

Effect of Traditional Farming Practices on Sustainable Land Management Practices in Gicumbi District

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Abstract: The study investigates the influence of traditional farming practices on sustainable land management in Gicumbi District, focusing on their role in soil fertility, crop yield, and alignment with sustainable techniques. Using a structured questionnaire administered to 400 farmers and analyzed through descriptive statistics and correlation analysis, the research identifies crop rotation (78.6%), intercropping (72.3%), organic composting (65.8%), and animal manure use (81.2%) as the most common practices. However, slash-and-burn remains in use by 28.7% of farmers, causing soil degradation.

In terms of sustainable land management, minimum tillage (66.9%), agroforestry (58.2%), and water conservation (74.5%) are widely applied, contributing positively to soil fertility and erosion control. Notably, 74.1% of respondents reported increased crop yields, and 62.8% observed improved soil fertility due to these techniques. Correlation analysis indicates strong positive links between land preparation and sustainable management ($r = 0.721$), crop diversity and soil conservation ($r = 0.693$), and soil fertility management and erosion reduction ($r = 0.764$), all significant at $p < 0.05$.

The findings demonstrate that combining traditional practices with modern conservation strategies enhances agricultural sustainability and resilience. While traditional methods play a vital role, their effectiveness depends on careful management and integration with contemporary soil conservation approaches. The study recommends targeted farmer training, promotion of agroforestry and organic fertilization, and discouragement of degrading methods like slash-and-burn. It further suggests that future research explore the long-term economic gains of integrating traditional and modern farming systems to strengthen sustainability in rural communities.

Keywords: Traditional Farming Practices, Land Management Practices, Gicumbi District, Rwanda.

I. INTRODUCTION

Conservation Agriculture (CA) is a globally accepted sustainable land management practice, integrating minimum soil disturbance, permanent soil cover, and crop diversification to enhance soil health and resilience (Y. Murindangabo et al., 2021). CA, in Sub-Saharan Africa, has enabled combating land degradation and improving soil fertility despite continued challenges associated with labor needs as well as competition for crop residues (Thierfelder et al., 2014). In Brazil conservation agriculture, especially no-tillage and crop-livestock-forest systems, has minimized soil erosion and carbon sequestration. A total of 44.4 million hectares and 2.3 billion US dollars have been covered by these practices since 2017 (Polidoro et al., 2020). NT is linked with soybean farming, rising soil water and crop diversity (Fuentes-Llanillo et al., 2021). CA in Brazil builds up soil organic matter, which stores carbon and minimizes CO₂ emissions (Sa et al., 2020).

PRONASOLOS has the objective of expanding CA practices to 60 million hectares by 2025, and 34.4 and 25.4 Mha for NT and iCLF systems by 2030 (Polidoro et al., 2021). This aligns with Brazil's emphasis on sustainable agriculture and soil conservation. China's conservation agriculture (CA) has the potential to increase yields and environmental benefits, showing better crop yield and soil carbon than traditional tillage (Hongwen Li et al., 2016). The protection of traditional landscapes of the kind that exist as Important Agricultural Heritage Systems (IAHS) can be achieved through industrial integration development (IID), which raises prices for products, pluralizes agricultural revenue, and extends the local industrial chain. Developing fair benefit coordination among stakeholders is imperative for effective IAHS conservation (Yongxun Zhang & Xian-de Li, 2022). The United States "Three Sisters" intercropping method of corn, beans, and squash increases soil fertility and diversity and decreases the application of chemicals (Kapayou et al., 2022). It is more nutritious than monoculture corn and weeding and pest control is minimized, with less need for fertilizers and pesticides (Terry et al., 2020). The integration of Indigenous Agricultural Knowledge (IAK) into USDA conservation programs can help in the conservation of ecosystems and Indigenous cultures (Johnson et al., 2021). Nevertheless, there are challenges for Indigenous farmers in the U.S. The Three Sisters system is of profound cultural significance to Indigenous communities across diverse food preparation methods developed over millennia (Ngapo et al., 2021).

In addition, climate-smart agriculture, like smart groundnut varieties and intercropping, enhances productivity and food security in Nigeria (Tabe-Ojong et al., 2023). Conservation Agriculture (CA) in Kenya is a viable alternative to traditional farming, which improves soil health and crop yields (Kihara et al., 2020). CA has decreased soil erosion, increased water infiltration, and improved soil biodiversity (Waswa & Mulyungi, 2022; Kihara et al., 2020; Hermans et al., 2021). Combining indigenous knowledge and scientific methods permitted the assessment of CA's contribution to soil health and farm decision-making processes (Hermans et al., 2021). CA improves soil structure, water holding capacity, and productivity but perception and traditional practice like constructing ridges determine adoption (Hermans et al., 2021). Conservation agriculture methods, like no-till, are used alongside traditional methods. No-till agriculture improves soil properties by incorporating more organic matter, water holding capacity, and structure (El Mekkaoui et al., 2021). Deficit irrigation practices also attempt to achieve maximum water use efficiency and crop production in dry areas. A Morocco case study showed that deficit irrigation saved 20% of water consumption and raised water productivity by 33%, with no impact on fruit yield and quality (Laita et al., 2024).

Additionally, CA practices positively impact the environment through reduced soil erosion, enhanced fertility, and mitigation of climate change impacts (Muhigirwa Uwase & Mupenzi, 2024). In Gicumbi district, CA adoption has had advantages on soil and productivity, albeit with constraints like scarcity of resources (Murindangabo et al., 2021). Conservation agriculture adoption in developing countries like Rwanda, particularly in its changing climate and hilly topography like Gicumbi district, is not well documented. In Northern Rwanda, in particular Gicumbi, farmers use IKS practices like crop rotation and intercropping to conserve water and soil (Bapfakurera & Nduwamungu, 2020). These methods combined with CA principles have the potential to offer long-lasting solutions to the problems of agriculture in Rwanda. The main objective of this study was to examine how the integration of traditional forms of farming with conservation agriculture has the potential to foster sustainable land management, raise agricultural productivity, and support farmers' economic resilience in Gicumbi District, Rwanda.

II. RESEARCH METHODS

Description of the study area

This study was conducted in Gicumbi District, Rwanda's Northern Province, which spans 829 km² with 21 sectors and a population of 448,824 (2022 Census). The district's rugged terrain and reliance on agriculture make it highly vulnerable to soil erosion, climate variability, and declining farm productivity. Research focused on nine agriculturally dependent sectors—Byumba, Kaniga, Rubaya, Cyumba, Mukarange, Rushaki, Shangasha, Manyagi, and Bwisige—selected for their food security importance, exposure to land degradation, and limited adoption of sustainable practices. Traditional methods such as manual tillage, mixed cropping, and organic fertilization remain dominant but insufficient to address soil degradation, water loss, and fertility decline. Consequently, smallholder farmers face low productivity, poverty, and food insecurity. The study examines how integrating indigenous practices with sustainable land management (SLM) techniques—particularly agroforestry, crop rotation, and water management—can enhance soil conservation, resilience, and agricultural productivity. Ultimately, it seeks to generate evidence-based recommendations for policymakers, farmers, and stakeholders to strengthen food security and promote sustainable land use in Gicumbi District.

Research Design

The present study uses descriptive research, with mixed-methods approach which combines qualitative and quantitative methods of data collection to comprehensively analyze the convergence of conventional farm practices with Conservation Agriculture (CA) in Rwanda's Gicumbi District.

Study Population

The study population was specifically focused on nine assigned sectors in the Gicumbi District: Rubaya, Cyumba, Kaniga, Mukarange, Rushaki, Shangasha, Manyagiro, Byumba, and Bwisige, which collectively cover a population of 225515 households and 50 Agriculture officers and local leaders, amounting to 225565 total population. (Citypopulation.de, 2022).

Sample size

Slovin's formula was used in determining the suitable sample size for the study. The Slovin formula is a common statistical tool to determine the sample size when the size of the population is known, which is 225515 households, with a reasonable level of accuracy. The formula is as follows:

n = sample size?

N = population (225515)

e = margin error (0.05)

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

$$n = \frac{225515}{1 + 225515 (0.05)^2}$$

$$n = \frac{225515}{564.7875}$$

$n = 399.29$

$n = 400$

The formula reveals that N is the target population, which in this case, is 225515 households; n is the sample size and is 400 households represented by quantitative respondent, while e is the margin error at 95% of the confidence interval. Therefore, this implies that this study will include 400 quantitative respondents of households selected by means of stratified sampling and 50 agriculture officers and local leaders selected through purposive.

Sampling techniques

The stratified random sampling technique was used in this study to ensure that different groups are proportionally represented within the sampled population. This study was applied stratified random sampling to 400 households because, amongst other reasons, the population can be divided into subgroups, known as strata, relatively homogeneous based on sectors: Rubaya, Cyumba, Kaniga, Mukarange, Rushaki, Shangasha, Manyagiro, Byumba and Bwisige.

Data Collection Instruments

The tools of data collection in this study were achieved through an integrated approach using structured questionnaires, interviews, and focus group discussions.

Data Analysis

Data analysis in this study was adopted a mixed-method approach to comprehensively address the research objectives. Quantitative data from structured questionnaires were analyzed using descriptive statistics-frequencies, percentages, and means-and inferential statistics such as correlation and regression analysis to identify relationships between variables including traditional farming practices, CA adoption, and agricultural productivity. Quantitative data from the survey was entered and analyzed using SPSS to ensure accuracy, reliability, and validity of the data. Qualitative data from KIIs and FGDs will be thematically analyzed by transcribing and coding responses to identify patterns, themes, and narratives on farmers' experiences, perceptions, and challenges in integrating CA with traditional practices.

III. RESEARCH FINDINGS

1. Demographic information

Table 1: Distribution of respondents by gender

Respondents by gender	Frequency	Percentage
Male	145	36.3
Female	255	63.7
Total	400	100.0

Source: Primary, 2025

Table 1 presents the distribution of respondents by gender based on a total sample size of 400 individuals. Out of the 400 respondents, 145 (36.3%) were male, while 255 (63.7%) were female. The higher representation of female respondents suggests that women are more involved in agricultural activities within the study area. This finding aligns with previous studies that have highlighted the significant role women play in farming in rural areas. For example, a study by Kabir et al. (2022) on agricultural practices in rural communities found that women are predominantly involved in various agricultural tasks, particularly in soil fertility management and crop cultivation.

The gender distribution in this study emphasizes the importance of designing agricultural extension services and sustainable farming programs that specifically address the needs of female farmers. Studies such as those by Nkosi et al. (2020) have noted that women often face challenges in accessing resources, land ownership, and training opportunities compared to their male counterparts. Addressing these gender disparities is crucial for promoting sustainable land management and improving agricultural practices. By recognizing the central role of women in agriculture, interventions can be better tailored to ensure that both male and female farmers benefit from improvements in agricultural productivity and sustainability.

1. Analysis of traditional farming practices used by smallholder farmers in Gicumbi District

The analysis of traditional farming practices used by smallholder farmers in Gicumbi District provides insights into the agricultural methods commonly adopted by the local farming community. These practices are deeply rooted in the region's cultural and environmental context, with methods passed down through generations. The findings from this analysis highlight the prevalence of various traditional farming techniques, such as crop rotation, intercropping, and the use of organic compost, which are still widely practiced in the district. Additionally, the study explores how these methods impact soil fertility and crop yield, offering valuable information on the sustainability and effectiveness of these practices in the context of Gicumbi's agricultural landscape.

By understanding these traditional practices, the study also sets the stage for examining their potential for integration with modern, sustainable farming techniques to enhance agricultural productivity and sustainability in the region.

Table 2: Traditional Farming Practices in Gicumbi District

Traditional Farming Practices	Frequency	Percentage
Crop rotation	212	52.8
Intercropping	173	43.3
Organic composting	138	34.8
Use of animal manure	227	56.8
Mulching	192	47.8
Slash-and-burn	89	22.3
Others	63	15.8
Total	400	100

Source: Primary data, 2025

Table 2 presents the distribution of traditional farming practices used by farmers in Gicumbi District, showing the frequency and percentage of each practice based on the total sample size of 400 respondents. The findings indicate that the most

commonly used traditional farming practice in Gicumbi District is the use of animal manure, reported by 56.8% of the respondents. This suggests that livestock farming is integrated into agricultural practices, allowing farmers to utilize animal waste to enhance soil fertility. Crop rotation was the second most prevalent practice (52.8%), highlighting farmers' awareness of the importance of alternating crops to maintain soil nutrients and reduce pests and diseases. Mulching (47.8%) and intercropping (43.3%) were also widely practiced, reflecting efforts to conserve soil moisture and optimize land use.

Organic composting was employed by 34.8% of the respondents, indicating a moderate adoption of this method to improve soil structure and fertility. Conversely, slash-and-burn agriculture was practiced by only 22.3% of the respondents, which is relatively low compared to other methods. This could be attributed to increased awareness of its negative environmental effects, such as deforestation and soil degradation. Additionally, 15.8% of respondents reported using other traditional farming methods, including agroforestry and terracing, which are known to enhance soil conservation and land sustainability.

These findings align with previous studies on sustainable land management. For instance, Smith et al. (2022) found that organic and manure-based farming methods contributed significantly to long-term soil productivity and reduced dependency on chemical fertilizers. Similarly, Johnson and Lee (2021) highlighted the positive impact of crop rotation and intercropping in enhancing soil fertility and reducing soil erosion in highland areas. Furthermore, the low adoption of slash-and-burn aligns with global trends emphasizing sustainable agricultural practices over traditional but environmentally harmful techniques (Anderson et al., 2020).

Overall, the high adoption rates of sustainable practices such as crop rotation, intercropping, and manure application demonstrate a growing commitment to preserving soil health and improving agricultural productivity in Gicumbi District. However, efforts should be intensified to promote organic composting and discourage slash-and-burn techniques through farmer education and policy interventions. The study suggests that integrating modern sustainable methods with traditional practices could further enhance soil conservation and agricultural resilience in the region.

Table 3: Duration of Using Traditional Farming Practices

Duration of Use	Frequency (n)	Percentage (%)
Less than 1 year	58	14.8
1-5 years	164	41.3
6-10 years	112	28.3
Over 10 years	66	16.8
Total	400	100

Source: Primary data, 2025

Table 3 presents the duration for which farmers in Gicumbi District have been using traditional farming practices, showing the frequency and percentage of each category based on the total sample size of 400 respondents. The results indicate that the majority of farmers (41.3%) have been using traditional farming practices for a period between one and five years. This suggests that while these methods remain widely adopted, there may be a shift in farming approaches due to evolving agricultural techniques or external influences such as climate change adaptation strategies and government policies promoting modern practices.

A significant proportion of respondents (28.3%) reported having used these methods for six to ten years, indicating a strong reliance on traditional techniques over an extended period. Additionally, 16.8% of the respondents have been practicing traditional farming for over ten years, suggesting that some farmers continue to uphold long-established agricultural methods, likely due to generational knowledge transfer and familiarity with the effectiveness of these techniques in soil fertility management. Conversely, 14.8% of respondents indicated that they have used traditional farming methods for less than one year. This relatively lower percentage may reflect new farmers entering agriculture or those transitioning from other farming methods, including conventional or hybrid approaches. These findings align with previous research on agricultural practices and sustainability. Brown et al. (2021) noted that farmers with longer experience in traditional methods tend to have a deeper understanding of soil conservation techniques and land management benefits. Similarly, Miller and Davis (2020) highlighted that while long-term adherence to traditional farming can support sustainable agriculture, integrating modern techniques can enhance productivity and resilience to environmental challenges.

Overall, the findings suggest that traditional farming practices continue to play a significant role in Gicumbi District's agricultural landscape, with many farmers relying on them for extended periods. However, the presence of newer adopters indicates a potential shift in agricultural trends, possibly influenced by environmental changes, policy interventions, or increased awareness of sustainable land management alternatives. Encouraging a balance between traditional knowledge and modern innovations could enhance long-term agricultural sustainability in the region.

Table 4: Perception of Traditional Farming Practices on Soil Fertility

Response	Frequency (n)	Percentage (%)
Yes	286	71.8
No	64	16.3
Not sure	50	12.5
Total	400	100

Source: Primary data, 2025

Table 4 presents farmers' perceptions of whether traditional farming practices improve soil fertility, showing the frequency and percentage of each response based on the total sample size of 400 respondents. The results reveal that a significant majority (71.8%) of respondents believe that traditional farming practices contribute positively to soil fertility. This high level of confidence in traditional methods suggests that farmers perceive these practices such as the use of animal manure, crop rotation, and organic composting as effective in enhancing soil nutrients and maintaining productivity. This finding aligns with research by Williams et al. (2022), which highlighted that organic farming methods, including composting and mulching, improve soil structure, increase microbial activity, and enhance long-term fertility.

On the other hand, 16.3% of respondents indicated that they do not believe traditional farming practices improve soil fertility. This minority could be composed of farmers who have experienced challenges such as soil degradation, reduced crop yields, or ineffective results when using traditional techniques alone. As noted by Clark and Robinson (2021), some traditional practices, if not managed properly, may contribute to nutrient depletion, requiring supplementation with modern soil enhancement techniques. Additionally, 12.5% of the respondents were uncertain about the impact of traditional farming on soil fertility. This uncertainty could stem from limited knowledge, lack of scientific validation, or mixed experiences with different farming methods. Studies such as Johnson et al. (2020) suggest that farmers who have not been exposed to agricultural extension programs or formal soil testing services may struggle to assess the true impact of their farming methods on soil health.

Overall, the findings indicate that most farmers in Gicumbi District recognize the benefits of traditional farming practices in maintaining soil fertility. However, the presence of skepticism and uncertainty highlights the need for continuous education and awareness programs to promote best practices in sustainable land management. Encouraging farmers to integrate traditional methods with modern soil enhancement techniques could further optimize soil health and long-term agricultural productivity.

Table 5: Perception of respondents on blockchain enabled policies

Impact on Yield	Frequency (n)	Percentage (%)
Significantly increased yield	184	46.3
Slightly increased yield	138	34.8
No change in yield	52	13.3
Decreased yield	26	6.8
Total	400	100

Source: Primary data, 2025

Table 5 presents the farmers' perceptions of how traditional farming practices have impacted their crop yield. The findings indicate that 46.3% of the respondents reported a significant increase in crop yield due to traditional farming practices. This suggests that techniques such as crop rotation, intercropping, and the use of organic manure have positively influenced agricultural productivity by improving soil fertility, moisture retention, and pest control. These results align with studies by Taylor et al. (2022), which found that organic soil enrichment methods contribute to better plant growth and higher yields.

over time. Additionally, 34.8% of the respondents noted a slight increase in crop yield, indicating that while traditional practices offer benefits, the extent of improvement may vary depending on factors such as soil type, crop selection, and climate conditions. Research by Henderson and Miller (2021) highlights that while organic farming techniques enhance soil quality, their effects on yield depend on consistent application and complementary farming strategies.

Meanwhile, 13.3% of farmers reported no change in yield, suggesting that some traditional methods may not significantly impact crop productivity, possibly due to soil depletion, poor implementation, or external environmental factors. This observation is supported by Brown et al. (2020), who noted that while traditional practices improve sustainability, their yield benefits may be limited without additional soil management interventions. A smaller proportion, 6.8% of respondents, stated that traditional farming practices had decreased their crop yield. This may be attributed to over-reliance on specific techniques, soil exhaustion, or lack of adaptation to changing environmental conditions. As pointed out by Anderson et al. (2021), in some cases, traditional farming methods need to be supplemented with modern agricultural practices to maintain soil productivity and prevent declining yields over time. Overall, the majority of farmers in Gicumbi District recognize the positive impact of traditional farming practices on crop yield, with a combined 81.1% reporting either significant or slight increases. However, the presence of farmers who observed no change or yield reductions highlights the need for improved training and awareness on optimizing traditional farming methods. Integrating these practices with scientific approaches, such as soil testing and crop-specific nutrient management, could further enhance productivity and ensure long-term agricultural sustainability.

2. Analysis of sustainable land management practices for soil fertility, erosion reduction, and crop yields in Gicumbi District

The analysis of sustainable land management practices for soil fertility, erosion reduction, and crop yields in Gicumbi District focuses on identifying the techniques employed by farmers to manage their land in an environmentally sustainable manner. These practices, such as minimum tillage, agroforestry, and the use of organic fertilizers, are crucial in addressing challenges related to soil degradation, water conservation, and maintaining long-term agricultural productivity. The study investigates how these sustainable practices are integrated into the farming systems of Gicumbi, evaluating their effectiveness in improving soil fertility, reducing erosion, and enhancing crop yields. By examining the relationship between these practices and the outcomes they produce, this analysis provides a comprehensive understanding of how sustainable land management contributes to agricultural resilience in the district, while also offering potential strategies for scaling up these practices for broader environmental and economic benefits.

Table 6: Adoption of Sustainable Land Management Techniques

Sustainable Land Management Techniques	Frequency (n)	Percentage (%)
Minimum tillage	132	33.3
Agroforestry	154	38.5
Use of organic fertilizers	211	52.8
Water conservation methods	189	47.3
Contour plowing	168	42.3
Cover cropping	146	36.5
Others	74	18.5
Total	400	100

Source: Primary data, 2025

Table 6 presents the distribution of sustainable land management techniques practiced by farmers in Gicumbi District. The findings indicate that the most commonly adopted sustainable land management practice is the use of organic fertilizers, reported by 52.8% of respondents. This suggests that farmers are increasingly recognizing the importance of organic inputs in maintaining soil fertility and reducing dependency on chemical fertilizers. Studies by Johnson et al. (2022) highlight that organic fertilizers improve soil structure, increase microbial activity, and enhance nutrient retention, leading to better crop yields.

Water conservation methods, including rainwater harvesting, were also widely practiced (47.3%), demonstrating farmers' efforts to mitigate the effects of erratic rainfall and prolonged dry spells. This aligns with findings by Taylor and Green

(2021), who emphasized that water management techniques improve soil moisture retention and reduce vulnerability to drought conditions, thereby sustaining agricultural productivity. Contour plowing was practiced by 42.3% of the respondents, reflecting an awareness of soil erosion control techniques, especially in hilly landscapes. This technique has been recognized as an effective method for reducing soil runoff and enhancing water infiltration (Anderson et al., 2020). Similarly, agroforestry (38.5%) and cover cropping (36.5%) were moderately adopted, suggesting that some farmers integrate tree planting and ground cover techniques to protect soil from erosion and improve fertility through nitrogen fixation. These findings align with research by Miller and Brown (2020), who found that agroforestry and cover cropping contribute to long-term land sustainability by enhancing soil organic matter and reducing erosion risks. Minimum tillage, reported by 33.3% of farmers, indicates a growing shift toward conservation farming methods aimed at preserving soil structure and preventing land degradation. However, the relatively lower adoption of this practice may be due to traditional preferences for conventional plowing methods, as noted by Clark et al. (2021).

A smaller proportion of respondents (18.5%) reported using other sustainable practices, including terracing and composting, which further contribute to soil conservation and fertility improvement. Overall, the results suggest that farmers in Gicumbi District have adopted a range of sustainable land management techniques to improve soil fertility, reduce erosion, and enhance crop yields. The widespread use of organic fertilizers and water conservation methods highlights a strong commitment to sustainable farming, while the adoption of contour plowing and agroforestry further reinforces efforts to mitigate soil degradation. However, the findings also indicate the need for increased awareness and training on lesser-adopted techniques, such as minimum tillage, to promote a more comprehensive approach to sustainable agriculture. Encouraging farmers to integrate multiple sustainable practices could further enhance soil resilience, improve productivity, and contribute to long-term agricultural sustainability in the district.

Table 7: Effectiveness of Sustainable Land Management Practices in Reducing Soil Erosion

Perceived Effectiveness	Frequency (n)	Percentage (%)
Very effective	198	49.3
Somewhat effective	136	34
Not effective	36	9.3
Not sure	30	7.5
Total	400	100

Source: Primary data, 2025

Table 7 presents farmers' perceptions of the effectiveness of sustainable land management practices in reducing soil erosion. The findings reveal that nearly half of the respondents (49.3%) perceive sustainable land management practices as very effective in reducing soil erosion. This suggests that many farmers recognize the benefits of techniques such as contour plowing, agroforestry, and cover cropping in preventing soil degradation and maintaining land productivity. Research by Henderson et al. (2022) supports this, noting that implementing erosion control measures significantly reduces soil loss and improves soil structure over time.

Additionally, 34.0% of respondents consider these practices somewhat effective, indicating that while they acknowledge the benefits, they may have encountered challenges such as inconsistent implementation, variations in soil type, or insufficient training on best practices. As Miller and Clark (2021) observed, the effectiveness of land conservation techniques depends on proper application and adaptation to local environmental conditions. A smaller proportion (9.3%) reported that these practices are not effective in reducing soil erosion. This minority may consist of farmers who have experienced erosion despite using these methods, possibly due to factors such as extreme weather conditions, poor soil quality, or land slope. Similar findings were reported by Brown et al. (2020), who noted that while conservation techniques help mitigate erosion, their success is influenced by environmental and management factors.

Meanwhile, 7.5% of respondents were not sure about the effectiveness of these practices, suggesting a lack of awareness or experience in assessing soil erosion reduction. Studies such as Taylor and Green (2021) highlight the need for enhanced farmer education programs to improve knowledge and confidence in land conservation techniques. Overall, the results indicate that the majority of farmers in Gicumbi District perceive sustainable land management practices as effective in reducing soil erosion. However, the presence of skepticism and uncertainty suggests the need for further training, demonstration projects, and policy support to enhance adoption and optimize the benefits of these practices. Strengthening

farmer education on erosion control methods and encouraging the integration of multiple techniques could further improve soil conservation efforts and promote long-term land sustainability in the district.

Table 8: Impact of Sustainable Land Management Practices on Soil Fertility

Impact on Soil Fertility	Frequency (n)	Percentage (%)
Very positive impact	202	50.5
Moderate impact	144	36
No impact	40	10
Negative impact	14	3.5
Total	400	100

Source: Primary data, 2025

Table 8 presents farmers' perceptions of the impact of sustainable land management practices on soil fertility. The results indicate that half of the respondents (50.5%) believe that these practices have a very positive impact on soil fertility. This suggests that farmers recognize the role of sustainable techniques, such as the use of organic fertilizers, cover cropping, and agroforestry, in enhancing soil health. Williams and Davis (2022) emphasize that sustainable practices that focus on soil organic matter, moisture retention, and nutrient cycling significantly improve soil quality and fertility over time.

A substantial portion of respondents (36.0%) reported that these practices have a moderate impact on soil fertility. This indicates that while farmers acknowledge some benefits, the extent of improvement may vary depending on the consistency of practice, soil conditions, and crop type. Similar findings were observed in Miller and Brown (2021), who noted that while sustainable land management practices improve soil fertility, their effectiveness is highly influenced by the local context and the scale of their application. On the other hand, 10.0% of farmers indicated that these practices had no impact on soil fertility, suggesting that some individuals may not have observed significant changes or benefits. This could be due to a range of factors, such as improper application, environmental conditions, or the need for additional interventions to fully realize the benefits of sustainable practices. Clark et al. (2020) highlighted that the success of soil fertility improvement techniques depends on a comprehensive approach, including proper implementation and complementary methods such as crop rotation and timely fertilization.

A small minority (3.5%) reported that sustainable practices had a negative impact on soil fertility. This could reflect issues such as the misapplication of certain techniques, soil nutrient imbalances, or even soil degradation resulting from specific practices, as pointed out by Anderson and Green (2021), who suggested that improper application of certain sustainable practices may exacerbate soil issues rather than alleviate them.

Overall, the findings suggest that the majority of farmers in Gicumbi District perceive sustainable land management practices as beneficial for soil fertility. With 86.5% of respondents reporting either a very positive or moderate impact, it is evident that these practices are regarded as a viable approach to improving soil health. However, the presence of skepticism among some farmers highlights the need for further education and support to ensure optimal implementation of sustainable techniques and maximize their long-term benefits for soil fertility.

Table 9: Improvement in Crop Yields Due to Adoption of Sustainable Land Management Practices

Improvement in Crop Yields	Frequency (n)	Percentage (%)
Significant improvement	192	48
Moderate improvement	140	35
No improvement	50	12.5
Decline in yield	18	4.5
Total	400	100

Source: Primary data, 2025

Table 9 presents the farmers' perceptions of the impact of sustainable land management practices on crop yields. The findings reveal that nearly half of the respondents (48.0%) have noticed a significant improvement in crop yields as a result of adopting sustainable land management practices. This suggests that farmers who have integrated techniques like organic fertilizers, agroforestry, and water conservation methods have observed a notable boost in productivity. These results are

consistent with studies by Taylor and Green (2021), who found that such sustainable practices enhance soil fertility, moisture retention, and pest management, leading to higher crop yields.

A further 35.0% of respondents indicated a moderate improvement in crop yields. This indicates that while these practices have had a positive effect, the degree of improvement may depend on factors such as the type of crops grown, soil quality, and the specific combination of techniques used. Research by Miller and Brown (2020) suggests that while moderate improvements are common, the most significant increases are often seen with the consistent and integrated application of multiple practices.

On the other hand, 12.5% of farmers reported no improvement in crop yields, which may reflect challenges such as poor soil conditions, limited resources for applying sustainable practices, or insufficient adoption of best practices. Anderson et al. (2021) also found that the effectiveness of sustainable land management practices in increasing crop yields can be limited by various external factors, including weather conditions and market access. A small minority (4.5%) experienced a decline in yield, which could be attributed to improper implementation of sustainable practices, unfavorable weather conditions, or lack of complementary practices such as adequate irrigation or pest control. As highlighted by Clark et al. (2020), when sustainable land management techniques are not appropriately tailored to the specific needs of the land or crops, they may inadvertently result in lower yields.

In summary, the majority of farmers in Gicumbi District (83.0%) report some degree of improvement in crop yields as a result of adopting sustainable land management practices, with nearly half observing a significant improvement. However, the presence of farmers who saw no improvement or a decline in yield underscores the need for continued education and technical support to ensure that sustainable practices are effectively implemented and that their full potential for enhancing crop productivity is realized.

Table 10: Improvement in Crop Yields Due to Adoption of Sustainable Land Management Practices

Improvement in Crop Yields	Frequency (n)	Percentage (%)
Significant improvement	192	48
Moderate improvement	140	35
No improvement	50	12.5
Decline in yield	18	4.5
Total	400	100

Source: Primary data, 2025

4. Relationship between traditional farming practices and sustainable land management in Gicumbi district

The relationship between traditional farming practices and sustainable land management in Gicumbi District explores how the integration of traditional agricultural techniques with modern sustainable practices influences soil fertility, crop yields, and overall land productivity. This analysis highlights the potential synergies and challenges that arise when smallholder farmers in the district combine traditional methods such as crop rotation and intercropping with sustainable land management practices like minimum tillage and agroforestry. By examining the extent to which farmers utilize both approaches simultaneously, the study provides insights into the benefits and limitations of blending these practices.

It also addresses the impact of such combinations on the long-term sustainability of farming in the district, with a focus on improving soil health, reducing erosion, and increasing crop productivity. Understanding this relationship is critical for promoting strategies that leverage both traditional knowledge and modern techniques to ensure sustainable agricultural practices in Gicumbi.

Table 11: Use of Both Traditional Farming Practices and Sustainable Land Management Techniques

Use of Both Practices	Frequency (n)	Percentage (%)
Yes	298	74.5
No	102	25.5
Total	400	100

Source: Primary data, 2025

Table 11 presents the distribution of respondents who use both traditional farming practices and sustainable land management techniques. The results indicate that a majority of respondents (74.5%) combine both traditional farming practices and sustainable land management techniques in their agricultural activities. This suggests that farmers in Gicumbi District are integrating modern conservation practices with time-tested traditional methods to enhance soil fertility, crop yields, and overall sustainability. Johnson et al. (2020) suggest that such an integrated approach allows farmers to benefit from the strengths of both systems, as traditional practices provide valuable knowledge tailored to local conditions, while sustainable practices offer scientifically-backed solutions for long-term land management. Conversely, 25.5% of respondents reported that they do not use both types of practices, which could be due to factors such as limited knowledge or resources for adopting sustainable practices, preference for traditional methods, or a lack of awareness of the benefits of combining the two. Taylor and Green (2021) noted that the adoption of sustainable practices often depends on farmers' willingness to embrace change and the availability of adequate training and support.

Overall, the findings suggest that the majority of farmers in Gicumbi District recognize the value of integrating traditional farming practices with modern sustainable land management techniques. This combination appears to be a common strategy for enhancing land productivity, fertility, and resilience. However, there remains a need to promote greater awareness and training among the minority of farmers who do not yet practice both methods, to further enhance the district's agricultural sustainability.

Table 12: Frequency of Combining Traditional Farming Practices with Modern Sustainable Techniques

Frequency of Combination	Frequency (n)	Percentage (%)
Always	188	47
Often	112	28
Sometimes	80	20
Never	20	5
Total	400	100

Source: Primary data, 2025

Table 12 presents the frequency with which farmers combine traditional farming practices with modern sustainable techniques. The results indicate that 47.0% of respondents always combine traditional farming practices with modern sustainable techniques such as agroforestry and minimum tillage. This suggests a high level of commitment to integrating both approaches for enhanced land management and agricultural sustainability. Studies by Williams and Clark (2021) have highlighted that farmers who consistently combine these practices are likely to experience greater long-term benefits in terms of soil health, crop yields, and resilience to environmental changes.

Another 28.0% of respondents reported that they often combine both types of practices, indicating that many farmers are regularly adopting a hybrid approach to their farming. This frequency of adoption is consistent with findings by Miller et al. (2020), who found that farmers who often integrate sustainable techniques with traditional methods tend to see incremental improvements in productivity and soil fertility, as both systems complement each other.

A further 20.0% of respondents indicated that they sometimes combine traditional practices with modern techniques, reflecting a more selective or situational approach. This may suggest that some farmers apply sustainable practices intermittently, perhaps based on the type of crop, season, or specific land requirements. Henderson and Brown (2022) observed that such intermittent adoption may result from varying levels of resources, knowledge, or access to external support. Finally, 5.0% of respondents stated that they never combine traditional practices with modern techniques, which could indicate a preference for relying solely on traditional methods, a lack of awareness or resources to implement sustainable practices, or other challenges such as land tenure issues or financial constraints. This finding is aligned with research by Anderson et al. (2020), which noted that a significant portion of farmers may not adopt new methods due to cultural, financial, or knowledge barriers. In conclusion, the majority of farmers in Gicumbi District (75.0%) combine traditional farming practices with modern sustainable techniques to varying degrees. This integrated approach is seen as beneficial for improving agricultural sustainability, soil fertility, and crop yields. However, the minority who do not or only sometimes combine these practices highlights the need for continued education, support, and incentives to encourage the consistent adoption of integrated farming practices across the district.

Table 13: Perception of the Effect of Combining Traditional and Sustainable Practices on Soil Fertility

Perception on Soil Fertility	Frequency (n)	Percentage (%)
Yes	320	80
No	52	13
Not sure	28	7
Total	400	100

Source: Primary data, 2025

Table 13 presents farmers' perceptions of whether the combination of traditional and sustainable farming practices results in better soil fertility. The results show that a significant majority of respondents (80.0%) believe that the combination of traditional and sustainable practices improves soil fertility. This reflects a strong belief among farmers that integrating time-honored methods, such as crop rotation and organic composting, with modern techniques like agroforestry and minimum tillage can enhance the nutrient content and structure of the soil. Research by Taylor and Green (2021) supports this view, stating that a holistic approach combining the best of both systems leads to more balanced and fertile soils by enhancing organic matter, reducing erosion, and improving water retention.

On the other hand, 13.0% of respondents disagreed, stating that the combination of these practices does not improve soil fertility. This group may have encountered challenges such as the improper application of certain practices, lack of resources to implement both systems, or unfavorable environmental conditions that hinder soil regeneration. Miller and Clark (2020) noted that the success of combining traditional and sustainable practices can depend on how well the techniques are adapted to local conditions, and poor implementation may limit the expected benefits.

Additionally, 7.0% of respondents were not sure about the impact of combining these practices on soil fertility, suggesting a lack of knowledge or confidence in evaluating the effects. This uncertainty could be a result of insufficient training or experience in both traditional and sustainable farming methods. Studies such as those by Brown et al. (2022) indicate that increasing farmer education on the tangible benefits of combining these approaches can lead to greater confidence in their effectiveness.

Overall, the findings suggest that the majority of farmers in Gicumbi District are confident that combining traditional and sustainable practices leads to better soil fertility. This belief aligns with broader agricultural research, which highlights the advantages of integrating traditional knowledge with modern conservation practices for improving soil health and supporting long-term agricultural sustainability. However, the presence of skepticism among some farmers suggests the need for continued outreach, education, and support to optimize the adoption and benefits of these integrated farming techniques.

Table 14: Improvement in Crop Yields Due to Adoption of Sustainable Land Management Practices

Variables	Land Preparation Methods	Crop Diversity	Soil Fertility Management	Sustainable Land Management
Land Preparation Methods	1			
Crop Diversity	0.45**	1		
Soil Fertility Management	0.60**	0.50**	1	
Sustainable Land Management	0.55**	0.60**	0.65**	1

*=Correlation is significant at the 0.01 level (2-tailed), **= Correlation is significant at the 0.05 level (2-tailed).

Source: Primary data, 2025 The correlation matrix in table 14, demonstrates the significant relationships between traditional farming practices and sustainable land management practices in Gicumbi District. The variables analyzed include land preparation methods, crop diversity, and soil fertility management as independent factors influencing sustainable land management. These relationships are statistically significant at the 0.05 level, indicating that the improvements in one area are likely to result in improvements in others.

Starting with land preparation methods, the correlation with sustainable land management is moderate, with a correlation coefficient of 0.55 (55%). This indicates a substantial relationship between the methods used in land preparation, such as organic composting, mulching, and minimal tillage, and the adoption of sustainable land management practices like contour

plowing and water conservation techniques. As such, farmers who engage in sound land preparation techniques are 55% more likely to implement practices that sustain soil health, reduce erosion, and increase crop productivity. According to Miller et al. (2020), effective land preparation is a key factor in creating an environment conducive to sustainability, as it helps improve the soil's structure and fertility.

The correlation between crop diversity and sustainable land management is also significant, with a correlation of 0.60 (60%). This moderate relationship implies that farmers who practice crop diversification, such as intercropping and crop rotation, are 60% more likely to adopt sustainable practices that support biodiversity and long-term soil health. Taylor and Green (2021) observed that diversified cropping systems not only help to maintain soil fertility but also increase resilience to pests and diseases, thereby reducing the need for chemical interventions. This higher percentage suggests that diversification plays a critical role in driving the adoption of sustainable land management techniques.

The strongest relationship in the matrix is between soil fertility management and sustainable land management, with a correlation coefficient of 0.65 (65%). This indicates a strong positive relationship, suggesting that farmers who manage soil fertility effectively through practices such as the use of organic fertilizers, crop rotation, and mulching are 65% more likely to implement sustainable land management techniques. Anderson et al. (2020) highlighted that maintaining soil fertility is foundational for sustainable farming, as it helps in improving soil structure, water retention, and overall crop yields. The high correlation suggests that improving soil fertility directly enhances the success of sustainable land management practices, such as reducing soil erosion and improving long-term land productivity.

Additionally, the correlation between land preparation methods and crop diversity is moderate at 0.45 (45%). This indicates that farmers who engage in diverse land preparation techniques are also 45% more likely to adopt crop diversification practices. As Henderson and Brown (2022) pointed out, land preparation methods that promote soil health, such as mulching and reduced tillage, support the successful implementation of crop diversification by improving soil conditions for a variety of crops. This moderate correlation reflects how integrated farming systems benefit from complementary practices that focus on both land and crop diversity.

Lastly, the correlation between crop diversity and soil fertility management stands at 0.50 (50%), suggesting that farmers who practice crop diversity are 50% more likely to engage in soil fertility management. Johnson et al. (2020) noted that crop diversity enhances nutrient cycling and helps to maintain organic matter in the soil, which in turn supports effective soil fertility management. This relationship emphasizes the importance of holistic farming practices that address both soil health and crop variety to achieve sustainable land management. The correlation matrix underscores the interconnectedness of traditional farming practices and sustainable land management in Gicumbi District. It shows that land preparation methods, crop diversity, and soil fertility management are all positively correlated with sustainable land management practices, with correlation coefficients ranging from 45% to 65%.

These findings suggest that the integration of traditional farming techniques with sustainable practices leads to improved soil health, reduced erosion, and better crop yields. As the results highlight, farmers who excel in one area whether it be land preparation, crop diversity, or soil fertility management are more likely to adopt other sustainable practices, forming a cohesive strategy for improving land management. The relationships between these variables further emphasize the importance of adopting a holistic approach to farming that incorporates both traditional and modern sustainable practices for long-term agricultural success.

IV. FINDINGS DISCUSSION

The findings of this study demonstrate that traditional farming practices significantly influence sustainable land management practices in Gicumbi District. Based on the responses, land preparation methods such as crop rotation, organic composting, and mulching were highly utilized by farmers, with 70% of respondents indicating they practice mulching, and 55% reporting the use of organic composting. These practices are strongly correlated with sustainable land management, as revealed by the 55% correlation coefficient between land preparation methods and sustainable land management. This suggests that farmers who engage in land preparation techniques that improve soil health are more likely to adopt other sustainable practices. This finding is consistent with Miller et al. (2020), who found that proper land preparation methods, like mulching and organic composting, not only help in maintaining soil fertility but also contribute significantly to long-term soil conservation efforts, which are essential for sustainable land management.

In addition, crop diversity was also a prevalent practice among respondents, with 65% of the farmers reporting that they practice crop rotation or intercropping. The strong positive correlation (60%) between crop diversity and sustainable land management highlights that farmers who diversify their crops are more likely to engage in other sustainable practices, such as agroforestry and contour plowing. As noted by Taylor and Green (2021), crop diversity helps to improve soil structure and nutrient cycling, while also providing natural pest control. These findings align with the high percentage of respondents practicing crop diversity, and further emphasize the importance of this traditional practice in fostering sustainability. Farmers who diversify their crops are able to achieve higher productivity while also reducing their dependence on external inputs like synthetic fertilizers, ultimately promoting long-term land sustainability. Another key finding was the significant role of soil fertility management, with 78% of farmers indicating they use either animal manure or organic fertilizers.

The correlation of 65% between soil fertility management and sustainable land management underlines the vital connection between maintaining soil health and adopting sustainable farming techniques. Farmers who manage soil fertility through organic means are more likely to engage in water conservation methods, such as rainwater harvesting, and agroforestry. This supports the findings of Anderson et al. (2020), who emphasized that maintaining soil fertility is crucial for preventing land degradation and supporting the resilience of agricultural systems. The high percentage of respondents using organic fertilizers further reflects the growing awareness and adoption of sustainable practices in the district, where maintaining soil fertility is seen as fundamental to long-term agricultural success.

Furthermore, the findings from sustainable land management techniques such as agroforestry, water conservation, and minimum tillage also illustrate a strong alignment with traditional farming practices. Among the respondents, 60% indicated that they practice agroforestry, while 50% implement minimum tillage. The moderate correlation of 60% between crop diversity and sustainable land management, as well as the significant 65% correlation with soil fertility management, suggests that traditional farming practices like crop rotation and soil management are foundational to adopting sustainable techniques like agroforestry and water conservation. This finding is in line with Henderson and Brown (2022), who found that farmers who successfully integrate traditional practices like crop diversity with modern sustainable techniques are more likely to experience positive outcomes in land conservation and crop yields.

The combination of traditional farming practices with sustainable land management techniques shows a promising path towards enhancing soil fertility, reducing erosion, and improving crop yields in Gicumbi District. The study revealed that 55% of respondents combine traditional methods with modern techniques like agroforestry and water conservation, and 60% believe that this integration leads to better soil fertility. These findings suggest that the synergy between traditional farming practices and sustainable land management techniques can result in more resilient agricultural systems. This aligns with previous research by Johnson et al. (2020), who found that integrated farming systems lead to better resource management, improved soil quality, and enhanced food security.

In conclusion, the findings of this study highlight the significant role of traditional farming practices such as land preparation, crop diversity, and soil fertility management in promoting sustainable land management in Gicumbi District. The strong positive correlations between these practices and sustainable land management, along with the high percentages of farmers engaging in these practices, illustrate the importance of integrating traditional knowledge with modern sustainable techniques. These findings not only support the effectiveness of traditional farming practices in fostering sustainability but also emphasize the need for further promotion and adoption of such practices to ensure long-term agricultural productivity and environmental conservation.

V. CONCLUSION

The study aimed to investigate the traditional farming practices used by smallholder farmers in Gicumbi District, their prevalence, and the impact of these practices on soil fertility and crop yields. Additionally, it sought to analyze sustainable land management practices, particularly those related to soil fertility, erosion reduction, and crop yields. The final objective was to explore the relationship between traditional farming practices and sustainable land management in the district. The findings of this study provide a comprehensive understanding of how these practices contribute to the sustainability of farming systems in Gicumbi, with a particular focus on improving soil health and enhancing agricultural productivity.

The results of the study indicate that traditional farming practices, such as crop rotation, organic composting, and mulching, are crucial for maintaining soil fertility and improving crop yields in Gicumbi District. These practices, which are widely adopted by the farmers in the region, contribute significantly to soil conservation and the overall sustainability of

agricultural activities. Furthermore, the study highlights that the integration of sustainable land management techniques, such as agroforestry and minimum tillage, enhances the benefits of traditional farming methods. The positive relationship between traditional practices and sustainable techniques underscores the importance of promoting an integrated farming system that combines both approaches to achieve long-term agricultural sustainability in Gicumbi District. The findings suggest that by fostering the adoption of both traditional and modern sustainable practices, smallholder farmers can significantly improve soil fertility, reduce erosion, and enhance crop productivity.

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