square tests and regression. The results were presented using tables and figures.

Objective 1

Descriptive statistics involved calculating percentages and frequencies of adoption status of soil nutrient management practice; soil testing, mulching, integrated weed management and integrated sugarcane harvesting methods. Farming practices were determined using farmers' reported application of the practices. Farmers who reported actively applying a

practice at least once during the production cycle were classified as adopters, while those who had never applied it were considered non-adopters. The data were analyzed using frequencies to show the proportion of farmers adopting each practice.

Objective 2

Data was analyzed using inferential statistics. It majorly involved conducting a chi-square test to determine the association between the socioeconomic factors and the adoption of sustainable sugarcane farming practices. The sampled respondents were classified into categories suitable for chi-square analysis as shown in Table 3.3.

Table 3.3: Categorization of variables for chi-square analysis.

Variables	Category 1	Category 2	Category 3	Category 4
Age	18-35 years	36-60 years	Above 60 years	-
Gender	Male	Female	-	-
Farming experience	Less than 5 years	5-10 years	11-15 years	More than 15 years
Education	Tertiary institutions	Secondary	Primary	Informal
Income level	Less than 10,000	10000-50000	51000-100000	Over 100000
Land ownership	Family land	Leased land	Communal land	Owned land
Farmer group	Members to farmer group	Not members to farmer group	-	-
Extension services	Access to extension services	Lack of access to extension services	-	-
Market access	Access to ready market	Lack of access to ready market	-	-

Objective 3

Regression models were used to determine the influence of farmer groups on the adoption of sustainable sugarcane farming practices. This analysis helped assess the significance of

membership in the farmer group in predicting the likelihood of sugarcane smallholder farmers adopting sustainable sugarcane farming practices while controlling for other variables.

Table 3.4: Research objectives, variables, and type of analysis conducted

Objectives	Research variables	Analysis
To assess the current adoption status of sustainable sugarcane farming practices among sugarcane smallholder farmers in the study area	Adoption of Soil Nutrient Management; Soil testing, mulching, integrated weeding practices, and integrated harvesting methods.	Descriptive
To determine socioeconomic factors influencing the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers in Kakamega North Sub-County.	Market access, extension services, and membership in farmer groups, age, gender, income level, farming experience, land ownership, education level	Chi square
To investigate the role of Farmer Group on the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers.	Farmer groups	Regression.

3.9. Reliability and Validity.

Pre-testing of research instruments using Cronbach's Alpha formula enhanced the validity and reliability of the data obtained. A larger sample size was used to increase reliability by reducing the impact of individual variations. The sample size was sufficient for the statistical analyses to be performed. Seeking expert reviews also improved the validity of data collection tools.

3.10. Ethical considerations during data collection.

The research study was approved by the Postgraduate Studies office of Masinde Muliro University of Science and Technology and the National Commission for Science, Technology and Innovation gave the research permit (NACOSTI). The ethical issues in data collection involved informed consent on the smallholder sugarcane farmers in the study area, which involved the researcher informing the farmers about the purpose of the study, the process, potential risk, and the right of the participant to withdraw any time. The respondents were fully aware of the research study before they gave their consent. Another important ethical issue was confidentiality. The researcher ensured the confidentiality of the participants by avoiding the use of their names and by placing personal data in secure places. The other important aspect was the consideration of avoiding harm, the objective of which was to reduce the possible physical, emotional, or psychological harm to participants. Treatment equality was also significant and was associated with treating the participants equally without discriminating them on the basis of their age, race, ethnicity, and religion.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Overview.

This chapter entails presentation and discussion of the research findings from the data collected from sugarcane smallholder farmers.

4.2.0. Adoption status of sustainable sugarcane farming practices by sugarcane smallholder farmers.

Research findings on the adoption status of sustainable sugarcane farming practices such as soil testing, mulching, Integrated Weed Management Practices, and integrated sugarcane harvesting methods among sugarcane smallholder farmers in the study area were obtained.

4.2.1. Adoption status of Soil Nutrient Management practice; Soil testing by sugarcane smallholder farmers.

The findings on the adoption status of soil testing by sugarcane smallholder farmers in the Kakamega North sub-county are presented in Figure 4.1.

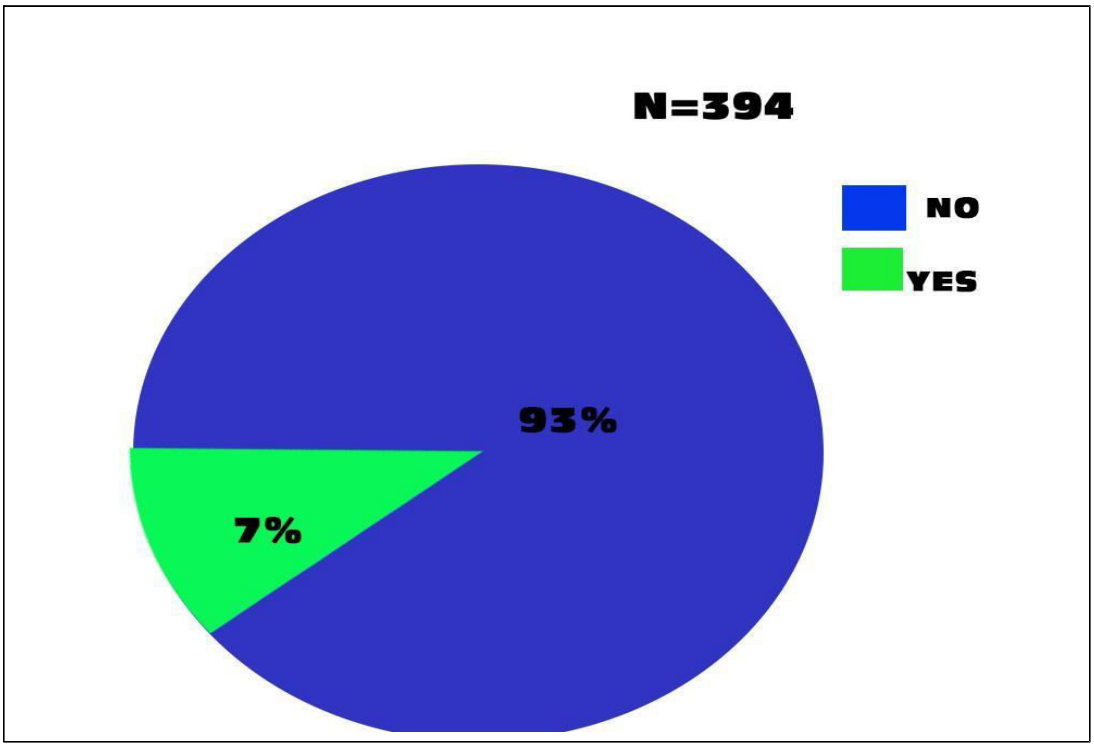


Figure 4.1: Distribution of sugarcane smallholder farmers based on adoption of soil testing in Kakamega North Sub-County, Kenya.

Source: Field data (2024)

Findings showed that 93% of sugarcane smallholder farmers didn't conduct soil testing while 7% conducted soil testing practices. This indicated that majority of sugarcane smallholder farmers did not conduct soil testing. Kumar *et al.* (2023), found that sugarcane yield increased by 16% for plant cane and 15% for ratoon crops when nutrients were applied to cane crops at the correct rate, time, place, and using the right nutrient source. Bhatt (2020), revealed that meeting crop nutrient demand and ensuring efficient nutrient utilization can be achieved by conducting regular soil testing practices on crop farms. The reasons for the low adoption of soil testing practices by the smallholder farmers within the study location are indicated in Table 4.1.

Table 4.1: Distribution of sugarcane smallholder farmers' reasons for not conducting soil testing.

Reasons for not conducting soil testing	Frequency	Percent (%)
Cost prohibitive	25	7
Lack of access to soil testing services	212	58
Lack of awareness concerning soil testing practices	129	35
Total	**366**	**100**

Source: Field data (2024)

Table 4.1 outlines the reasons given by smallholder sugarcane farmers for not adopting soil testing practices. The most commonly cited reason was lack of access to soil testing services, accounting for 58% of responses, followed by lack of awareness concerning soil testing practices at 35%, and cost being prohibitive at 7%. The results aligned with the findings of Mugo *et al*. (2020), who assessed soil fertility and nutrient status in potato crops across the Central and Eastern highlands of Kenya. They reported that smallholder farmers are faced majorly with high costs and lack of access to soil testing services during crop production.

4.2.2. Adoption status of Integrated Weeding Practices by sugarcane smallholder farmers.

The results of the adoption status of Integrated Weeding Practice by sugarcane smallholder farmers are presented in Figure 4.2.

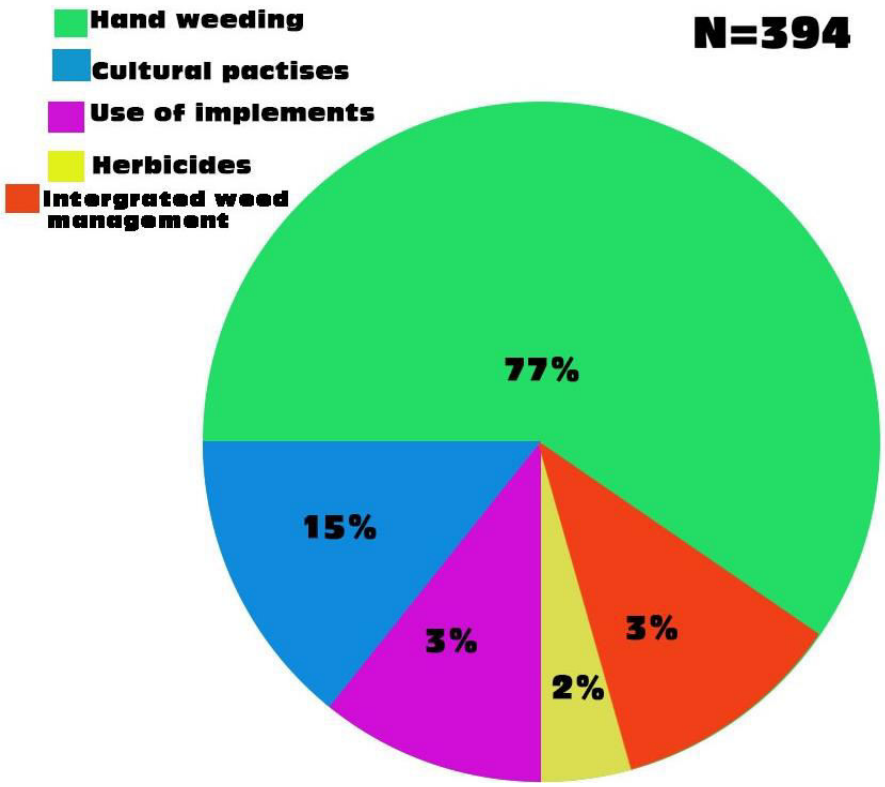


Figure 4.2 Distribution of sugarcane smallholder farmers based on the adoption of weeding practices in Kakamega North Sub-County, Kenya.

Source: Field data (2024)

Research findings indicated that 77% practiced hand weeding, 15% used cultural practices (crop rotation, intercropping, cover cropping, and mulching), 3% practiced Integrated Weed Management, 2% applied chemicals(herbicides) and 3% used implements such as ox plough for weeding. Findings revealed majority of the sugarcane smallholder farmers practiced hand weeding. Findings by Coleman *et al*. (2024), indicated significant knowledge gaps related to Integrated Weed Management practices existed among sugarcane growers thus leading to low adoption of the practice. Shukla *et al.* (2021), conducted a study on identifying suitable agricultural technologies to minimize yield gaps in various sugarcane-growing states of India. The study found that using Integrated Weed

Management in cane production increased sugarcane yields by 13% to 19% compared to the state average yield of 59 tons per hectare. Singh *et al*. (2024), conducted a study on sugarcane growers' knowledge of Integrated Weed Management practices in Meerut, UP, India. The findings revealed Integrated Weed Management had a significant positive impact on cane yield thus improving cane production. IWM improves soil health, reduces weed competition, and minimizes herbicide resistance, thereby enhancing crop growth and increasing cane yield, which boosts overall cane production (Scavo *et al.,* 2020).

4.2.3. Adoption status of mulching as a practice by sugarcane smallholder farmers.

The study sought to determine the adoption status of the sugarcane smallholder farmers. Findings are presented in Figure 4.3.

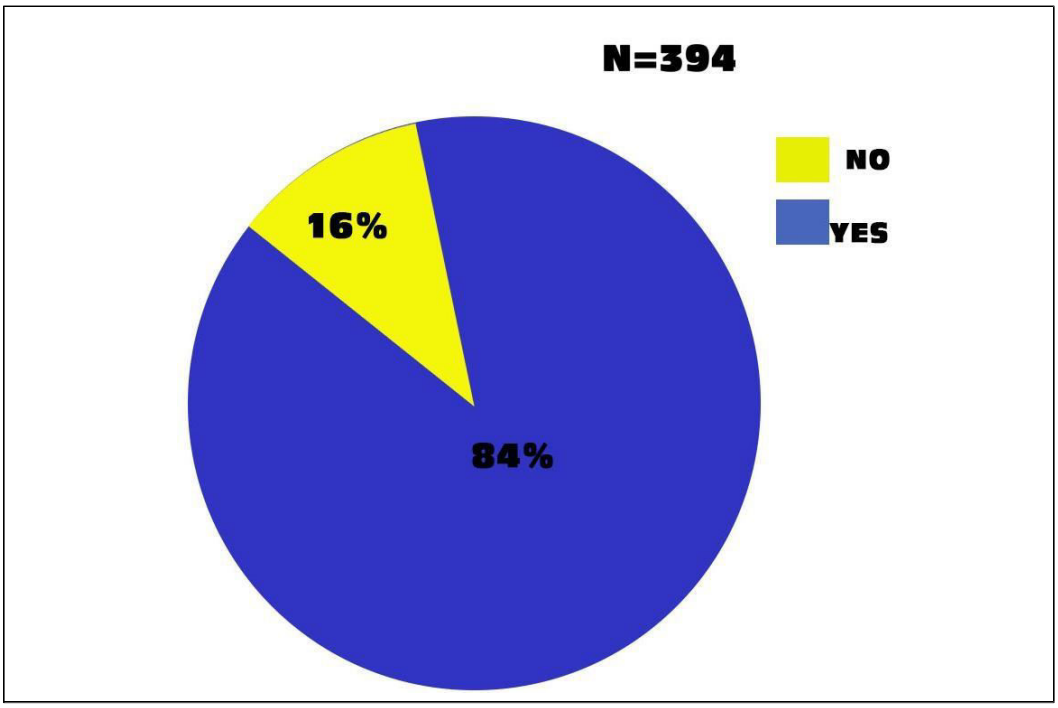


Figure 4.3: Distribution of sugarcane smallholder farmers based on adoption of mulching practice in Kakamega North Sub-County, Kenya.

Source: Field data (2024)

Findings showed that 84% of the farmers adopted mulching while 16% did not adopt the practice. This aligns with research findings from Fadeyi *et al*. (2022), who conducted a systematic review in Africa on factors influencing adoption among smallholder farmers, and findings revealed farmers would adopt a technology due to factors like the comparative cost of technology, perceived simplicity of use, and perceived benefits of adopting the technology. Application of mulch conserve soil moisture, enhance the nutrient status of soil, control erosion losses, suppress the weeds in crop plants, and remove the residual effects of pesticides, fertilizers, and heavy metals (Iqbal *et al*., 2020). An experimental study by Iqbal *et al*. (2020), revealed plot treated with 6 t ha^{-1} of mulch improved cane yield and quality. Although the majority of sugarcane farmers in the study area use organic mulch in cane production, other factors such as inadequate soil nutrients, weed competition, disease attacks, and pest infestations may still contribute to low cane production (Tabriz *et al.,* 2021).

4.2.4. Adoption status of integrated sugarcane harvesting methods by sugarcane smallholder farmers.

The study sought to determine the adoption status of integrated sugarcane harvesting methods among sugarcane smallholder farmers as presented in Figure 4.4.

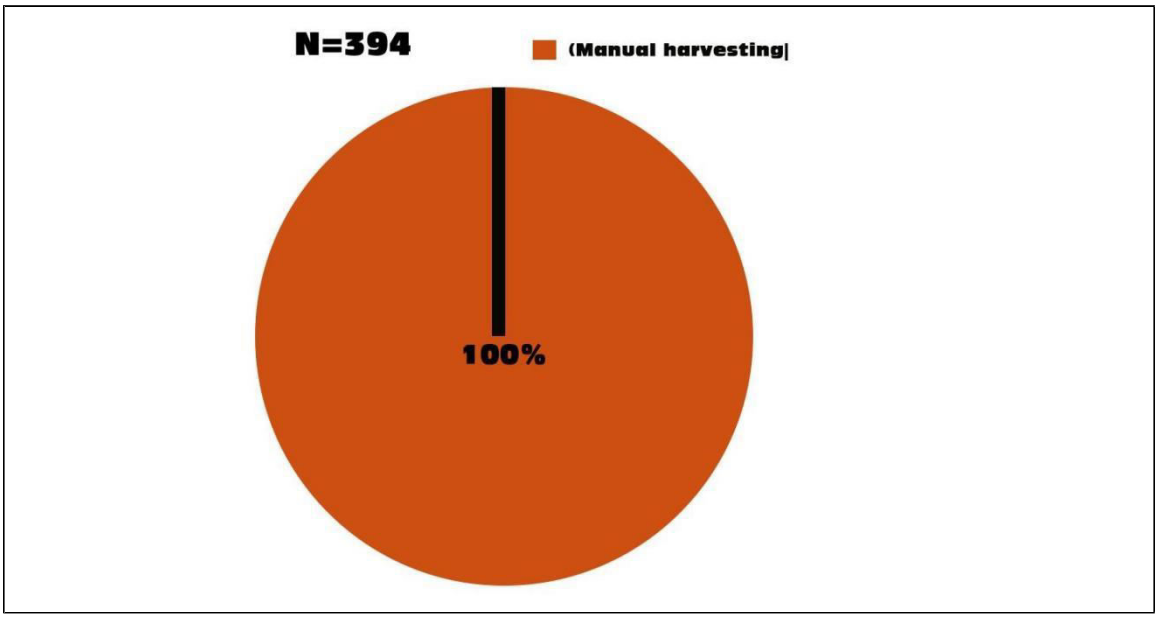


Figure 4.4: Distribution of sugarcane smallholder farmers based on adoption of integrated sugarcane harvesting methods in Kakamega North Sub-County, Kenya.

Source: Field data (2024)

Harvesting of sugarcane in the study area was primarily done manually. It was indicated by findings in Figure 4.4 whereby 100% of the population harvested cane manually. Nanjala *et al*. (2022), conducted research titled "The Economic Challenges Facing Small-Scale Sugarcane Farmers in Malava Sub- County, Kakamega, Kenya." The findings revealed that 100% of sugarcane smallholder farmers in the study area use manual sugarcane harvesting methods. Manual harvesting of cane takes more time compared to mechanized methods (da Silva *et al*., 2021). Even though it is time consuming it requires less capital investment since it doesn't involve expensive machinery. Mechanical harvesting of cane improves efficiency by ensuring cane production is done at high speed. If transportation facilities are readily available, the harvested cane can promptly be delivered to processing plants to ensure freshness and maintain optimal quality (Ma *et al*., 2014). Research indicated that India, Brazil, and Sudan were found employing manual and

mechanical processes in harvesting cane (Ashraf et al., 2023). The combination of the two in harvesting makes sure that there is constant productivity in a variety of field conditions. Because the farmers in the study area are paid on cane weight, when harvesting manually consumes more time, there is the risk of weight loss as a result of various factors like loss of moisture and farmers will be faced by a loss of money. The low income level influences the adoption of sustainable agricultural practices by the smallholder farmers (Oyetunde-Usman et al., 2021).

4.3.0. Relationship among various socio-economic factors influencing adoption of sustainable sugarcane farming practices.

4.3.1. Age and Market Access Crosstabulation.

Age group	Lack of market access	Market access	Total
18–35 years	44 (40.9)	72 (75.1)	116
36–60 years	78 (81.1)	152 (148.9)	230
Above 60 years	17 (16.9)	31 (31.1)	48
Total	**139 (139.0)**	**255 (255.0)**	**394**

Note:

Values are observed frequencies with expected frequencies in parentheses

Chi-Square Test for Age and Market Access

Test Statistic	Value	df	p-value
Pearson Chi-Square	0.546	2	0.761
Likelihood Ratio	0.543	2	0.762
Linear-by-Linear Association	0.260	1	0.610

Test Statistic	Value	df	p-value
N of valid cases	394		

The findings revealed that out of the total number of farmers aged between 18-35 years, 38 percent (44) of them had no access to ready market and 62 percent (72) indicated access. Among the 36 years to 60 years of age, 34% (78) did not have access to the market as opposed to 66% (152) who did. In the same manner, 35% (17) of farmers above 60 years were not in the market whereas 65% (31) were. The observed frequencies were also almost similar to the expected frequencies with all age groups indicating that there were only small deviations.

Chi-square results revealed no significant association between age and market access since $p > 0.05$, χ^2 (2, N = 394) = 0.546, p = .761. This means that the availability of ready markets was relatively similar in the three age groups and that age did not substantially factor in determining how farmers could find ready market outlets to sell their produce. These results indicate that there could be other factors that can have more influence on the ability of farmers to access markets as opposed to age. As an example, the market infrastructure, collective action in the form of cooperatives, obtaining timely information about the market, and connections with buyers have been widely mentioned as more decisive factors in determining market access (Ma et al., 2024: Okelai et al., 2020: Liverpool-Tasie et al., 2020). The findings align with those of Musara et al. (2021), who showed that there is no significant influence of age on market access among smallholder horticultural farmers in Zimbabwe. Likewise, noted by Ogutu (2022), both young and old farmers did not succeed in connecting to markets due to the institutional inefficiencies and not because of the nature of the individuals.

4.3.2. Age and Farmer Group Membership Crosstabulation.

Age group	Not member	Member	Total
18–35 years	111 (109.2)	5 (6.8)	116
36–60 years	214 (216.6)	16 (13.4)	230
Above 60 years	46 (45.2)	2 (2.8)	48
Total	**371 (371.0)**	**23 (23.0)**	**394**

Note: Values are observed frequencies with expected frequencies in parentheses.

Test statistic	χ^2	df	p
Pearson Chi-Square	1.26	2	0.533
Likelihood Ratio	1.30	2	0.521
Linear-by-Linear Association	0.11	1	0.738

Chi-square test Result for Age and Farmer Group Membership

Findings showed that in the farmers aged 1835 years, none (0) of the farmers were members of their groups as 96% (111) were non members. The percentage of non-members was 93% (214) and 7% (16) among the 36 years to 60 years old. On the same note, non-members (46) and members (2) were 96% and 4% respectively in the farmers who were above 60 years. The observed counts were similar to what was expected in all categories with minor deviations.

A chi-square test result indicated no statistically significant association between age and farmer group membership, χ^2 (2, N = 394) = 1.260, p = .533. This showed that farmers in various categories by age had equal chances to be less or more prone to be in farmer groups. The results indicate that the age factor is not significant in the determination of participation of the farmer groups in the study region. As an alternative, membership in the group can be determined by other factors including perceived benefits of collective action, extension services accessibility and institutional arrangements..

4.3.3. Age and Access to Extension Services Crosstabulation.

Age group	No Access	Access	Total
18–35 years	97 (91.9)	19 (24.1)	116
36–60 years	179 (182.1)	51 (47.9)	230
Above 60 years	36 (38.0)	12 (10.0)	48
Total	**312 (312.0)**	**82 (82.0)**	**394**

Note: Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Age and Access to Extension Services

Test Statistic	Value	df	p-value
Pearson Chi-Square	2.153	2	0.341
Likelihood Ratio	2.208	2	0.332
Linear-by-Linear Association	2.033	1	0.154
N of Valid Cases	394		

The findings indicated that of the farmers aged between 1855 years, 84% (97) said they had no access to extension services and 16% (19) said they had access to the same. Under 36-60 years bracket, 78 percent (179) did not have any access in comparison with 22

percent (51) who did. Among the persons aged over 60 years, 75% (36) had no access and 25% (12) persons had access to extension services. The observed counts were similar to the anticipated ones in all the age groups, and there were minimal deviations.

The statistical significance of these differences was determined by a chi-square test of Independence. The results revealed no significant association between age and access to extension services, χ^2 (2, N = 394) = 2.153, p = .341. This implied that the availability of extension services was comparatively similar with all age groups.

These results revealed that access to services offered by the extension was not related to age but must have been dependent on other factors like geographical positioning, institutional performance, and government policies of providing extension services. This is in tandem with the findings of Agwu et al. (2023) who also observed that institutional capacity and resource allocation usually limit the execution of extension service delivery in most African countries rather than the demographic characteristics of farmers. Equally, Sahu et al. (2015) observed that access to extensions is usually influenced by the endowment of resources in the household, nature of farming, and access to extension staff and not the age of the farmers.

4.3.4. Education Level and Access to Extension Services Crosstabulation.

Education Level	No Access	Access	Total
Higher education (University/College/Vocational/Tertiary)	48 (48.3)	13 (12.7)	61
Informal education	22 (19.8)	3 (5.2)	25
Primary education	122 (121.2)	31 (31.8)	153
Secondary education	120 (122.7)	35 (32.3)	155

Education Level	No Access	Access	Total
Total	**312 (312.0)**	**82 (82.0)**	**394**

***Note**: Values are observed frequencies with expected frequencies in parentheses.*

Chi-Square Test Results for Education Level and Access to extension services

Test Statistic	Value	df	p-value
Pearson Chi-Square	1.509	3	0.680
Likelihood Ratio	1.665	3	0.645
Linear-by-Linear Association	0.268	1	0.604
N of Valid Cases	394		

Farmers who were well educated (university, college, vocational, or tertiary) had 21% (13) access to extension services, and 79% (48) did not. Among the individuals who had informal education, access was only reported by 12% (3) of the respondents, as compared to 88% (22) who did not. Primary education Farmers with primary education registered 20 per cent (31) access and 80 per cent (122) no access. The proportion of people who had access to secondary education was 23% (35) among individuals who had secondary education and 77% (120) did not.

In general, the findings indicated that access to extensions service was not high in all levels of education. Nevertheless, the farmers who have secondary education (23% and higher education 21) had a little higher access levels than the farmers with primary (20) and informal education (12).

The chi-square test results indicated no statistically significant relationship between farmers' education level and their access to extension services, χ^2 (3, N = 394) = 1.509, *p*

= .680. This observation means that the extension service providers in the research region offered services to the farmers irrespective of the level of their education.

The findings are consistent with other studies carried by Inkoom et al. (2025), which indicated that in most developing nations, the provision of extension services is usually balanced in the spread among categories of farmers irrespective of the level of education. The absence of significant correlation in the current study, however, indicated that the provision of extension services was not very discriminatory by education category yet there was low level of access.

4.3.5. Education Level and Market Access Crosstabulation.

Education Level	**No Access**	**Yes Access**	**Total**
Higher education(University/College/Vocational/Tertiary)	21 (21.5)	40 (39.5)	61
Informal education	11 (8.8)	14 (16.2)	25
Primary education	40 (54.0)	113 (99.0)	153
Secondary education	67 (54.7)	88 (100.3)	155
Total	**139 (139.0)**	**255 (255.0)**	**394**

Note: Values are observed frequencies with expected frequencies in parentheses.

Chi-square Test Results for Education level and Market Access

Test Statistic	**Value**	**df**	**p-value**
Pearson Chi-Square	10.731	3	0.013*
Likelihood Ratio	10.858	3	0.013
Linear-by-Linear Association	1.288	1	0.256

Test Statistic	Value	df	p-value
N of Valid Cases	394		

Amongst those farmers who had received higher education (university, college, vocational and tertiary) 66% (40) of these had access to markets and 34% (21) had no such access. Among informal educated individuals, 56% (14) of the respondents had access and 44% (11) did not have access. The farmers who have primary education had the most access to the market with 74% (113) having market access and 26% (40) lacking market access. Of the farmers who were in the secondary education 57% (88) were able to access markets and 43% (67) could not.

The findings revealed that there was moderate access of the markets by all levels of education with farmers of primary education showing the best level of access (74%), and those of informal (56%), and secondary (57) education showed relatively low access levels. The chi-square test revealed a statistically significant association between farmers' education level and their access to ready markets, χ^2 (3, N = 394) = 10.731, p = .013. This implied that education to the farmers is a significant factor in determining their accessibility to markets. Farmers who were more educated in terms of having both secondary and farm education had greater access to the market than those who were merely educated at primary school level, or even informally. These findings suggested that education increases the capacity of the farmers to recognize and exploit marketing opportunities, understand marketing information and communicate better with the buyers. This result is equal to that of Mutea et al. (2025), who concluded that among the smallholder farmers in Kenya, education increases commercialization. Equally, Magesa et al. (2020) indicated that better

literacy and information-seeking behavior enabled educated cocoa farmers in Nigeria to use the organized markets.

Results indicated that the policies that could be used to enhance market access should incorporate farmer education and capacity building. Training programs, adult education, and farmer field schools may be of great help in empowering the less-educated farmers to be able to effectively participate in the markets.

4.3.6. Education Level and Farmer Group Membership Crosstabulation.

Education Level	Not member	Member	Total
Higher education	56 (57.4)	5 (3.6)	61
Informal education	25 (23.5)	0 (1.5)	25
Primary education	148 (144.1)	5 (8.9)	153
Secondary education	142 (146.0)	13 (9.0)	155
Total	**371 (371.0)**	**23 (23.0)**	**394**

Note: Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Education Level and Farmer Group Membership

Test Statistic	Value	df	p-value
Pearson Chi-Square	5.838	3	0.120
Likelihood Ratio	7.354	3	0.061
Linear-by-Linear Association	0.275	1	0.600
N of Valid Cases	394		

The results indicated that out of higher-educated farmers (university, college, vocational, or tertiary) 8% (5) reported being members of a farmer group as opposed to 92% (56) who did not. Among informally educated it was none (0% (0)) among the members and all (100% (25) non-members. Of the farmers who had primary education, 3% (5) were members and 97 percent (148) were not. Among the secondary-educated, 8% (13) were members as compared to 92% (142) who were not.

Generally, the findings revealed that membership in farmer groups was not that high even at all levels of education. Farmers who received secondary education (8%), higher education (8%), primary education (3%), and informal education (0%) were slightly higher in membership as compared to other farmers and none of the farmers was found to have membership.

The chi-square test results revealed no statistically significant association between farmers' education level and membership in farmer groups, $\chi^2(3, N = 394) = 5.838$, $p = .120$. This implied that the level of education of farmers did not have a significant effect on the membership of the farmer groups. The farmers of various levels of education (informal, primary, secondary, and higher education) had an equal (or non-equal) possibility to be members of farmer groups.

The implication of this finding is that institutional arrangements, collective benefits accessibility or local leadership dynamic instead of formal education may cause farmer groups in the study area to join the membership. This observation aligns with those of Mulungu and Mudege (2020) who concluded that the degree of trust on the leadership of a group and access to resources influenced the choice of group membership than the demographic or educational features of farmers.

This study indicates a non-significant relationship, which implies that the introduction of farmer group membership should focus on everyone farmer as opposed to the level of education, and work on institutional factors that may put a person off the membership.

4.3.7. Gender and Access to Extension Services Crosstabulation.

Gender	No Access	Access	Total
Female	153 (142.5)	27 (37.5)	180
Male	159 (169.5)	55 (44.5)	214
Total	**312 (312.0)**	**82 (82.0)**	**394**

Note: Values are observed frequencies with expected frequencies in parentheses

Chi-Square Test Results for Gender and Access to Extension Services

Test Statistic	Value	df	p-value
Pearson Chi-Square	6.793	1	0.009*
Continuity Correction (2x2)	6.159	1	0.013
Likelihood Ratio	6.934	1	0.008
Fisher's Exact Test			0.012
Linear-by-Linear Association	6.776	1	0.009
N of Valid Cases	394		

The gender results revealed that, out of the female farmers, 15 percent (27) had access to extension services whereas 85 percent (153) did not. Male farmers on the other hand were found to have more access with 26% (55) accessing versus 74% (159) without access. The results implied that male farmers were more prone to access the extension services compared with female farmers but generally both had a low access to the extension.

The chi-square test indicated a statistically significant association between gender and access to extension services, χ^2 (1, N = 394) = 6.793, p = .009. This implied that there were disparities between the access to male and female farmers of extension services. Namely, there is a higher access to extension services by male farmers (55 observed vs. 44.5 expected) and lower access to extension services by female farmers.

These results brought out the existence of the gender disparities in the extension services whereby men were believed to access extension services more than women. This is in line with previous research in Sub-Saharan Africa (Mishra et al. 2024), which reported that women farmers tend to experience obstacles to extension services because of cultural beliefs, time, mobility, and gender household roles.

Nonetheless, other studies (Prajapati et al. 2025), underline the fact that the involvement of women in farmer groups, as well as in inclusive extension programs, can facilitate this gap. These differences in the current research thus, highlight the need to introduce gender-sensitive methods of agricultural extension strategies that specifically focus on female farmers so that they can have fair access to the advisory services.

4.3.8. Gender and Market Access Crosstabulation.

Gender	No Market Access	Market Access	Total
Female	73 (63.5)	107 (116.5)	180
Male	66 (75.5)	148 (138.5)	214
Total	**139 (139.0)**	**255 (255.0)**	**394**

Note: Values are observed frequencies with expected frequencies in parentheses

Chi-Square Test Results for Gender and Market Access

Test Statistic	Value	df	p-value
Pearson Chi-Square	4.041	1	0.044*
Continuity Correction (2x2)	3.626	1	0.057
Likelihood Ratio	4.036	1	0.045
Fisher's Exact Test			0.057
Linear-by-Linear Association	4.030	1	0.045

Considering gender disparity, 59% (107) of the female farmers were accessible to the markets whereas 41% (73) were not. Conversely, farmers who were male indicated more access with 69% (148) of them having access to the market compared to 31% (66) that did not.

The chi-square test revealed a statistically significant association between gender and market access, $\chi^2(1, N = 394) = 4.041$, $p = .044$. Male farmers were more likely than expected to have market access (148 observed vs. 138.5 expected), while female farmers were less likely than expected.

This observation showed that gender is a significant issue in the accessibility of ready markets by farmers. The findings are congruent with previous studies (Njuki et al. 2024), which indicate that women farmers that experience certain drawbacks like inadequate control over resources, lack of bargaining power, restricted mobility, and being locked out of marketing networks.

The resulting market access gap based on gender indicates that female farmers might not be enjoying all the benefits of commercialization opportunities, which reduces their income

and livelihood gains in their farms. Market interventions, which are gender sensitive, including empowering women cooperatives, enhancing access to credit and cultural limitations have to be engaged thus to guarantee fair participation in the agricultural market.

4.3.9. Gender and Farmer Group Membership Crosstabulation.

Gender	Not a Member	Member	Total
Female	169 (169.5)	11 (10.5)	180
Male	202 (201.5)	12 (12.5)	214
Total	**371 (371.0)**	**23 (23.0)**	**394**

Note:

Values are observed frequencies with expected frequencies in parentheses

Chi-Square Test Results for Gender and Farmer Group Membership

Test Statistic	Value	df	p-value
Pearson Chi-Square	0.045	1	0.832
Continuity Correction (2x2)	0.000	1	1.000
Likelihood Ratio	0.045	1	0.832
Fisher's Exact Test			0.833
Linear-by-Linear Association	0.045	1	0.832
N of Valid Cases	394		

Note: Values are observed frequencies with expected frequencies in parentheses.

Female farmers 6 percent (11) of the women in the group were women in a farmer group, and 94 percent (169) of the women were not. On the same note, male farmers had 6% (12)

members and 94% (202) non-members. The findings showed that the membership of the farmer groups was very low among the male and female farmers with a slight difference between the two sexes.

The chi-square test showed no significant association between gender and farmer group membership, $\chi^2(1, N = 394) = 0.045$, $p = .832$. This implied that both men and women were engaged in farmer groups equally with almost equal observed and expected numbers of both sexes. Membership of groups in this work seemed to be gender neutral. This can show that in the study region, the groups of farmers are open to both men and women.

Nevertheless, this low over-all membership in the group (23 of 394 or about 5.8 percent) is an indicator of a more general institutional problem. Farmer groups, as noted by Bizikova et al. (2020) play a central role in enhancing bargaining power, access to inputs and connection of the smallholder to markets. This implied that both men and women could be lagging behind in these benefits which are collectively enjoyed and that would restrict their opportunities in agriculture due to the low rate of participation.

4.3.10. Income Level and Access to Extension Services Crosstabulation.

Income Level (KES)	No Access	Access	Total
Less than 10,000	195 (178.2)	30 (46.8)	225
10,000–50,000	104 (113.2)	39 (29.8)	143
51,000–100,000	11 (18.2)	12 (4.8)	23
Over 100,000	2 (2.4)	1 (0.6)	3
Total	**312 (312.0)**	**82 (82.0)**	**394**

Note: Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Income Level and Access to Extension Services

Test Statistic	Value	df	p-value
Pearson Chi-Square	0.045	1	0.832
Continuity Correction (2x2)	0.000	1	1.000
Likelihood Ratio	0.045	1	0.832
Fisher's Exact Test			0.833
Linear-by-Linear Association	0.045	1	0.832
N of Valid Cases	394		

Out of the farmers with less than KES 10, 000, 13% (30) received the extension services and 87% (195) did not. Among the those with incomes between KES 10,000- 50,000, access was more as 27% (39) also indicated access as compared to 73% (104) who did not. The highest proportion of access was in the bracket of 51,000-100,000 with 52% (12) of farmers having access and 48% (11) having no access. Among the few who earn above KES 100,000, 1/3 (1) could access it and 2/3 (2) could not.

The results showed that the access of the extension services tended to be more in the high income level (52%), followed by middle income level (42%), and low income level (13%), as farmers earning less than KES 10,000 recorded the lowest level of access to the extension services.

The chi-square test revealed no statistically significant association between income level and access to extension services, $\chi^2(1, N = 394) = 0.045$, $p = .832$. This showed that the accessibility of extension services was similar among farmers at various income brackets.

Although observed frequencies revealed that middle-income farmers (KES 10,000–50,000 and KES 51,000–100,000) accessed services slightly more than expected, these differences were not statistically significant.

4.3.11. Income Level and Market Access Crosstabulation.

Income Level (KES)	No Market Access	Market Access	Total
Less than 10,000	85 (79.4)	140 (145.6)	225
10,000–50,000	53 (50.4)	90 (92.6)	143
51,000–100,000	1 (8.1)	22 (14.9)	23
Over 100,000	0 (1.1)	3 (1.9)	3
Total	**139 (139.0)**	**255 (255.0)**	**394**

Note: Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Income Level and Market Access

Test Statistic	Value	df	p-value
Pearson Chi-Square	12.087	3	0.007*
Likelihood Ratio	16.418	3	0.001
Linear-by-Linear Association	0.011	1	0.916
N of Valid Cases	394		

Markets were available to 62% (140) farmers earning less than KES 10,000 than 38% (85) who did not. Among the income earners who are in the KES 10,000-50,000 bracket, 63% (90) said they had market access and 37% (53) did not. The access to the market among farmers in KES 51,000-100,000 bracket was best with 96% (22) farmers reporting to have accessed market and 4% (1) farmers reporting to have no market access. In the small

category with income of above KES 100,000, 100% (3) had accessed the market, and 0% (0) had not.

The results indicated that there was generally an income effect as access to the market was lowest when farmers had less than KES 50,000 (approximately 62) and highest when they had KES 51,000 and above (more than 95 percent).

The chi-square test revealed a statistically significant association between income level and market access, $\chi^2(3, N = 394) = 12.087$, $p = .007$. This suggested that farmers' access to markets varied by their income categories.

The access to the market was more than expected among the farmers with the income levels of KES 51,000-100,000 (22 observed vs. 14.9 expected), but a little less among the very low income farmers (less than KES 10,000) (140 observed vs. 145.6 expected). The wealthy segment (more than KES 100,000) though not very large in sample also demonstrated complete market accessibility.

These results showed that farmers with more income are likely to have a better market access, which was consistent with the previous studies (Adefila et al. 2024), which underlined that more prosperous farmers have more mobility, network, and bargaining power.

Demand of inclusive market-interventions including rural infrastructure, aggregation facilities and specific assistance to smallholders so that the lower-income farmers are also able to share in the opportunities of commercialization.

4.3.12. Income Level and Farmer Group Membership Crosstabulation.

Income Level (KES)	Not a member	Member	Total
Less than 10,000	208 (211.9)	17 (13.1)	225

Income Level (KES)	Not a member	Member	Total
10,000–50,000	138 (134.7)	5 (8.3)	143
51,000–100,000	22 (21.7)	1 (1.3)	23
Over 100,000	3 (2.8)	0 (0.2)	3
Total	**371 (371.0)**	**23 (23.0)**	**394**

Note:Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Income Level and Farmer Group Membership

Test Statistic	Value	df	p-value
Pearson Chi-Square	2.913	3	0.405
Likelihood Ratio	3.226	3	0.358
Linear-by-Linear Association	2.372	1	0.124
N of Valid Cases	394		

Their members were those farmers who earned less than KES 10,000, 8% (17) and those who did not 92% (208). Among KES 10,000-50,000 income group, 4% (5) of people were members as opposed to 96% (138) who were not. Among farmers with incomes of between 51,000 and 100,000, only 4% (1) of them were members, and 96% (22) were not. In the highest income group of more than KES 100,000, none of the farmers 0% (0) were members, and all 100% (3) were non-members.

All in all, the results indicated that there was consistently low membership in farmer groups irrespective of income category with a slightly higher membership recorded among farmers who earn less than KES 10,000 (8%), and no reported membership to those with earnings more than KES 100,000.

The chi-square test showed no statistically significant association between income level and farmer group membership, $\chi^2(3, N = 394) = 2.913$, $p = .405$. It meant that the income level of farmers had no impact on the membership to the farmer groups in this study.

Descriptive findings were not important, but most of the sample population members of the farmer groups belonged to the lowest income group (< KES 10,000) (17 out of 23). The representation of higher-income farmers (KES 51,000 -100,000 and above 100,000) in groups was minimal, perhaps because of dependence on alternative networks, individual bargaining power or less necessity of collectivity.

It means that the farmer groups in the region might be poorly used as institutions, and the opportunities to increase their inclusiveness and functionality might improve social capital and access to the markets by the smallholder farmers.

4.3.13. Farming Experience and Access to Extension Services Crosstabulation.

Farming Experience	**No Access to**	**Access**	**Total**
Less than 5 years	95 (89.5)	18 (23.5)	113
5–10 years	83 (84.7)	24 (22.3)	107
11–15 years	56 (53.8)	12 (14.2)	68
More than 15 years	78 (83.9)	28 (22.1)	106
Total	**312 (312.0)**	**82 (82.0)**	**394**

Note: Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Farming Experience and Access to Extension Services

Test Statistic	Value	df	p-value
Pearson Chi-Square	4.237	3	0.237
Likelihood Ratio	4.243	3	0.236
Linear-by-Linear Association	1.003	1	0.317
N of Valid Cases	**394**		

Farmers who had an experience of less than 5 years began to demonstrate that 16% (18) of them had access to extensions services as opposed to 84% (95) who did not. In the group of people with 5-10 years of experience, 22% (24) are able to access it and 78% (83) are not. Among experienced farmers (11-15 years), there were 18% (12) that reported access and 82% (56) that lacked access. Lastly, 26% (28) of those who have over 15 years of experience had access along with 74% (78) of those who did not.

Results showed that the availability of extension services was low in all the categories of farming experience, but it was a relatively higher service with farmers having over 15 years experience of 26% than those with lower experience.

The chi-square test revealed no statistically significant association between farming experience and access to extension service, $\chi^2(3, N = 394) = 4.237$, $p = .237$. This suggested that access to extension services was not determined by how long farmers had been engaged in farming.

The descriptive findings reveal a comparatively comparable access pattern across the groups of experience with a range of between 10% to 26 percent of farmers in each of the experience groups reporting being accessing by the extension services. Curiously, the access of farmers with over 15 years of experience was a little better (26) in comparison to

the farmers with less than 5 years of experience (16). Nevertheless, these variations were not significant enough to draw the conclusion.

This observation also suggests that there can be a consistent constraint to the delivery of extension services in the research region, independent of experience in farming. It is in contrast to expectations that more experienced farmers should be better connected or be better known by extension officers. Stronger outreach efforts on extensions can thus focus on focusing on all types of farmers, to be inclusive of all levels of experience.

4.3.14. Farming Experience and Market Access Crosstabulation.

Farming Experience	No Access	Market Access	Total
Less than 5 years	33 (39.9)	80 (73.1)	113
5–10 years	43 (37.7)	64 (69.3)	107
11–15 years	24 (24.0)	44 (44.0)	68
More than 15 years	39 (37.4)	67 (68.6)	106
Total	**139 (139.0)**	**255 (255.0)**	**394**

Note:Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Farming Experience and Market Access

Test Statistic	Value	df	p-value
Pearson Chi-Square	3.062	3	0.382
Likelihood Ratio	3.095	3	0.377
Linear-by-Linear Association	0.134	1	0.714
N of Valid Cases	394		

Farmers who had less than 5 years of experience said that 71% (80) of them had access to the market and 29% (33) did not. Out of the 5-10 years experience, 60% (64) of those were able to access it as opposed to 40% (43) who could not. Among the farmers who had 11-15 years of experience, there was one hundred percent (44) access vs. 35 percent (24) non-access. Lastly, of the respondents that have over 15 years of experience, 63 percent (67) of the respondents reported their access and 37 percent (39) reported their lack of access.

Generally, the results indicated a moderate market access level in all categories of farming experience with the highest percentage recorded among farmers with less than 5 years of experience (71%). Farmers who had between 5-10 years of experience, on the contrary, had the lowest access (60%).

The chi-square test showed that there was no statistically significant association between farming experience and market access, $\chi^2(3, N = 394) = 3.062$, $p = .382$. This showed that the years of experience of the farmers did not significantly influence their prospects of accessing the market.

Descriptively, market access of farmers who had less than 5 years of experience was relatively high (71) than those who had 5-10 years (60) and greater than 15 years (63). The proportional access was the most similar to expectations with farmers who had experience of 11-15 years (65%). The differences were however not statistically significant.

This implied that it is possible that market linkages within the study area (do not) depend on certain categories of experience but rather on other determinants like income, institutional support or membership of a group. Enhancing the market access intervention should, therefore, be directed towards the development of inclusive market channels as

opposed to engaging farmers on the basis of their level of experience.

4.3.15. Farming Experience and Farmer Group Membership Crosstabulation.

Farming Experience	Not a Member	Member	Total
Less than 5 years	110 (106.4)	3 (6.6)	113
5–10 years	98 (100.8)	9 (6.2)	107
11–15 years	63 (64.0)	5 (4.0)	68
More than 15 years	100 (99.8)	6 (6.2)	106
Total	**371 (371.0)**	**23 (23.0)**	**394**

Note:Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Farming Experience and Farmer Group Membership

Test Statistic	Value	df	p-value
Pearson Chi-Square	3.662	3	0.300
Likelihood Ratio	3.998	3	0.262
Linear-by-Linear Association	1.038	1	0.308
N of Valid Cases	394		

The experience of the farmers that were below 5 years was only 3% (3), and the overall majority of 97% (110) were not members of farmer groups. In the case of people who had the experience between 5 and 10 years, 8% (9) said that they were members as opposed to 92% (98) of those who were not. Among the 1115 years category 7 (5) were members and 93 (63) were not. Likewise, out of the farmers who have a record of more than 15 years 6% (6) were the members and 94% (100) were not.

In general, farmer groups membership was also consistently low with a range of 3 to 8% with the highest membership recorded by farmers having 5 to 10 years experience (8) and lowest membership recorded by farmers having less than 5 years (3).

The chi-square test indicated no statistically significant association between farming experience and farmer group membership, $\chi^2(3, N = 394) = 3.662$, $p = .300$. The level of 5-10 years experience and 11-15 years experience showed higher group participation compared to other groups (less than 5 years experience and more than 15 years experience) but these were not significant differences. This implied that the experience in farming does not have a strong impact on the probability of farmers joining farmer groups.

4.3.16. Land Type and Access to Extension Services Crosstabulation.

Land Type	**No Access**	**Access**	**Total**
Community land	3 (3.2)	1 (0.8)	4
Family land	108 (106.1)	26 (27.9)	134
Hired/leased/rented land	38 (36.4)	8 (9.6)	46
Owned land	163 (166.3)	47 (43.7)	210
Total	**312 (312.0)**	**82 (82.0)**	**394**

Note:Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Land Type and Access to Extension Services

Test Statistic	Value	df	p-value
Pearson Chi-Square	0.844	3	0.839
Likelihood Ratio	0.854	3	0.836
Linear-by-Linear Association	0.408	1	0.523
N of Valid Cases	394		

The use of community land among farmers demonstrated that a quarter (1) of the farmers had access to extension services and three quarters (3) did not. About 19 percent (26) of those who were growing on family land indicated access versus 81 percent (108) of those without access. Among farmers in hired/leased/rented land, 17% (8) were able to access it, and 83% (38) were unable to access. Finally, 22% (47) of those who farmed on owned land had access and most, 78% (163), were not able.

The level of access to extension services was comparatively low (17% to 250) with even more access being recorded among farmers within community land (25.0) and owned land (22.4) than in the other categories.

The chi-square test revealed no significant association between land type and access to extension services $\chi^2(3, N = 394) = 0.844$, $p = .839$. The extension services were also offered to the farmers on similar rates irrespective of their land tenure arrangements (community, family, leased, or privately owned land). Indicatively 21.4% of people on community land and 22.4% on owned land said they had access as compared to 19.4% on family land and 17.4% hired/leased land.

This implied that the type of tenure of land does not play a factor of significant influence in farmers communicating with the extension officers. The access can be more reliant on such factors as geographic location, institutional reach, or membership in a group of farmers.

4.3.17. Land Type and Market Access Crosstabulation.

Land Type	No Access	Access	Total
Community land	1 (1.4)	3 (2.6)	4
Family land	60 (47.3)	74 (86.7)	134
Hired/leased/rented land	18 (16.2)	28 (29.8)	46
Owned land	60 (74.1)	150 (135.9)	210
Total	**139 (139.0)**	**255 (255.0)**	**394**

Note:Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Land Type and Market Access

Test Statistic	Value	df	p-value
Pearson Chi-Square	9.915	3	0.019
Likelihood Ratio	9.888	3	0.020*
Linear-by-Linear Association	8.473	1	0.004*
N of Valid Cases	394		

Community land farmers were also reported as experiencing market access 75% (3) and access 25% (1). Out of the individuals who grew on family land, 55% (74) were those who had access whereas 45% (60) did not. Among farmers on hired/leased/rented land, 61%

(28) indicated being able to access it, 39 percent (18) did not. Finally, 71% (150) of farmers in owned land had access to the market versus 29% (60) without market access.

In general, access to the market depended on the type of land with the highest access being in community land users (75%), followed by owned land farmers (71%) and the lowest access being in farmers who were on the family land (55%).

The chi-square test showed a statistically significant association between land type and market access, $\chi^2(3, N = 394) = 9.915$, $p = .019$. The results indicated that the type of land tenure is a contributing factor to access of markets by farmers with owners and lease holders having better incentives or opportunities to access markets. This may be due to the fact that secure tenure increases investment in production and marketing whereas uncertain land arrangements may limit participation.

4.3.18. Land Type and Farmer Group Membership Crosstabulation.

Land Type	No Membership	Membership	Total
Community land	4 (3.8)	0 (0.2)	4
Family land	125 (126.2)	9 (7.8)	134
Hired/leased/rented land	44 (43.3)	2 (2.7)	46
Owned land	198 (197.7)	12 (12.3)	210
Total	**371 (371.0)**	**23 (23.0)**	**394**

Note:Values are observed frequencies with expected frequencies in parentheses.

Chi-Square Test Results for Land Type and Farmer Group Membership

Test Statistic	Value	df	p-value
Pearson Chi-Square	0.628	3	0.890

Test Statistic	Value	df	p-value
Likelihood Ratio	0.870	3	0.833
Linear-by-Linear Association	0.049	1	0.825
N of Valid Cases	394		

On community land, the non-membership in farmer groups was 100 (4) and 0 (0) membership. Among the farmers who were working on family lands, 93% (125) of them were non-members, and 7% (9) of them stated that they belonged to an organization of farmers. In the case of farmers who worked on hired/leased/rented land, 96% (44) of the farmers did not belong to the membership, with 4% (2) being a member. Likewise, non-membership was 94% (198) with 6% (12) members on the owned land with the highest turnout being 7% (10) on the family land with none of the community land farmers (0) having any members.

The chi-square test showed no significant association between land type and farmer group membership, $\chi^2(3, N = 394) = 0.628$, $p = .890$. These findings suggest that land tenure type does not dictate the willingness and ability of the farmers to join farmer groups. Rather, institutional support, personal interest or perceived group benefits can have a stronger influence on group membership, as opposed to ownership or access to land.

4.4.0. Adoption of Sustainable Sugarcane Practices by Socio-economic Characteristics of Smallholder Farmers.

Various factors influenced the adoption of sustainable sugarcane farming practices. Analysis of data collected is presented in Table 4.4.1

Table 4.4.1. Adoption of Sustainable Sugarcane Practices by Socio-economic Characteristics of Smallholder Farmers

Category	Soil Testing (n, %)	IWM (n, %)	Mulching (n, %)	Harvesting (n, %)
Age				
18–35 years	11 (9.5%)	6 (5.3%)	88 (75.9%)	0 (0.0%)
36–60 years	216 (93.9%)	4 (1.8%)	197 (85.7%)	0 (0.0%)
Above 60 years	445 (99.3%)	3 (5.3%)	45 (93.8%)	0 (0.0%)
Gender				
Males	13 (7.2%)	3 (1.6%)	141 (78.3%)	0 (0.0%)
Females	15 (7.0%)	9 (4.3%)	189 (88.3%)	0 (0.0%)
Education level				
Higher education	8 (13.1%)	4 (6.7%)	50 (82.0%)	0 (0.0%)
Informal education	3 (12.0%)	0 (0.0%)	21 (84.0%)	0 (0.0%)
Primary education	6 (3.9%)	0 (0.0%)	134 (87.6%)	0 (0.0%)
Secondary education	11 (7.1%)	8 (5.3%)	125 (80.6%)	0 (0.0%)
Farming experience				
< 5 years	7 (6.2%)	6 (5.3%)	85 (75.2%)	0 (0.0%)
5–10 years	8 (7.2%)	3 (2.8%)	94 (87.9%)	0 (0.0%)
11–15 years	5 (7.4%)	0 (0.0%)	58 (85.3%)	0 (0.0%)
> 15 years	8 (7.5%)	3 (2.8%)	93 (87.7%)	0 (0.0%)
Income level				

< KES 10,000	15 (6.7%)	6 (5.3%)	85 (75.2%)	0 (0.0%)
KES10,000-50,000	12 (8.4%)	0 (0.0%)	58 (85.3%)	0 (0.0%)
KES51,000-100,000	1 (4.3%)	3 (2.8%)	94 (87.9%)	0 (0.0%)
> KES 100,000	0 (0.0%)	3 (2.8%)	103 (87.7%)	0 (0.0%)
Land ownership				
Community land	1 (25.0%)	0 (0.0%)	2 (50.0%)	0 (0.0%)
Family land	12 (8.4%)	4 (3.0%)	115 (85.8%)	0 (0.0%)
Leased land	5 (10.9%)	1 (2.2%)	42 (91.3%)	0 (0.0%)
Owned land	10 (4.8%)	7 (3.3%)	171 (81.4%)	0 (0.0%)
Group membership				
Member	3 (13.0%)	2 (8.7%)	17 (73.9%)	0 (0.0%)
Non-member	25 (6.7%)	10 (2.7%)	313 (81.6%)	0 (0.0%)
Market access				
Yes	11 (7.9%)	7 (5.3%)	124 (89.2%)	0 (0.0%)
No	17 (6.7%)	5 (2.0%)	206 (80.8%)	0 (0.0%)
Extension services				
Yes	19 (6.1%)	11 (3.5%)	256 (82.1%)	0 (0.0%)
No	9 (2.6%)	1 (1.2%)	74 (90.2%)	0 (0.0%)

Source: Field Data (2024) Note. *n = frequency of adopters; % = percentage of adopters within each category.*

4.4.2. Adoption by Age.

The findings indicated that there was a wide difference in the application of sustainable practices between the age groups. Of the farmers between the age of 18-35 years, only

9.5% (11 of 116) responded by saying they did soil testing and 5.3 percent responded by saying they did integrated weed management. Nonetheless, mulching was more embraced with a relatively high percentage of 75.9. Conversely, the adoption of soil testing (93.9%), mulching (85.6%), and low adoption of integrated weed management (1.8%), was high in those who were aged 36 60 years. The highest level of soil testing was among farmers over 60 years -99.3% but the minimum of 6.3% had adopted mulching practice. It is interesting to note that there was no age group who can adopt integrated methods of harvesting. According to O'Connell et al. 2022), older farmers perhaps because of their experience and the amount of acquired knowledge recognize the importance of soil testing. Nevertheless, the younger farmers, who are more labour-flexible, are more likely to use mulching. This assists the Diffusion of Innovation Theory as developed by Rogers as diffusion is a process where perceived benefits and compatibility to the needs of the farmers affect the adoption decisions (Rogers, 2003).

4.4.3. Adoption by Gender.

Among the overall number of male respondents 7.2 percent of the total number had engaged in soil testing, 1.6 percent in integrated weed management, and 78.3 percent in mulching. Female respondents who followed the practice of soil testing, integrated weed management, and mulching were 7.0, 4.3, and 88.3 percent respectively. The adoption of mulching and weed management was a little higher among women, which may be explained by the fact that women are more engaged in farm maintenance activities. (Musafili et al. 2023). The same gendered trends are cited in sustainable agriculture, as women embrace low-cost and labor-intensive strategies more easily (Doss, 2018).

4.4.4. Adoption by Education Level.

Education contributed towards adoption patterns. Farmers possessing an education level of higher education had a soil testing adoption of 13.1, integrated weed management of 6.7 and mulching at 81.9%. Adoption of 7.1, 5.3 and 80.6 respectively was among those with secondary education. Primary educated farmers had 3.9% adoption of soil testing, no adoption of integrated weed management, but 87.3 percent had adopted mulching. These findings revealed that better educated farmers tend to make use more of technical practices such as soil testing and mulching is very well accepted by all levels of educations. This is in line with the past research that reported the awareness and adoption of knowledge-intensive practices to be increased by education (Mazorodze et al. 2020).

4.4.5. Adoption by Farming Experience.

The farmer with less than 5 years of experience had an adoption of 6.2 in soil testing, integrated weed management of 5.3 and mulching of 75.2. There were 7.2, 2.8 and 87.9 percent respectively among those whose duration was 5-10 years. The adoption of soil testing (7.5) and mulching (87.7) were a little higher among farmers who had more than 15 years of experience in farming.

It was found out that farming experience increased adoption of technical practices like soil testing. Farmers with extensive experience will probably benefit in the long run, which is in agreement with Piineiro et al. 2020 results indicating that experience is positively correlated with the adoption of a sustainable practice.

4.4.6. Adoption by Income Level.

The adoption of soil testing of 6.7, weed management of 5.3, and mulching at 75.2 was evidenced by farmers whose income per month was less than KES 10,000. The 8.4% soil

testing, 0% weed management and 85.3% mulching were observed in those who earn KES 10,000 -50,000. Interestingly, those with a high level of income (KES 100,000 and above) demonstrated the adoption of 0% soil testing, 0% weed management, and 87.7% mulching. This is contrary to what was expected; the richer farmers were supposed to adopt more practices because resources would provide that. Instead, farmers with low income embrace low cost practices such as mulching, which might be a survival measure. This observation is compatible with the study of Sui et al. (2023), who observed that the intensity of adoption decisions relies on resource endowments as well as risk perceptions.

4.4.7 Adoption by Land Ownership.

3.3%, and mulching at 81.4%. Those farming on leased land reported 10.9% soil testing and 91.3% mulching. Community land farmers had negligible adoption. Secure land tenure appears to motivate farmers to adopt long-term soil health practices like soil testing. This finding supports Abab *et al.* (2023), who emphasized that tenure security influences sustainable land management investments**.** Farmers with owned land had soil testing adoption of 4.8%, integrated weed management at

4.4.8. Adoption by Farmer Group Membership.

The proportions of adoption in groups were greater, 13% soil testing, 8.7% integrated weed management, and 73.9% mulching. The percentages of non-members were lower (6.7%, 2.7 and 81.6 respectively). This implies that groups of farmers will be more knowledgeable and peer-learned to encourage adoption. It has been discovered that group membership is influential in the diffusion of technology in rural areas (Cole et al. 2021).

4.4.9. Adoption by Market Access.

The adoption of soil testing was 7.9, integrated weed management was 5.3, and mulching was 89.2 in the farmers with access to the market. Others who were not accessing it recorded 6.7, 2.0 and 80.8 percent respectively. It means that market incentives promote the use of practices which enhance better sugarcane production. The same results were indicated by Mulwa et al. (2021) who demonstrated that availability of output markets encourages practice of sustainable intensification.

4.4.10. Adoption by Access to Extension Service.

The adoption was strongly affected by extension access. The extension services also included soil testing, 6.1%; integrated weed management, 3.5% and mulching, 82.1% in farmers with extensions. The non-extended registered significantly lower adoption (2.6, 1.2 and 90.2 respectively).

This highlights the importance of having extension in ensuring sustainable practices, which is in line with results by Masambuka-Kanchewa, et al. (2020) who theorized that effective extensions increase the spread of agricultural innovations.

4.5.0. Relationship between adoption of the various sustainable sugarcane farming practices and socio-economic characteristics of smallholder sugarcane farmers.

Adoption of sustainable sugarcane farming practices in the study area had various socioeconomic factors attached to it. The chi-square was used to test the association between socio-economic variables and adoption levels of the different sustainable sugarcane farming practices by smallhold sugarcane farmers in the research area. This section describes the results and discusses them.

Table 4.5.1: Relationship between adoption of mulching practice and the socio-economic factors

Variables	Category detected	χ^2	df	*p*-value
Personal factors				
Age	3	7.93	2	0.160
Gender	2	13.59	1	0.001*
Farming experience	4	9.09	3	0.028*
Education level	4	2.93	3	0.402
Income level	4	396.49	3	0.001*
Land ownership	4	6.19	3	0.103
Institutional factors				
Farmer group	2	0.60	1	0.438
Extension services	2	3.00	1	0.083
Market access	2	0.40	1	0.527

Chi-square value ($\chi^2_{1, 0.001}$ = 13.586) showed gender, farming experience ($\chi^2_{3, 0.028}$ =9.092, and income level ($\chi^2_{3, 0.001}$= 396.494) had significant association ($p<0.05$) with the adoption of mulching. This implies gender, farming experience and income level of sugarcane smallholder farmers play a crucial role in influencing adoption of sustainable sugarcane farming practices. Owiti (2019) found that gender has a notable positive significant association with cane productivity with males having higher cane productivity than females.

The chi-square analysis revealed that age ($\chi^2_{3,\ 0.160} = 7.925$) did not have a statistical significant association with the adoption of mulching, consistent with findings by Mishra *et al.* (2018) who also reported no significant impact of age on the adoption of sustainable farming practices whereby increasing farmer age had a negative impact on the adoption of sustainable agricultural practices. Similarly, education level ($\chi^2_{3,\ 0.402} = 2.933$) was also found to have no significant association with the adoption of mulching practice. Additionally, land ownership ($\chi^2_{3,\ 0.103} = 6.194$) showed no significant association with the adoption of mulching. This is due to the availability of readily available mulching resources by all types of land owners as indicated by key informants. Membership in farmer group ($\chi^2_{1,\ 0.438} = 0.601$) had no significant association with mulching practice adoption. Moreover, extension service provision ($\chi^2_{1,\ 0.083} = 2.996$) and market access ($\chi^2_{1,\ 0.527} = 0.401$) showed no significant association with the adoption of mulching practices.

Table 4.5.2. Relationship between the adoption of integrated weed management and the socio-economic factors.

Variables	Category detected	χ^2	df	*p*-value
Personal factors				
Age	3	20.16	2	0.448
Gender	2	29.04	1	0.001*
Farming experience	4	12.83	3	0.382
Education level	4	22.07	3	0.037*
Income level	4	430.22	3	0.001*

Variables	Category detected	χ^2	df	*p*-value
Land ownership	4	48.83	3	0.001*
Institutional factors				
Farmer group	2	63.42	1	0.001*
Extension services	2	10.14	1	0.038*
Market access	2	3.04	1	0.551

Chi-square value indicated income level ($\chi^2_{3.\ .001} = 430.224$), education level ($\chi^2_{3,\ .037} = 22.072$), gender ($\chi^2_{1\ .001} = 29.038$), land ownership ($\chi^2_{3,\ .001} = 48.826$), extension services ($\chi^2_{1\ .038} = 10.143$), membership into farmer group ($\chi^2_{1,\ .001} = 63.415$) had a significant association with the adoption of the weeding practices. Findings implies that income level, education level, gender, land ownership, extension services, and membership into farmer groups play crucial role in influencing adoption of weeding practices among sugarcane smallholder farmers. These results align with those of Usman *et al*. (2022) who revealed income level of farmers had a significant relationship($p<0.05$) with the adoption of weed management practices. Toure *et al.* (2024) revealed that gender has a significant relationship with the adoption of weed management practices among rice farmers.

The chi-square analysis revealed that age ($\chi^2_{3,\ .448} = 20.157$) did not have significant association with the adoption of weeding practices. Similarly, DeDecker *et al*. (2014) found that age were not statistically significant factors in the adoption of cover crops as weed management practices. Additionally, farming experience ($\chi^2_{3\ .382} = 12.827$), and market access ($\chi^2_{1,\ .551} = 3.040$) showed no significant relationship with the adoption of weeding practices.

Table 4.5.3. Relationship between adoption of soil testing and the socio-economic factors.

Variables	Category detected	χ^2	df	*p*-value
Personal factors				
Age	3	0.952	2	0.966
Gender	2	1.217	1	0.544
Farming experience	4	2.059	3	0.560
Education level	4	10.981	3	0.012*
Income level	4	395.537	3	0.001*
Land ownership	4	1.470	3	0.689
Institutional factors				
Farmer group	2	42.406	1	0.001*
Extension services	2	7.182	1	0.007*
Market access	2	0.581	1	0.446

The Chi-square value indicated that membership in farmer group ($\chi^2_{1, .001}$ =42.406), extension services ($\chi^2_{1, .007}$ =7.182), education level ($\chi^2_{3, .012}$ = 10.981) and income level ($\chi^2_{3, .001}$ =395.537) had significant association with the adoption of soil testing practices. This implies that farmer groups/organizations, extension services, education levels and income levels enhance the adoption of soil testing practices (Buckland *et al*., (2021)). Farmers with high income levels have resources, affordability, and access to relevant information and services hence, promoting the adoption of practices. Similarly, Ngwira *et al.* (2014)

revealed farmer groups/organizations were a significant variable in the adoption of conservation agriculture practices among smallholder farmers. Moreover, Liu *et al.* (2019) reported that training services provided through extension services have a positive and significant association with the adoption of soil testing practices.

The Chi-square values also indicated age ($\chi^2_{3, .966} = 0.952$, gender ($\chi^2_{1, .544} = 1.217$, farming experience ($\chi^2_{3, .560} = 2.059$, land ownership ($\chi^2_{3}, .689 = 1.470$) and market access ($\chi^2_{1, .446} = 0.581$) had no significant ($p>0.05$) association with adoption of soil testing practice. These findings are consistent with those of Huang *et al.* (2018) who revealed that gender and land ownership had no significant association with the adoption of soil testing services.

4.6.0 Role of Farmer groups in the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers.

The study sought to identify the influence of farmer groups in the adoption of sustainable sugarcane farming practices. Regression was used to determine the influence of smallholder farmers' membership in farmer group on the adoption of various sustainable sugarcane farming practices.

Table 4.6.1: Influence of sugarcane smallholder farmers' membership in farmer group(s) on adoption of soil testing practices in Kakamega North sub-county, Kenya.

	B	S.E.	Wald	df	Sig.	Exp(B)
Farmer group(s)	**.730**	**.653**	**1.252**	**1**	**0.263**	**2.076**

The analysis was conducted to assess the influence of farmer groups on the adoption of soil testing practices. The results indicated that membership in a farmer group has a positive association with the likelihood of adoption, as evidenced by a B coefficient of 0.730 However, this effect is not statistically significant, with a Wald value of 1.252, a p-value of 0.263, and an Exp(B) value of 2.076. The p-value being greater than 0.05 suggested that membership in farmer groups does not statistically significantly influence the adoption of soil testing practices among sugarcane smallholder farmers within the study area.

Table 4.6.2: Influence of farmer group on the adoption of Integrated Weed Management practices in Kakamega North sub-county, Kenya.

Weeding practice	B	S.E	Wald	df	p-value	Exp (B) Lower Bound	Exp(B) Upper Bound
Integrated Weed Management	-2.197	1.145	3.682	1	0.05	0.012	1.048

95% confidence level

Table 4.6.2. provided a regression output for influence of farmer group on adoption of Integrated Weed Management, the parameter estimates for sugarcane smallholder farmers not belonging to a farmer group (B = -2.197) indicated that these farmers are less likely to use Integrated Weed Management compared to other weeding practices. This suggested that being a member of a farmer group positively ($p \leq 0.05$) influences the adoption of

integrated weed management, as non-members have significantly lower odds of choosing this method over other weeding practices ($p \leq 0.05$). Similarly, Moss (2019) revealed that farmer groups serve as an effective solution in reducing reluctance towards the adoption of Integrated Weed Management practices. He found farmer groups had a positive significant influence on adoption of Integrated weed management among small-scale farmers.

Table 4.6.3: Influence of farmer group on the adoption of mulching practices by smallholder farmers in Kakamega North sub-county, Kenya.

Variable	B	S.E.	Wald	df	p-value	Exp(B)
Farmer group(s)	0.405	0.525	0.594	1	0.441	1.499

Binary logistic regression analysis was conducted to assess the influence of farmer group on the adoption of mulching practices. The results indicated that membership in farmer group(s) has a positive association with the likelihood of adoption, as evidenced by a B coefficient of 0.405. However, this effect is not statistically significant, with a Wald value of 0.594, a p-value of 0.441, and an Exp(B) value of 1.499. The p-value being greater than 0.05 suggests that membership in farmer groups or organizations does not significantly influence the adoption of mulching practices among sugarcane smallholder farmers. The Exp(B) value of 1.499 indicates that holding other variables constant, the odds of adopting mulching practices increase by approximately 49.9% for those who are members of a farmer group or organization, although this effect is not statistically significant.

Table 4.6.4: Major benefits obtained through membership into farmer group or organization in the adoption of sustainable sugarcane farming practices by smallholder farmers in Kakamega North sub-county, Kenya.

Benefits obtained	Total	Percent (%)
Shared knowledge and skills i.e. learning from each other on improved farming methods	3	15
Collective bargaining power i.e. negotiated with group members when buying fertilizers, seeds, or selling produce	5	25
Access to resources i.e. Money(capital), machinery e.g. tractors, ox-ploughs, tools, and equipment set.	6	30
Social support and networking i.e. encouraged by other farmers to adopt a practice.	6	30
Total	**20**	**100.0**

Source: Field data (2024)

The most significant benefits of group membership were described by sugarcane smallholders farmers, most of whom listed them to be the access to resources (e.g., capital, machinery), which was reported by 30% of the respondents. Equally, thirty percent of the respondents reported being given social support and networking opportunities, which motivated them to make new practices. They were reported to come up with better bargains when they were purchasing their inputs or selling the produce, which was one of the things that the 25% of the participants mentioned as collective bargaining power. In the meantime,

15 per cent of the farmers emphasized the significance of collective knowledge and skills especially in the acquisition of better methods of farming among colleagues. According to Sumane et al. 2018, farmer groups facilitate sharing of knowledge among farmers. Courtois et al. (2019) found that farmers belonging to the identified groups are able to sell their products easier than farmers that do not belong to any group because they are able to find a broader market of their products due to better networking. As Bizikova et al. (2020) suggest, group membership enhances access to farming resources by farmers, which could be the reason that the collaboration, knowledge sharing, and collective bargaining power make farmers more able to access inputs, financial assistance, and technical support. Cofré-Bravo et al. (2019) also found that farmer groups/organizations provide a platform to social network, and thus this can facilitate the sharing of knowledge and experiences to promote adoption of sustainable farming practices.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1. Overview

This chapter presents the conclusions, recommendations, and suggestions for further study obtained from findings of the study.

5.2.0. Conclusions

Implementation of the different sustainable sugarcane farming practices differed significantly depending on the various demographic and socio-economic factors. The most common practice adopted was mulching. Conversely, soil testing and integrated weed management were low in the adoption system though they were critical in improving the soil fertility and crop production. The findings also indicated that the older and more experienced farmers were more inclined to use the soil testing and younger farmers were more inclined to use mulching. Gender was also apparent where women were observed to be slightly higher in adopting mulching and weed management because they are more engaged in activities of maintaining the farm.

It was found that education and extension services were critical, as far as adoption was concerned. There was increased adoption of knowledge intensive practices like soil testing and integrated weed management by farmers who had higher education, and those who had a chance to access extension services. This highlights the role of information and technical advice in influencing choices among farmers. Also, secure land tenure and access to ready markets also proved to be powerful enablers of adoption because farmers who owned or leased their lands as well as those who had certain markets to sell their products were more inclined toward investing in sustainable operations.

Surprisingly, it was found that low-income farmers were more sustainable in their farming methods, which were mainly soil testing and mulching than those with high income. This implies that low-income farmers can resort to the cheaper and less resource-demanding approaches as a response mechanism, whereas richer farmers might have to depend rather on mechanization and traditional inputs. It is interesting to note that integrated harvesting methods were not adopted at all by all the categories of farmers indicating that there were a great deal of knowledge, resource, or technological obstacles.

5.3. Recommendations

i. Empower Agricultural Extension Services: Government and NGOs are supposed to step up the extension initiatives in order to facilitate the adoption of knowledge-intensive methods like soil testing, integrated weed and harvesting.

ii. Participation of Farmer Groups: Farmers are expected to be involved by encouraging them to join or create groups since group membership can be used to promote peer learning and group action in adoption.

iii. Capacity Building among Women and Youth: In this case, women and youth should be specifically focused in terms of training since these two groups are already demonstrating signs of embracing labor-intensive ways of farming such as mulching.

iv. Enhance Market Connections: It is possible to create strong market outlets in the production of sustainably produced sugarcane that would act as an incentive to farmers to utilize strategies that enhance cane production.

5.4 Suggestions for further studies.

The following suggestions for further studies came up during the process of the research within the study area;

i. Qualitative research should be conducted to provide deeper insights into farmers' perceptions, attitudes, and barriers toward specific practices.

ii.. Comparative studies across different counties or regions should be conducted to test the generalizability of these findings.

REFERENCES

Abab, S. A., Senbeta, F., & Negash, T. T. (2023). The effect of land tenure institutional factors on small landholders' sustainable land management investment: Evidence from the highlands of Ethiopia. *Sustainability, 15*(12), 9150. https://doi.org/10.3390/su15129150

Abay, K. A., Berhane, G., Barrett, C. B., & Abate, G. T. (2023). Meta-analysis of the impacts of agricultural technology adoption on productivity, food security, and poverty in Africa. *Heliyon, 9*(8), e04671. https://doi.org/10.1016/j.heliyon.2023.e04671

Abdul-Rahaman, A., & Abdulai, A. (2020). Farmer groups, collective marketing and smallholder farm performance in rural Ghana. *Journal of Agribusiness in Developing and Emerging Economies, 10*(5), 511–527. https://doi.org/10.1108/JADEE-04-2019-0059

Adenuga, A. H., Jack, C., & McCarry, R. (2021). The case for long-term land leasing: A review of the empirical literature. *Land, 10*(3), 238. https://doi.org/10.3390/land10030238

Adesina, A. A., & Zinnah, M. M. (1993). Technology characteristics, farmers' perceptions, and adoption decisions: A Tobit model application in Sierra Leone. *Agricultural Economics, 9*(4), 297–311. https://doi.org/10.1111/j.1574-0862.1993.tb00276.x

Agwu, A. E., Suvedi, M., Chanza, C., Davis, K., Oywaya-Nkurumwa, A., Najjingo Mangheni, M., & Sasidhar, P. V. K. (2023). Agricultural extension and advisory services in nigeria, malawi, south africa, uganda, and kenya. *Partnerships for Innovative Research in Africa (PIRA) Research Report. East Lansing, Michigan, USA: Alliance for African Partnership, Michigan State University*.

Agwu, A. E., Suvedi, M., Chanza, C., Davis, K., Oywaya-Nkurumwa, A., Najjingo Mangheni, M., & Sasidhar, P. V. K. (2023). *Agricultural extension and advisory services in Nigeria, Malawi, South Africa, Uganda, and Kenya.* East Lansing, MI: Alliance for African Partnership, Michigan State University.

Alkhazaleh, R., Mykoniatis, K., & Alahmer, A. (2022). The success of technology transfer in the Industry 4.0 era: A systematic literature review. *Journal of Open Innovation: Technology, Market, and Complexity, 8*(4), 202. https://doi.org/10.3390/joitmc8040202

Ambetsa, F. (2020). *Adoption of best agronomic practices, technical efficiency and profitability of sugarcane production among smallholders in Malava Sub-County of Kakamega County, Kenya* (Doctoral dissertation, University of Embu).

Arlauskienė, A., Jablonskytė-Raščė, D., & Šlepetienė, A. (2020). Effect of legume and legume–festulolium mixture and their mulches on cereal yield and soil quality in organic farming. *Archives of Agronomy and Soil Science, 66*(8), 1058–1073. https://doi.org/10.1080/03650340.2019.1641741

Arslan, A., Floress, K., Lamanna, C., Lipper, L., & Rosenstock, T. S. (2022). A meta-analysis of the adoption of agricultural technology in Sub-Saharan Africa. *PLOS Sustainability and Transformation, 1*(7), e0000018. https://doi.org/10.1371/journal.pstr.0000018

Arunrat, N., et al. (2021). Comparison of GHG emissions and farmers' profit of large-scale and individual farming in rice production across four regions of Thailand. *Journal of Cleaner Production, 278*, 123945. https://doi.org/10.1016/j.jclepro.2020.123945

Ayenew, W., Lakew, T., & Kristos, E. H. (2020). Agricultural technology adoption and its impact on smallholder farmers' welfare in Ethiopia. *African Journal of Agricultural Research, 15*(3), 431–445. https://doi.org/10.5897/AJAR2019.14456

Ayim, C., Kassahun, A., Tekinerdogan, B., & Addison, C. (2020). Adoption of ICT innovations in the agriculture sector in Africa: A systematic literature review. *Agriculture & Food Security, 9*(1), 1–20. https://doi.org/10.1186/s40066-020-00259-3

Balana, B. B., & Oyeyemi, M. A. (2022). Agricultural credit constraints in smallholder farming in developing countries: Evidence from Nigeria. *World Development Sustainability, 1*, 100012. https://doi.org/10.1016/j.wds.2022.100012

Barbier, E. B. (2023). Overcoming digital poverty traps in rural Asia. *Review of Development Economics, 27*(3), 1403–1420. https://doi.org/10.1111/rode.12992

Barrera, V., Norton, G. W., Alwang, J. R., & Mauceri, M. (2005). Adoption of integrated pest management technologies: A case study of potato farmers in Carchi, Ecuador. *Journal of Agricultural and Applied Economics, 37*(2), 403–415. https://doi.org/10.1017/S1074070800022140

Bashiru, M., Ouedraogo, M., Ouedraogo, A., & Läderach, P. (2024). Smart farming technologies for sustainable agriculture: A review of promotion and adoption strategies by smallholders in Sub-Saharan Africa. *Sustainability, 16*(11), 4817. https://doi.org/10.3390/su16114817

Bhatt, R. (2020). Resources management for sustainable sugarcane production. In M. Kumar (Ed.), *Resources use efficiency in agriculture* (pp. 647–693). Springer. https://doi.org/10.1007/978-981-15-6953-1_27

Bizikova, L., Nkonya, E., Minah, M., Hanisch, M., Turaga, R. M. R., Speranza, C. I., ... & Timmers, B. (2020). A scoping review of the contributions of farmers' organizations to smallholder agriculture. *Nature Food, 1*(10), 620–630. https://doi.org/10.1038/s43016-020-00156-8

Buckland, S. F., & Campbell, D. (2021). An assessment of factors influencing awareness, access and use of agro-climate services among farmers in Clarendon, Jamaica. *Geoforum, 126*, 171–191. https://doi.org/10.1016/j.geoforum.2021.07.003

Chau, V. S., & Quire, C. (2020). Back to the future of women in technology: Insights from understanding the shortage of women in innovation sectors for managing corporate

foresight. In R. Rohrbeck, S. Hölzle, & H. G. Gemünden (Eds.), *Corporate foresight and innovation management* (pp. 123–140). Routledge.

Chen, Y. J., & Tang, C. S. (2015). The economic value of market information for farmers in developing economies. *Production and Operations Management, 24*(9), 1441–1452. https://doi.org/10.1111/poms.12365

Cofré-Bravo, G., Klerkx, L., & Engler, A. (2019). Combinations of bonding, bridging, and linking social capital for farm innovation: How farmers configure different support networks. *Journal of Rural Studies, 69*, 53–64. https://doi.org/10.1016/j.jrurstud.2019.04.004

Cole, S. A., & Fernando, A. N. (2021). 'Mobile'izing agricultural advice: Technology adoption, diffusion and sustainability. *The Economic Journal, 131*(633), 192–219. https://doi.org/10.1093/ej/ueaa092

Coleman, M. J., Kristiansen, P., Sindel, B. M., & Fyfe, C. (2024). Imperatives for integrated weed management in vegetable production: Evaluating research and adoption. *Weed Biology and Management, 24*(1), 3–14. https://doi.org/10.1111/wbm.12274

Courtois, P., & Subervie, J. (2015). Farmer bargaining power and market information services. *American Journal of Agricultural Economics, 97*(3), 953–977. https://doi.org/10.1093/ajae/aav012

da Silva, M. J., Neves, L. D. O., Correa, M. H., & de Souza, C. H. (2021). Quality indexes and performance in mechanized harvesting of sugarcane at a burnt cane and green cane. *Sugar Tech, 23*(3), 499–507. https://doi.org/10.1007/s12355-020-00910-9

David, S., & Asamoah, C. (2011). Farmer knowledge as an early indicator of IPM adoption: A case study from cocoa farmer field schools in Ghana. *The Journal of Sustainable Development, 4*(1), 263–276. https://doi.org/10.5539/jsd.v4n1p263

Debela, B. L., Shumeta, Z., & Tadesse, T. (2021). The impact of agricultural extension on farmers' technical efficiency in Ethiopia: A stochastic production frontier approach. *Cogent Food & Agriculture, 7*(1), 1882105. https://doi.org/10.1080/23311932.2021.1882105

Derso, D., Hailu, B. K., & Bogale, A. (2023). Factors affecting the adoption of improved sugarcane production technologies in Ethiopia. *Heliyon, 9*(5), e15825. https://doi.org/10.1016/j.heliyon.2023.e15825

Devaney, L., & Henchion, M. (2018). Who is a Delphi 'expert'? Reflections on a bioeconomy expert selection procedure from Ireland. *Futures, 99*, 45–55. https://doi.org/10.1016/j.futures.2018.03.017

Diiro, G. M., et al. (2018). Women's empowerment in agriculture and agricultural productivity: Evidence from rural maize farmer households in western Kenya. *PLOS ONE, 13*(5), e0197995. https://doi.org/10.1371/journal.pone.0197995

Doss, C., Meinzen-Dick, R., Quisumbing, A., & Theis, S. (2018). Women in agriculture: Four myths. *Global Food Security, 16*, 69–74. https://doi.org/10.1016/j.gfs.2017.10.001

Elliott, J., Kelly, B., Peel, M., & Barnett, J. (2022). Climate-smart agriculture in practice: Evidence from farmer-led adaptation projects in East Africa. *Agriculture and Human Values, 39*(4), 1101–1116. https://doi.org/10.1007/s10460-022-10377-2

Foster, A. D., & Rosenzweig, M. R. (2010). Microeconomics of technology adoption. *Annual Review of Economics, 2*, 395–424. https://doi.org/10.1146/annurev.economics.102308.124433

Gálvez, C., et al. (2021). Crop residue mulching and its impact on soil quality and yield in smallholder farming systems: Evidence from Sub-Saharan Africa. *Soil and Tillage Research, 212*, 105071. https://doi.org/10.1016/j.still.2021.105071

Gebremedhin, B., Jaleta, M., & Hoekstra, D. (2009). Smallholders, institutional services, and commercial transformation in Ethiopia. *Agricultural Economics, 40*(s1), 773–787. https://doi.org/10.1111/j.1574-0862.2009.00414.x

Ghosh, B. N., Dogra, P., Sharma, N. K., & Dadhwal, K. S. (2016). Impact of conservation tillage on soil properties and crop productivity in maize-wheat system. *Soil and Tillage Research, 163*, 213–218. https://doi.org/10.1016/j.still.2016.05.005

Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics' view. *Field Crops Research, 114*(1), 23–34. https://doi.org/10.1016/j.fcr.2009.06.017

Gitau, R., Kimenju, S. C., Kibaara, B. W., & Nyoro, J. K. (2013). Agricultural productivity in Kenya: Trends, determinants, and effects. *Tegemeo Institute of Agricultural Policy and Development Working Paper, 51*.

Greiner, R., Patterson, L., & Miller, O. (2009). Motivations, risk perceptions and adoption of conservation practices by farmers. *Agricultural Systems, 99*(2–3), 86–104. https://doi.org/10.1016/j.agsy.2008.10.003

Hagos, F., Pender, J., & Gebreselassie, N. (1999). Land degradation in the highlands of Tigray and strategies for sustainable land management. *Socioeconomics and Policy Research Working Paper, 25.* International Livestock Research Institute.

Harrison, R. D., et al. (2019). Wildlife damage and crop productivity in smallholder agriculture: A case study from western Kenya. *Crop Protection, 119*, 142–149. https://doi.org/10.1016/j.cropro.2019.01.002

He, X. F., Li, H. W., Wang, Q. J., Qiu, J. J., Zhang, X. P., & Li, L. J. (2009). The adoption of mulching for water conservation in dryland farming in China. *Agricultural Water Management, 96*(5), 1211–1216. https://doi.org/10.1016/j.agwat.2009.03.001

Hermans, F., Geerling-Eiff, F., Potters, J., & Klerkx, L. (2013). Public–private partnerships as systemic agricultural innovation policy instruments—Assessing their contribution to innovation system function dynamics. *NJAS: Wageningen Journal of Life Sciences, 64–65*, 63–70. https://doi.org/10.1016/j.njas.2013.10.001

Hunecke, C., Engler, A., Jara-Rojas, R., & Poortvliet, P. M. (2017). Understanding the role of social capital in adoption decisions: An application to irrigation technology. *Agricultural Systems, 153*, 221–231. https://doi.org/10.1016/j.agsy.2017.02.002

International Sugar Organization. (2022). *World sugar market report 2022*. London: ISO.

Isabirye, J., Rwomushana, I., & Tukahirwa, J. (2020). Adoption of integrated pest management technologies in smallholder agriculture: A case of coffee production in Uganda. *Crop Protection, 132*, 105–125. https://doi.org/10.1016/j.cropro.2020.105125

Jayne, T. S., Chamberlin, J., & Headey, D. D. (2014). Land pressures, the evolution of farming systems, and development strategies in Africa: A synthesis. *Food Policy, 48*, 1–17. https://doi.org/10.1016/j.foodpol.2014.05.014

Jin, H., Jayne, T. S., & Shao, J. (2020). Productivity and welfare impacts of land rental markets in rural China. *China Agricultural Economic Review, 12*(2), 267–285. https://doi.org/10.1108/CAER-06-2018-0135

Kabunga, N. S., Dubois, T., & Qaim, M. (2014). Impact of tissue culture banana technology on farm household income and food security in Kenya. *Food Policy, 45*, 25–34. https://doi.org/10.1016/j.foodpol.2013.12.009

Kansiime, M. K., et al. (2018). Farmer perceptions of pests and pest management practices in smallholder maize production systems in East Africa. *Crop Protection, 112*, 213–221. https://doi.org/10.1016/j.cropro.2018.06.014

Kassie, M., Shiferaw, B., & Muricho, G. (2011). Agricultural technology, crop income, and poverty alleviation in Uganda. *World Development, 39*(10), 1784–1795. https://doi.org/10.1016/j.worlddev.2011.04.023

Kassie, M., Teklewold, H., Jaleta, M., Marenya, P., & Erenstein, O. (2015). Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy, 42*, 400–411. https://doi.org/10.1016/j.landusepol.2014.08.016

Kebede, Y., Gunjal, K., & Coffin, G. (1990). Adoption of new technologies in Ethiopian agriculture: The case of Tegulet-Bulga District, Shoa Province. *Agricultural Economics, 4*(1), 27–43. https://doi.org/10.1111/j.1574-0862.1990.tb00106.x

Kenya Sugar Board. (2020). *Annual report on sugar sector performance*. Nairobi: KSB.

Khaemba, P. F., & Muiruri, P. W. (2022). Potential socio-economic challenges facing small-scale sugarcane production in Bungoma County, Kenya. *Research Journal in Advanced Social Sciences, 3*(2), 50–66.

Khanal, U., Wilson, C., Lee, B. L., & Hoang, V. N. (2018). Farmers' willingness to pay for crop insurance in the face of climate change and variability. *Agricultural Systems, 159*, 25–34. https://doi.org/10.1016/j.agsy.2017.10.007

Kinyili, J. M., et al. (2021). Socio-economic determinants of adoption of improved maize varieties among smallholder farmers in Kenya. *Journal of Agricultural Extension and Rural Development, 13*(3), 159–167. https://doi.org/10.5897/JAERD2020.1221

Kipkorir, L., & Cheruiyot, E. (2021). Impact of mulching on soil conservation and maize yields in Kericho County, Kenya. *East African Agricultural and Forestry Journal, 85*(2), 90–102. https://doi.org/10.1080/00128325.2021.1890167

Kiplimo, K. J., et al. (2020). Factors influencing sugarcane production in western Kenya: Evidence from smallholder farmers. *International Journal of Agricultural Policy and Research, 8*(5), 101–113. https://doi.org/10.15739/IJAPR.20.013

Kisaka, S. T., et al. (2016). Effects of integrated soil fertility management on maize yields in Kakamega, western Kenya. *Nutrient Cycling in Agroecosystems, 105*(3), 275–290. https://doi.org/10.1007/s10705-016-9790-8

Kitur, K. J., & Koech, R. K. (2022). Challenges in smallholder sugarcane farming in Kenya. *African Journal of Agricultural Research, 17*(2), 246–255. https://doi.org/10.5897/AJAR2021.15876

Langyintuo, A. S., & Mekuria, M. (2008). Assessing the influence of neighborhood effects on the adoption of improved agricultural technologies in developing agriculture. *African Journal of Agricultural and Resource Economics, 2*(2), 151–169.

Läpple, D., & Rensburg, T. V. (2011). Adoption of organic farming: Are there differences between early and late adoption? *Ecological Economics, 70*(7), 1406–1414. https://doi.org/10.1016/j.ecolecon.2011.03.002

Liverpool-Tasie, L. S. O., Wineman, A., Young, S., Tambo, J., Vargas, C., Reardon, T., ... & Celestin, A. (2020). A scoping review of market links between value chain actors and small-scale producers in developing regions. *Nature sustainability*, *3*(10), 799-808.

Ma, W., Sonobe, T., & Gong, B. (2024). Linking farmers to markets: Barriers, solutions, and policy options. *Economic Analysis and Policy*, *82*, 1102-1112.

Makokha, S., et al. (2021). Effects of farmer group membership on adoption of sustainable agricultural practices in Kenya. *Environment, Development and Sustainability, 23*(11), 16639–16658. https://doi.org/10.1007/s10668-021-01362-y

Marenya, P., & Barrett, C. B. (2007). Household-level determinants of adoption of improved natural resource management practices among smallholder farmers in western Kenya. *Food Policy, 32*(4), 515–536. https://doi.org/10.1016/j.foodpol.2006.10.002

Matsumoto, T., Yamano, T., & Sserunkuuma, D. (2013). Technology adoption and dissemination in agriculture: Evidence from households in rural Uganda. *World Development, 43*, 85–96. https://doi.org/10.1016/j.worlddev.2012.10.025

Meijer, S. S., Catacutan, D., Sileshi, G. W., & Nieuwenhuis, M. (2015). Tree planting by smallholder farmers in Malawi: Using the theory of planned behaviour to examine the relationship between attitudes and behaviour. *Journal of Environmental Psychology, 43*, 1–12. https://doi.org/10.1016/j.jenvp.2015.05.008

Melesse, B., & Bulte, E. (2015). Does land registration and certification boost farm productivity? Evidence from Ethiopia. *Agricultural Economics, 46*(6), 757–768. https://doi.org/10.1111/agec.12199

Miroro, O. O., Anyona, D. N., Nyamongo, I., Bukachi, S. A., Chemuliti, J., Waweru, K., & Kiganane, L. (2023). Determinants of smallholder farmers' membership in co-operative societies: evidence from rural Kenya. *International Journal of Social Economics*, *50*(2), 165-179.

Morris, M., Kelly, V. A., Kopicki, R. J., & Byerlee, D. (2007). *Fertilizer use in African agriculture: Lessons learned and good practice guidelines.* Washington, DC: World Bank.

Mugwe, J., et al. (2009). Adoption potential of conservation tillage and organic inputs for maize production in central Kenya. *Soil and Tillage Research, 103*(2), 142–150. https://doi.org/10.1016/j.still.2008.10.015

Musara, J. P., Watetepa, K., Bandason, W., Munyati, V. T., Zivenge, E., Musemwa, L., & Mafuse, N. (2021). Constrained crop enterprise choices by smallholder farmers in semi-arid Zimbabwe. *Cogent Social Sciences*, *7*(1), 1984657.

Mwangi, M., & Kariuki, S. (2015). Factors determining adoption of new agricultural technology by smallholder farmers in developing countries. *Journal of Economics and Sustainable Development, 6*(5), 208–216.

Ndiritu, S. W., Kassie, M., & Shiferaw, B. (2014). Are there systematic gender differences in the adoption of sustainable agricultural intensification practices? Evidence from Kenya. *Food Policy, 49*(1), 117–127. https://doi.org/10.1016/j.foodpol.2014.06.010

Ng'ang'a, T., et al. (2022). Determinants of adoption of improved sugarcane varieties in western Kenya. *Journal of Agricultural Extension, 26*(4), 67–80. https://doi.org/10.4314/jae.v26i4.6

Nyaga, J., et al. (2020). Effects of farmer field schools on adoption of climate-smart agricultural practices in Kenya. *Climate and Development, 12*(9), 799–811. https://doi.org/10.1080/17565529.2019.1701973

Odame, H. H., Muange, E., & Ariga, J. (2021). Agricultural extension reforms in Kenya: Lessons from policy and practice. *The Journal of Agricultural Education and Extension, 27*(3), 313–331. https://doi.org/10.1080/1389224X.2020.1809929

Oduol, J., et al. (2006). Adoption of improved maize and soil fertility technologies in western Kenya. *African Journal of Agricultural and Resource Economics, 1*(1), 123–138.

Ogutu, W. (2022). Economic evaluation of market participation and adoption of sustainable agricultural intensification practices among maize-legume smallholder producers in Kenya.

Ojo, T. O., Baiyegunhi, L. J. S., & Salami, A. O. (2020). Determinants of adoption of improved rice varieties among smallholder farmers in Nigeria. *Scientific African, 8*, e00358. https://doi.org/10.1016/j.sciaf.2020.e00358

Okelai, J. A., Isoh, A. V. N., & Angundaru, G. (2020). Determinants of Collective Marketing Action and Profitability of Smallholder Farmers Enterprise in Uganda. *International Journal of Science and Business*, *4*(4), 180-190.

Omamo, S. W. (1998). Farm-to-market transaction costs and specialisation in small-scale agriculture: Explorations with a non-separable household model. *Journal of Development Studies, 35*(2), 152–163. https://doi.org/10.1080/00220389808422562

Omwoyo, A. O., et al. (2021). Adoption of improved sugarcane farming practices in Kakamega County, Kenya. *International Journal of Agricultural Extension, 9*(3), 177–184.

Pannell, D. J., et al. (2006). Understanding and promoting adoption of conservation practices by rural landholders. *Australian Journal of Experimental Agriculture, 46*(11), 1407–1424. https://doi.org/10.1071/EA05037

Pretty, J., Toulmin, C., & Williams, S. (2011). Sustainable intensification in African agriculture. *International Journal of Agricultural Sustainability, 9*(1), 5–24. https://doi.org/10.3763/ijas.2010.0583

Qaim, M., & Kouser, S. (2013). Genetically modified crops and food security. *PLOS ONE, 8*(6), e64879. https://doi.org/10.1371/journal.pone.0064879

Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.

Sahu, S., Bishnoi, S., Sharma, P. R., Satyapriya, Mahra, G. S., Burman, R. R., ... & Sharma, S. (2024). Exploring popular information sources and determinants of farmers' access to agricultural extension services in the Indo-Gangetic plains. *Frontiers in Sustainable Food Systems*, *8*, 1339243.

Suri, T. (2011). Selection and comparative advantage in technology adoption. *Econometrica, 79*(1), 159–209. https://doi.org/10.3982/ECTA7749

Teklewold, H., Kassie, M., & Shiferaw, B. (2013). Adoption of multiple sustainable agricultural practices in rural Ethiopia. *Journal of Agricultural Economics, 64*(3), 597–623. https://doi.org/10.1111/1477-9552.12011

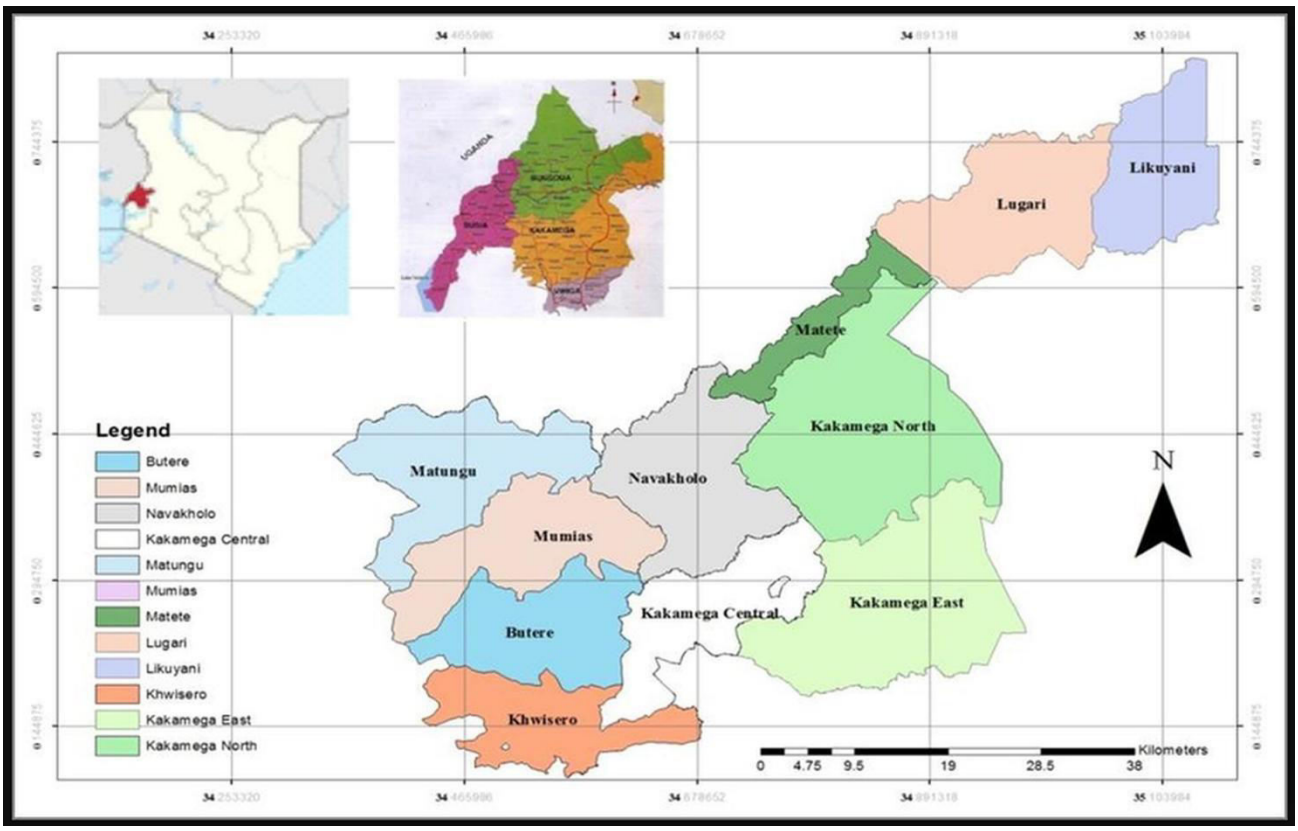
Tittonell, P., et al. (2012). Towards sustainable intensification of smallholder farming systems: Lessons from African case studies. *Current Opinion in Environmental Sustainability, 4*(1), 139–150. https://doi.org/10.1016/j.cosust.2012.01.009

Wainaina, P., Okello, J., & Nzuma, J. (2012). Impact of contract farming on smallholder poultry farmers' income in Kenya. *Agricultural Economics, 43*(5), 495–506. https://doi.org/10.1111/j.1574-0862.2012.00594.x

World Bank. (2019). *Enabling the business of agriculture 2019*. Washington, DC: World Bank.

APPENDICES

APPENDIX 1: MAP OF KAKAMEGA NORTH SUB-COUNTY.



Source: (KNBS, 2009)

APPENDIX 2: NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION RESEARCHER'S LICENSE.

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APPENDIX 3: QUESTIONNAIRE FOR INDIVIDUAL SMALLHOLDER SUGARCANE FARMERS

Title: Survey on socio-economic factors influencing adoption of sustainable sugarcane farming practices among smallholder farmers in Kakamega North sub-county.

Date …… Questionnaire number…….

SECTION A: PERSONAL CHARACTERISTICS

Instructions

Tick the correct responses in the spaces provided in brackets.

1.In which age group do you belong?

MALE			FEMALE		
( )18-35	( ) 36-60	( ) above 60 years	( )18-35	( ) 36-60	( ) above 60 years

2.Which one of the following is the highest level of education you have attained?

MALE				FEMALE			
( ) Tertiary institution	( ) Secondary education	( ) Primary education	( ) Informal education	( ) Tertiary institution	( ) Secondary education n n	( ) Primary education	( ) Informal education

3.How many years have you been involved in sugarcane farming?

MALE				FEMALE			
( )	( ) 5 -10 years	( ) 11-15 years	( ) More than 15 years	( )	( ) 5 -10 years	( ) 11-15 years	( ) More than 15 years

Less than 5 years				Less than 5 years			

4. Which one of the following is the combined monthly income (KSH) of your household members?

(A household can be defined as a group of individuals who live together, share responsibilities, work collaboratively, and prepare and consume meals together).

MALE				FEMALE			
( ) Less than 10000	( ) 10000-50000	( ) 51000-100000	( ) Over 100000	( ) Less than 10000	( ) 10000-50000	( ) 51000-100000	( ) Over 100000

5.Which of the following best describes the type of land on which you cultivate sugarcane?

( ) Family land

( ) Communal land

( ) Hired/leased/rented land

( ) Family land

SECTION B: SUSTAINABLE SUGARCANE FARMING PRACTICES

(Tick the correct response in the spaces provided)

In this section, you will be asked questions about sustainable sugarcane farming practices you may have currently adopted on your farm.

6 a. Do you conduct regular soil testing on your sugarcane farm?

( ) YES ( ) NO

b. If NO, what is the major reason for not conducting soil testing?

7. Which method do you use when harvesting sugarcane?

( ) Manual (use of human beings) ( ) Mechanical method (use of machines) (Intergrated harvesting method)

8). Which one of the following methods do you use to weed your growing sugarcane on the farm?

( ) Hand weeding

( ) Use of machines e.g. tractors and ox plough

( ) Chemical (Herbicide) application

( ) Cultural practices (Crop rotation, intercropping, cover cropping, mulching)

( ) Integrated Weed Management

9. Do you practice mulching on your sugarcane farm?

( ) YES ( ) NO

10. Have you ever been or are you currently a member of any Farmer Group/Organization related to sugarcane farming?

( ) YES ( ) NO

11. If yes, which one of the following is the major benefit you gained from working with other farmers in improving how you grow sugarcane?

( ) Shared knowledge and skills. i.e. learning from each other on improved farming methods

( ) Collective bargaining power. i.e. negotiated with group members when buying fertilizers, seeds, or selling produce.

( ) Access to resources i.e. money(capital), machines e.g. ox-ploughs, tools and equipment, tractors

( ) Social support and networking i.e. encouraged by other farmers to adopt a practice..

12. Have you ever obtained any benefit from agricultural officers/agents in the adoption of sustainable sugarcane farming practices?

( ) YES ( ) NO

13. Do you have regular market access where you can sell your harvested produce or purchase farming inputs?

( ) YES ( ) NO