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# ASSESSMENT OF SUSTAINABLE SUGARCANE FARMING PRACTICE ADOPTION AMONG SMALLHOLDER FARMERS IN KAKAMEGA NORTH SUB-COUNTY, KENYA.

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**ABSTRACT:** *This study aimed to assess the current adoption status of Sustainable Sugarcane Farming Practices (SSFPs) among smallholder farmers in Kakamega North Sub-County, Kenya. A cross-sectional survey of 394 farmers assessed the use of each practice. Descriptive and chi-square tests quantified differences between adopters and non-adopters. Organic mulching enjoyed widespread adoption (84 %), driven by ready access to cane residue ($\chi^2 = 179.58$, $df = 1$, $p < 0.05$). In contrast, only 7 % of farmers conducted soil tests ($\chi^2 = 289.96$, $df = 1$, $p < 0.05$), and a mere 3 % practiced Integrated Weed Management (IWM), despite its proven yield benefits. Coordinated extension strategies are needed to enhance the adoption of these practices: deploy mobile soil-testing units to inform mulch and fertilizer recommendations and strengthen farmer field schools on IWM. Such integrated interventions break the cycle of limited resources and low practice uptake, ultimately improving sugarcane production.*

**KEYWORDS**: Sustainable sugarcane farming; Adoption of agricultural practice; Smallholder farmers.

## INTRODUCTION

Sugarcane (Saccharum officinarum L.) is a major tropical and sub-tropical crop grown for its sugar-rich stalk and as a feedstock for ethanol, molasses, and bioenergy from bagasse. Globally, it supplies about 86% of total sugar (Voora et al., 2023). Brazil, India, China, Pakistan, and Thailand together produce over 70% of the world's cane (de Matos et al., 2020), yet their uptake of sustainable sugarcane-farming practices varies dramatically. Brazil has achieved over 90% adoption of green harvest (non-burning) and trash-blanket mulching, supported by precision-fertilization and routine soil-testing protocols. In contrast, India's no-till and mulching systems cover under 20% of its cane area, and organic amendments are used by only 10–15% of farmers (Somasundaram et al., 2020). In China, Conservation Agriculture (CA) (no-till plus straw mulching) remains below 5% adoption despite the erodibility benefits of up to 64% reductions in soil loss (Qin et al., 2024). Pakistan and neighboring countries average about 15% uptake of CA practices, constrained by water-management challenges (Janjua et al., 2021). Thailand's smallholder sector has reached ~70% mechanization for planting and residue handling, but soil testing and integrated weed management lag at under 25% (Cramb & Thepent, 2020). Across Africa, CA adoption—including no-till, mulching, and crop diversification—remains below 10% in major producing countries such as South Africa, Zambia, Zimbabwe, and Kenya (Ngoma et al., 2021).

Against this backdrop, Kenya's sugar industry contributes about 16% to national GDP (Tiema et al., 2024) but suffers declining yields, mill closures, and rising imports. Kakamega County—with circa 65,000 smallholder cane farmers in North Sub-County—experienced factory shutdowns from August to December 2023 due to low cane supply. A major driver is limited SSFP uptake—particularly soil testing, IWM, mulching, and integrated harvesting methods—compounded by continuous ratooning (up to seven ratoon cycles) without rotation. This study therefore, assesses the current status of SSFP adoption and its socio-economic determinants among smallholders in Kakamega North Sub-County, to inform targeted interventions that can close these practice gaps and revitalize Kenya's sugarcane sector.

## LITERATURE REVIEW

### Overview on Sustainable Sugarcane Farming Practice Adoption

Mulching, Soil testing, Integrated Weed Management, and Integrated Harvesting Methods practices enhance sustainable sugarcane production. The literature not only highlights the varying rates of practice adoption but also the resource, knowledge, and infrastructural factors that shape uptake, thereby guiding policy and extension programming for smallholders in Kakamega North Sub-County.

Mulching conserves soil moisture, suppresses weeds, and protects against erosion. A recent review found that surface mulches reduce evaporation and improve soil water retention across agroecological systems (Ramos et al., 2024), and field trials in tropical crops reported significant increases in yield and stalk quality under organic mulch treatments (Kumar et al., 2023; Turyasingura et al., 2024). Integrated Weed Management (IWM), combines cultural, mechanical, and chemical methods to tackle early-season weed pressure more effectively than single tactics; coordinated approaches can cut weed seedbanks by over 50% compared to


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herbicide-only regimes (Misra et al., 2022; Scavo et al., 2020). Soil testing guides precise fertilizer decisions: consistent testing programs are a best management practice that improve economic fertilization choices, though samples are often taken only at planting and not for ratoon crops (Sadeghibaniani et al., 2025). Finally, integrated harvesting methods, application of optimized manual cutting, and mechanization influence sucrose retention and field losses: delays between cutting and milling can cause 5–7% daily declines in sugar content (Vajantha et al., 2019), while mechanized cutters preserve uniform stubble height and reduce bud damage (Urgesa et al., 2021).

All the practices discussed offer a roadmap for enhancing productivity, resilience, and long-term soil health in smallholder sugarcane systems, provided that financial, institutional, and informational barriers to adoption are addressed.

**Challenges to Sustainable Sugarcane Farming Practices Adoption**

Despite the clear agronomic and environmental benefits of mulching, soil testing, integrated weed management, and integrated harvesting methods, smallholder farmers face a constellation of barriers that inhibit widespread uptake. The high labour and material costs associated with mulching, along with competing uses for crop residues, make it difficult for farmers to commit to regular application (Agidi et al., 2025). Similarly, the direct and indirect costs of soil testing—laboratory fees, transport of samples, and interpretation of results—combined with limited local facilities and technical support, leave many growers unable or unwilling to test their fields (Fan et al., 2022). In the case of integrated weed management, the need to coordinate mechanical, cultural, and chemical controls, procure appropriate equipment, and rely on precise timing and labour forces farmers to default to simpler, familiar methods such as hand-weeding or single-application herbicides (Nath et al., 2024). Meanwhile, the capital outlays, financing hurdles, technical skills, and infrastructure deficiencies required for mechanized harvesting mean that manual cutting remains the norm, despite its inefficiencies and the potential for greater yield preservation under mechanization (Fofanah, 2020)

Addressing these multifaceted constraints will require a concerted and holistic approach. Subsidized or group-procured inputs and services could lower financial barriers to mulching and mechanization (Hazell & Varangis, 2020), while mobile or community-based soil testing facilities could improve access and reduce turnaround times for nutrient analyses. Strengthening extension services through on-farm demonstrations, farmer-to-farmer learning networks, and targeted training programs would bridge critical knowledge gaps around best practices for weed management and harvest timing (Prajapati et al., 2025). Finally, public-private partnerships to upgrade rural infrastructure—particularly roads and transport links—would enhance the feasibility of mechanized operations and ensure that harvested cane reaches factories promptly.

By tackling economic, informational, and institutional barriers in tandem, policymakers and development agencies can help smallholder farmers move beyond isolated "obvious" techniques to an integrated management.

In view of the foregoing, the objectives of this study were to: (1) assess the current adoption status of the SSFPs among smallholder sugarcane farmers in Kakamega North Sub-County; (2) determine the relationship between socioeconomic factors and the adoption of sustainable


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sugarcane farming practices among the smallholder farmers and (3) investigate the role of farmer groups in the adoption of SSFPs among smallholder farmers within the study location.

**Theoretical framework**

This study was guided by the Diffusion of Innovation Theory, developed by Everett Rogers in 1962. The theory provided a useful lens for understanding how new ideas and technologies are communicated and adopted within a social system over time. In the context of this research, the innovation referred to sustainable sugarcane farming practices, and the focus is on how these practices are adopted—or not adopted—by smallholder sugarcane farmers in Kakamega North Sub-County.

The theory posits that the adoption of innovations is influenced by several interrelated factors. First, the nature of the innovation itself plays a crucial role. Sustainable farming practices may be perceived differently by farmers depending on their perceived benefits, complexity, compatibility with existing practices, trialability, and observability.

Communication also plays a central role in the diffusion process. Information about sustainable sugarcane farming practices is transmitted through various channels, including extension officers, farmer groups, peers, media, and training sessions. The way in which this information is received and interpreted by farmers greatly influences their willingness to adopt the practices.

Time is another important element in the diffusion process. Adoption does not occur simultaneously among all members of a social system. Instead, individuals move through a series of stages: from gaining knowledge about the innovation, to forming an attitude toward it, making the decision to adopt or reject it, implementing it, and finally confirming the decision. Farmers adopt innovations at different times and rates, depending on their access to information, risk tolerance, and other socio-economic characteristics.

The social system within which farmers operate also has a significant influence. Norms, peer influence, group membership, and institutional support can all affect adoption behavior. For example, farmers who belong to well-organized farmer groups or cooperatives may be more likely to adopt new practices due to peer learning and collective decision-making. Similarly, farmers with strong linkages to extension services or support organizations may have greater exposure to innovations and technical knowledge.

Furthermore, the theory categorizes adopters into five groups based on the timing of their adoption: innovators, early adopters, early majority, late majority, and laggards. Understanding where farmers fall within this continuum can help explain variations in adoption behavior and guide targeted interventions.

Applying the Diffusion of Innovation Theory to this study helped to explain how different factors influence the adoption of sustainable sugarcane farming practices. It provided a structured way to assess how farmers learn about these practices, the challenges they face in adopting them, and the role of social and institutional networks in the diffusion process.

This theoretical framework provided a comprehensive lens to explore the intricate dynamics influencing the adoption of sustainable sugarcane farming practices among sugarcane smallholder farmers in Kakamega North Sub-County.


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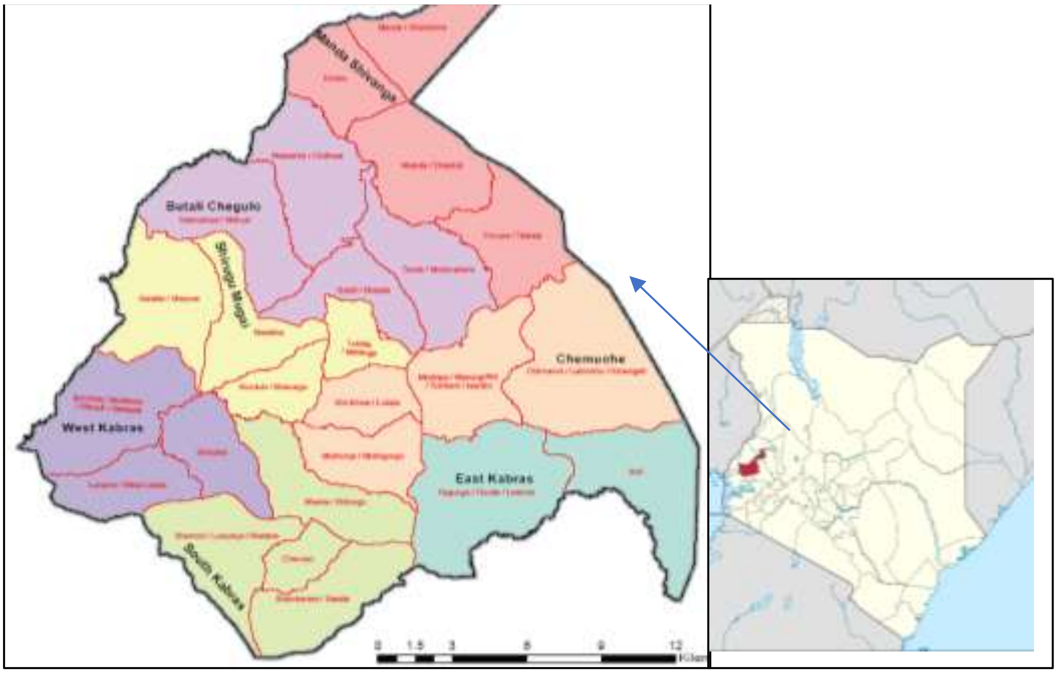
## METHODOLOGY

### Profiling the Study Location

The study area was Kakamega North sub-county, which is among the twelve sub-counties that make up Kakamega County. The sub-county covers a total area of 423.3 square kilometers. It comprises a population of 238,093 individuals, with around 51,083 households (Ambetsa, 2020). The area is characterized by its varying topography, ranging from lush plains to gentle hills. The climate is defined by an average temperature of 20.5 $^{o}$C and annual rainfall between the ranges of 1250-1750 milliliters. The study area typically has long rainy seasons between March and July and a short rainy season between September and December. A brief, dry period is experienced between January and February. However, in recent years, the predictability of rainfall patterns has been disrupted, attributed to various factors such as global warming and other environmental influences. With a latitude of 0$^{o}$ 26' 42.15" N and a longitude of 34$^{o}$ 51' 14.90" E, the study area is situated within the tropical climate zone. The fertile soils and favorable weather conditions support the growth of various crops, including maize, groundnuts, cassava, sorghum, beans, and sweet potatoes. However, sugarcane stands as the primary crop, contributing significantly to the local economy. Data was collected from seven administrative wards, namely Manda-Shivanga, Butali-Chegulo, Shirugu-Mugai, Chemuche, East Kabras, South Kabras, and West Kabras, as shown in Figure 1.

**Figure 1: Map of Kakamega North Sub-County**




**Source:** *(KNBS, 2009)*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**Positivist Paradigm and Quantitative Research Designs**

The study employed a positivist paradigm, which recognizes quantitative approaches in research. A cross-sectional survey was used to allow for the collection of data from a diverse range of sugarcane smallholder farmers at a specific point in time, providing a comprehensive understanding of the current adoption status of sustainable sugarcane farming practices within the study area (Wang et al., 2020). The target population was the sugarcane smallholder farmers within each of the seven wards in the sub-county. These wards have greater economic significance within the sub-county concerning sugarcane production. A probability sampling technique was used as it ensured every member of the population had an equal chance of being selected and participating in the study. Each of the seven wards in the sub-county formed a stratum. Proportionate sampling was used to obtain the sample size for each stratified ward. This helped to ensure that each stratified ward was proportionally represented based on its population size. Within each stratified ward, a simple random sampling technique was used to select the respondents. Primary data was collected using a structured questionnaire administered at the household level to the sugarcane smallholder farmers in Kakamega North sub-county. Structured questionnaires enabled the collection of data from a larger sample size within a short period. Structured items ensured that collected data were relevant to the research objectives by avoiding unnecessary responsesData analysis involved descriptive and inferential analysis. Frequencies and percentages showing the distribution of sugarcane smallholder farmers based on the adoption of various sustainable sugarcane farming practices were calculated. Inferential statistics majorly involved conducting a chi-square test of independence on the research variables to determine statistically significant differences between adopters and non-adopters of various SSFPs among smallholder farmers in the study area.

## RESULTS/FINDINGS

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

**Table 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%) |


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| | | | | |
|---|---|---|---|---|
| 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. Source: (Field study, 2024)*

Table 4.1 showed that the adoption of sustainable practices varied significantly among the smallholder farmers. For instance, farmers aged 18–35 years, only 9.5% (11 out of 116) practiced soil testing, and 5.3% adopted integrated weed management. However, a relatively higher 75.9% adopted mulching. In contrast, those aged 36–60 years had a high adoption of soil testing (93.9%) and mulching (85.6%) but low adoption of integrated weed management (1.8%). Farmers above 60 years reported the highest soil testing adoption (99.3%), but only 6.3% adopted the mulching practice. Notably, integrated harvesting methods were not adopted by any age group. In terms of gender, out of the total male respondents, 7.2% adopted soil testing, 1.6% adopted integrated weed management, and 78.3% practiced mulching. Among female respondents, 7.0% adopted soil testing, 4.3% adopted integrated weed management, and 88.3% adopted mulching. Furthermore, education played a role in shaping adoption patterns. Farmers with higher education had soil testing adoption of 13.1%, integrated weed management at 6.7%, and mulching at 81.9%. Those with secondary education had adoption of 7.1%, 5.3%, and 80.6% respectively. Farmers with primary education had soil testing adoption of 3.9%, no adoption of integrated weed management, but 87.3% practiced mulching. Farmers with less than 5 years of experience had soil testing adoption of 6.2%, integrated weed management at 5.3%, and mulching at 75.2%. Those with 5–10 years recorded 7.2%, 2.8%, and 87.9% respectively. Farmers with more than 15 years of experience showed slightly higher adoption of soil testing (7.5%) and mulching (87.7%). Farmers earning less than KES 10,000


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per month showed soil testing adoption of 6.7%, integrated weed management at 5.3%, and mulching at 75.2%. Those earning KES 10,000–50,000 recorded 8.4% soil testing, 0% integrated weed management, and 85.3% mulching. Interestingly, higher-income farmers (KES 100,000 and above) showed 0% soil testing adoption, 0% integrated weed management, and 87.7% mulching. 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. Farmers belonging to groups showed higher adoption proportions: 13% soil testing, 8.7% integrated weed management, and 73.9% mulching. Non-members had lower percentages (6.7%, 2.7%, and 81.6% respectively). Extension access strongly influenced adoption. Farmers with access to extension services had 6.1% adoption of soil testing, 3.5% integrated weed management, and 82.1% mulching. Those who had no access to extension recorded much lower adoption (2.6%, 1.2%, and 90.2% respectively). Farmers with market access reported soil testing adoption of 7.9%, integrated weed management at 5.3%, and mulching at 89.2%. Those without access recorded 6.7%, 2.0%, and 80.8% respectively.

**Table 4.2. Significant Differences Between Adopters and Non-Adopters of SSFPs Among Sugarcane Smallholder Farmers in Kakamega North Sub-County, Kenya.**

| | **Chi-Square ($\chi^2$)** | **df** | **p-value** |
|---|---|---|---|
| **Soil Testing Practice** | 289.959 | 1 | 0.001 |
| **Weeding practices** | 822.294 | 4 | 0.001 |
| **Mulching Practices** | 179.584 | 1 | 0.001 |

In Table 4.2, the chi-square tests revealed a highly significant difference ($p<0.05$) in the adoption of soil testing, weeding, and mulching practices among smallholder sugarcane farmers in Kakamega North Sub-County, Kenya.

## DISCUSSIONS

The results indicated that farmers above 60 years reported the highest soil testing adoption (99.3%). O'Connell et al. (2022) suggested that older farmers, possibly due to greater experience and accumulated knowledge, appreciate the value of soil testing. However, younger farmers, being more labor-flexible, are more likely to adopt mulching. This supports Rogers' Diffusion of Innovation Theory, which posits that adoption decisions are influenced by perceived benefits and compatibility with farmers' needs. The slightly higher adoption of mulching and weed management among women could be attributed to their closer involvement in farm maintenance tasks (Musafili et al. 2023). Similar gendered patterns have been reported in sustainable agriculture, where women adopt low-cost, labor-intensive techniques more readily (Doss, 2018).

Farmers with primary education had soil testing adoption of 3.9%, no adoption of integrated weed management, but 87.3% practiced mulching. These results showed that technical practices like soil testing are more common among better-educated farmers, while mulching is widely accepted across all education levels. This aligns with previous studies, which found that education enhances awareness and uptake of knowledge-intensive practices (Mazorodze et al.


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2020). The findings revealed that farming experience enhanced the adoption of technical practices such as soil testing. Experienced farmers are likely to appreciate long-term benefits, consistent with findings by Piñeiro et al. (2020) that experience is positively linked to sustainable practice uptake. Interestingly, higher-income farmers (KES 100,000 and above) showed 0% soil testing adoption, 0% integrated weed management, and 87.7% mulching. This contradicts expectations that wealthier farmers would adopt more practices due to resources. Instead, low-income farmers adopt cost-effective practices like mulching, perhaps as a survival strategy. This finding resonates with Sui et al. (2023), who noted that adoption decisions depend on both resource endowments and risk perceptions. 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. Adoption of SSFPs by Farmer Group Members suggests that farmer groups enhance knowledge sharing and peer learning, promoting adoption. Group membership has been found to significantly influence technology diffusion in rural settings (Cole et al., 2021). Farmers with market access reported soil testing adoption of 7.9%, integrated weed management at 5.3%, and mulching at 89.2%. Those without access recorded 6.7%, 2.0%, and 80.8% respectively. This implies that market incentives encourage adoption of practices that improve sugarcane production. Similar findings were reported by Mulwa et al. (2021), who showed that access to output markets fosters adoption of sustainable intensification practices. Extension access strongly influenced adoption. Farmers with extension services had 6.1% adoption of soil testing, 3.5% integrated weed management, and 82.1% mulching. Those without extension recorded much lower adoption (2.6%, 1.2%, and 90.2% respectively). This underscores the critical role of extension in promoting sustainable practices, consistent with findings by Masambuka-Kanchewa et al. (2020), who argued that effective extension services enhance the diffusion of agricultural innovations. Despite widespread mulching, persistent constraints, such as inadequate soil fertility, weed pressure, disease, and pest incidence, may still limit overall cane productivity in the region (Tabriz et al., 2021). Addressing these gaps alongside mulching could further enhance smallholder yields and system resilience.

Results in Table 4.2 suggested that the disparity in soil testing uptake is unlikely to be due to chance and may be driven by underlying factors such as access to services, farmer awareness, or perceived benefits. Given this pronounced difference, extension programs and policy interventions should prioritize promoting soil testing to enhance soil fertility management and crop productivity in the region. Similarly, in terms of weed control measures, the chi-square test result ($\chi^2 = 822.294$, df = 4, $p < 0.05$) indicated a statistically significant difference in their adoption. These findings suggested that weed control practices are not uniformly adopted across the population, reflecting variability in access, knowledge, or preferences. This also highlighted the need for targeted extension services and capacity-building efforts to promote the adoption of IWM strategies among smallholder sugarcane farmers in the region. Moreover, the chi-square test ($\chi^2_1 = 179.584$, $p < 0.05$) demonstrated a highly significant difference in mulching practice adoption between adopters and non-adopters among sugarcane smallholder farmers. These results underscore that factors such as material availability, labor requirements, and perceived benefits are likely driving adoption decisions. To promote broader uptake of mulching—and thereby realize its benefits for moisture conservation, weed suppression, and soil health—it is essential to investigate these influencing factors through targeted surveys and focus-group discussions. Such insights can guide extension messages and policy incentives to address barriers and reinforce the advantages of mulching in smallholder sugarcane systems.


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## IMPLICATIONS TO RESEARCH AND PRACTICE.

The findings of this study have the following implications for research practice: (i) strengthening agricultural extension services: Government and Non-Governmental Organizations should intensify extension programs to promote knowledge-intensive practices such as soil testing, integrated weed and harvesting methods. (ii) promote farmer group participation: Farmers should be encouraged to join or form groups, as group membership enhances peer learning and collective action in adoption (iii) capacity building for women and youth: Training programs should specifically target women and youth, who are already showing potential in adopting labor-intensive practices like mulching and (iv)strengthen market linkages: Establishing reliable market outlets for sustainably produced sugarcane can provide incentives for farmers to adopt practices that improve cane production.

## CONCLUSION

In conclusion, our assessment of sugarcane smallholder practices in Kakamega North reveals a highly uneven adoption landscape that undermines both productivity and resilience. Mulching enjoys near-universal uptake because cane residue is free and easily handled, yet its benefits are blunted by the almost complete absence of systematic soil testing, which would otherwise guide optimal mulch rates and nutrient management. Likewise, Integrated Weed Management remains marginal, as farmers default to hand weeding in the absence of training or affordable implements, limiting their ability to suppress weeds effectively and sustainably. These gaps are not isolated; rather, they interlock, producing a cycle in which limited income prevents investment in soil tests, which in turn prevents evidence-based improvements to mulching, weeding, and harvesting. Breaking this cycle will require holistic extension services that introduce mobile soil-testing units, showcase the yield and income gains from integrated weed control. Only by weaving together support for each SSFP can we achieve the coordinated uptake necessary to lift both yields and livelihoods in this region.

## FUTURE REFERENCES

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 adoption, and (ii) comparative studies across different counties or regions should be conducted to test the generalizability of these findings.


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