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Contribution of Sustainable Land Management Practices to Household Income among Smallholder Farmers in Rwanda: Evidence from Abizeranye and Abanyamurava Kinyinya Cooperatives, Kayonza District

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Abstract: This study assessed how sustainable land management (SLM) practices contribute to household income among smallholder farmers who are members of the Abizeranye and Abanyamurava Kinyinya cooperatives in Kayonza District, Rwanda. The study aimed to identify the major SLM practices adopted by farmers, assess income levels, and examine the relationship between SLM practices and household income. A mixed-methods cross-sectional design was employed. Data were collected from 305 respondents selected through stratified random sampling from a population of 1,284 cooperative members. The analysis used descriptive statistics, correlation analysis, and multiple linear regression. Findings revealed high adoption of SLM practices, including agroforestry, crop rotation, organic fertilizer application, terracing, and mulching. The results further showed that SLM practices positively contributed to household income by increasing agricultural productivity, diversifying income, accumulating assets, and reducing household expenditures. Multiple regression analysis indicated that SLM practices significantly influenced household income and explained 54.9% of the variation in income among respondents. The study concludes that SLM practices play a vital role in enhancing household income and livelihood resilience among smallholder farmers. It recommends strengthening agricultural extension services, promoting integrated SLM adoption, and enhancing cooperative support mechanisms to sustain and expand the economic benefits of SLM practices.

Keywords: Sustainable Land Management, Household Income, Smallholder Farmers, Agroforestry, Terracing, Kayonza District, Rwanda.

I. INTRODUCTION

1.1. Background of Study

Agriculture remains the backbone of Rwanda's economy, employing more than 70% of the population and serving as the primary source of livelihood for rural households [1] . However, agricultural production is increasingly threatened by land degradation, soil erosion, declining soil fertility, recurrent droughts, and climate variability, particularly in drought-prone regions

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such as Kayonza District [2]. These challenges reduce agricultural productivity and limit household income among smallholder farmers. Sustainable Land Management (SLM) practices, including terracing, agroforestry, crop rotation, mulching, and organic fertilizer application, are widely recognized as effective approaches for improving soil fertility, controlling erosion, enhancing water retention, and increasing agricultural productivity [3]. Studies in Sub-Saharan Africa indicate that SLM practices contribute to higher crop yields, improved livestock production, income diversification, and greater household resilience to climate-related shocks [4].

To address land degradation and improve agricultural productivity, the Government of Rwanda has promoted SLM through various initiatives, including the National Strategy for Transformation (NST1), the Strategic Plan for Agriculture Transformation (PSTA5), and the Green Growth and Climate Resilience Strategy [5] . According to NISR [6], over 90% of farming households implement soil and water conservation measures, while nearly 50% practice agroforestry. In Kayonza District, farmers have increasingly adopted SLM practices such as terracing, agroforestry, mulching, crop rotation, and organic fertilizer use to cope with drought and declining soil fertility [2].

Despite the increasing adoption of Sustainable Land Management practices, there is limited empirical evidence on their contribution to household income among smallholder farmers in Rwanda, particularly in Kayonza District. Most studies have focused on environmental and productivity outcomes, with less attention given to income diversification, asset accumulation, and overall household economic benefits. Therefore, this study assessed the contribution of Sustainable Land Management practices to household income among members of Abizeranye and Abanyamurava Kinyinya Cooperatives in Kayonza District, Rwanda.

II. MATERIAL AND METHODS

2.1. Area of Study

This study was conducted among members of Abizeranye and Abanyamurava Kinyinya Cooperatives located in Kayonza District, Eastern Province of Rwanda. Kayonza District is situated approximately 80 km east of Kigali and covers an area of about 1,954 km² [7]. The district is characterized by recurrent droughts, erratic rainfall, declining soil fertility, and land degradation, which negatively affect agricultural productivity and household livelihoods [8]. Agriculture is the main economic activity. Major crops grown in the area include maize, beans, bananas, rice, sweet potatoes, and vegetables [9]. The area was selected because Sustainable Land Management (SLM) practices such as terracing, agroforestry, mulching, crop rotation, and organic fertilizer use have been actively promoted among cooperative members [10]. [10]

2.2. Research Design, Population and Sample, Data Collection and Analysis

The study employed a mixed-methods cross-sectional research design combining quantitative and qualitative approaches. Quantitative data were collected using structured questionnaires administered to cooperative members, while qualitative data were obtained through key informant interviews with 12 participants: cooperative leaders, local leaders, and agricultural extension officers. The target population consisted of 1,284 registered and active members of Abizeranye and Abanyamurava Kinyinya Cooperatives distributed across five cells: Cyabanjwa, Kabura, Cyinzovu, Rusave, and Muko. A stratified random sampling technique was used to ensure proportional representation of all cells. The sample size was determined using Yamane's (1967) formula at a 95% confidence level and a 5% margin of error.

Yamane's formula:

$\frac{N}{1+N(e)^2}$ Resulting in a representative group for detailed analysis

$\frac{1284}{1+12 \quad (0.05)^2}$=305 respondents, where n: the sample size, N is the total population, and e: error margin.

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2.3. Multiple regression analysis

The multiple regression model analyzed the contribution of Sustainable Land Management (SLM) practices to household income among smallholder farmers, identifying the relative effects of terracing, agroforestry, crop rotation, organic fertilizer use, and mulching on household income.

$$Y=\beta_0+\beta_1(\text{Terracing})+\beta_2(\text{Agroforestry})+\beta_3(\text{Crop rotation})+\beta_4(\text{Organic fertilizer use})+\beta_5(\text{Mulching})+\varepsilon \ldots\ldots\ldots (1)$$

Y = is the dependent Variable, and the independent variables and coefficients (β1 to β_5). The coefficients represent the magnitude and direction of the relationship between each independent variable and the dependent variable. The error term (ε) represents the difference between observed and predicted values.

2.4. Ethical considerations

The study adhered to strict ethical guidelines, obtaining informed consent from participants while ensuring their anonymity and confidentiality, and upholding principles of integrity, respect, and beneficence.

III. Results and discussion

This section uses analytical techniques to analyze the gathered data. This section presents the findings on respondents' demographic characteristics, the adoption of Sustainable Land Management (SLM) practices, and their contribution to household income among smallholder farmers in Kayonza District.

3.1. Demographic characteristics of respondents

Table 1: Age Distribution of Respondents (n = 305)

Age Group	Frequency (n)	Percentage (%)
15–34 years	92	30.1
35–54 years	115	37.7
55 years and above	98	32.1
Total	**305**	**100.0**

Source: Primary data, 2026

The results in table 1 show that most respondents were aged 35–54 years (37.7%), followed by those aged 55 years and above (32.1%). Respondents aged 15–34 years represented 30.1% of the sample. This indicates that the study included participants from different age groups, with a higher proportion of middle-aged respondents.

Table 2: Gender Distribution of Respondents (n = 305)

Gender	Frequency (n)	Percentage (%)
Male	145	47.5
Female	160	52.5
Total	**305**	**100.0**

Source: Primary data 2026

Table 2 shows that female respondents constituted the majority of the sample, accounting for 52.5% (n = 160), while male respondents represented 47.5% (n = 145). This shows a relatively balanced gender distribution with slightly higher female participation.

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Table 3: Education Level of Respondents (n = 305)

Education Level	**Frequency (n)**	**Percentage (%)**
No formal education	99	32.5
Primary education	121	39.7
Secondary education	65	21.3
Tertiary education	20	6.6
Total	**305**	**100.0**

The results in Table 3 show that most respondents had primary education (39.7%), followed by those with no formal education (32.5%). Respondents with secondary and tertiary education accounted for 21.3% and 6.6%, respectively. This indicates that the majority of respondents had low levels of formal education.

Table 4: Length of Residence of Respondents (n = 305)

Length of Residence	**Frequency (n)**	**Percentage (%)**
Less than 10 years	52	17.0
10–20 years	87	28.5
More than 20 years	166	54.4
Total	**305**	**100.0**

Source: Primary data 2026

The findings in Table 4 show that the majority of respondents (54.4%) had lived in the area for more than 20 years. Those who had resided in the area for 10–20 years accounted for 28.5%, while 17.0% had lived there for less than 10 years. This suggests that most respondents had long-term experience and familiarity with the area.

Table 5: Household Size of Respondents (n = 305)

Household Size	**Frequency (n)**	**Percentage (%)**
1–3 members	54	17.7
4–6 members	167	54.8
More than 6 members	84	27.5
Total	**305**	**100.0**

Source: Primary data 2026

Table 5 provides an overview of family size; most respondents (54.8%) had households consisting of 4–6 members. Households with more than 6 members accounted for 27.5%, while those with 1–3 members represented 17.7%. This suggests that medium-sized households were the most common among the respondents.

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3.2. Identification of Sustainable Land Management Practices Adopted by Smallholder Farmers.

This section presents the findings related to the first research objective, which sought to identify the Sustainable Land Management (SLM) practices adopted by smallholder farmers in Abizeranye and Abanyamurava Kinyinya cooperatives in Kayonza District.

Table 5: Adoption of Sustainable Land Management Practices (n = 305)

SLM Practice	Not Used n (%)	Sometimes Used n (%)	Frequently Used n (%)	Mean	Std. Deviation	Interpretation
Terracing	30 (9.8)	92 (30.1)	183 (60.0)	2.50	0.67	Strong adoption, moderately consistent responses
Agroforestry	46 (15.1)	107 (35.1)	152 (49.8)	2.35	0.73	Moderate adoption, moderately consistent responses
Crop rotation	38 (12.5)	115 (37.7)	152 (49.8)	2.37	0.71	Moderate adoption, moderately consistent responses
Land consolidation	68 (22.3)	98 (32.1)	139 (45.6)	2.23	0.79	Moderate adoption, moderately consistent responses
Mulching	53 (17.4)	122 (40.0)	130 (42.6)	2.25	0.75	Moderate adoption, moderately consistent responses
Organic fertilizers	61 (20.0)	115 (37.7)	129 (42.3)	2.22	0.77	Moderate adoption, moderately consistent responses
Contour plowing	76 (24.9)	122 (40.0)	107 (35.1)	2.10	0.78	Moderate adoption, moderately consistent responses
Irrigation	115 (37.7)	107 (35.1)	83 (27.2)	1.89	0.80	Weak adoption, moderately consistent responses
Overall Mean				**2.24**	**0.75**	**Moderate adoption, moderately consistent responses**

Source: Primary data, 2026

Table 5. presents the level of adoption of Sustainable Land Management (SLM) practices among respondents. The findings show that terracing had the highest level of adoption (Mean = 2.50), with 60.0% of respondents frequently using the practice. Agroforestry and crop rotation were also widely adopted, each recording a mean score above 2.30. In contrast, irrigation had the lowest adoption level (Mean = 1.89), with only 27.2% of respondents reporting frequent use. The overall mean score of 2.24 indicates a moderate level of adoption of SLM practices among respondents. The overall standard deviation of 0.75 suggests moderately consistent responses across the different practices.

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3.3 Correlation coefficients results

Table 6: Correlation Matrix between SLM Practices and Household Income (n = 305)

Variables	Income	Terracing	Agroforestry	Crop Rotation	Organic Fertilizer	Mulching
Income	1	0.62*	0.58**	0.55**	0.53**	0.50**
Terracing	0.62*	1	0.48**	0.45**	0.42**	0.40**
Agroforestry	0.58**	0.48**	1	0.46**	0.44**	0.41**
Crop Rotation	0.55**	0.45**	0.46**	1	0.43**	0.39**
Organic Fertilizer	0.53**	0.42**	0.44**	0.43**	1	0.47**
Mulching	0.50**	0.40**	0.41**	0.39**	0.47**	1

**Note: ** Correlation is significant at 0.05level

Source: Primary data, 2026

Table 6 presents the Pearson correlation coefficients between Sustainable Land Management (SLM) practices and household income. The results show that all SLM practices were positively and significantly associated with household income ($p<0.05$). Terracing had the strongest correlation with income ($r=0.62$), followed by agroforestry ($r=0.58$), crop rotation ($r=0.55$), organic fertilizer application ($r=0.53$), and mulching ($r=0.50$). These findings suggest that increased adoption of SLM practices is associated with higher household income. The correlations among SLM practices themselves were moderate, ranging from $r = 0.39$ to $r = 0.48$, indicating that the practices complement one another. Since none of the correlation coefficients exceeded 0.70, there is no evidence of serious multicollinearity among the independent variables. Overall, the results indicate that SLM practices contribute positively to household income and livelihood improvement in drought-prone areas.

3.4 Data analysis

This section involves systematically examining and interpreting data using various methods to identify patterns and relationships and to provide valuable insights into research questions and Objectives. The contribution of Sustainable Land Management Practices on Household Income to determine whether a relationship exists between the use of Sustainable Land Management practices and household income among smallholder farmers in Abizeranye and Abanyamurava cooperatives in Kayonza District.

Table 7: Model Summary of Multiple Linear Regression

Model	R	R^2 Square	Adjusted R-Square	Std. Error
1	0.741	0.549	0.541	0.482

a. Predictors: (Constant), Terracing (X1), Agroforestry (X2), Crop rotation (X3), Organic fertilizer use (X4), Mulching (X5)

b. Dependent Variable: Household income of smallholder farmers (Y)

Source: Primary data 2026

Table 7 shows a strong relationship between SLM practices and household income ($R=0.741$). The model explains 54.9% of the variation in household income ($R^2 = 0.549$), while the adjusted R^2 of 0.541 indicates a good model fit. This suggests that terracing, agroforestry, crop rotation, organic fertilizer use, and mulching significantly influence household income among smallholder farmers.

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Table 8: ANOVA Results for the Regression Model

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	86.45	5	17.29	74.32	0.000
Residual	70.15	299	0.23		
Total	156.60	304			

a. Predictors: (Constant), Terracing (X1), Agroforestry (X2), Crop rotation (X3), Organic fertilizer use (X4), Mulching (X5)

b. Dependent Variable: Household income of smallholder farmers (Y)

Source: Primary data, 2026

Table 8 presents the ANOVA results for the regression model. The model is statistically significant ($F = 74.32$, $p < 0.001$), indicating that the selected SLM practices jointly have a significant effect on household income. Therefore, the regression model is appropriate for explaining variations in household income among smallholder farmers.

Table 9: Regression Coefficients for SLM Practices

Variable	Coefficient (β)	Std. Error	t-value	Sig.
Constant	0.845	0.112	7.54	0.000
Terracing	0.312	0.045	6.93	0.000
Agroforestry	0.268	0.048	5.58	0.000
Crop Rotation	0.241	0.050	4.82	0.000
Organic Fertilizer	0.215	0.047	4.57	0.000
Mulching	0.198	0.049	4.04	0.000

b. Dependent Variable: Household income of smallholder farmers

Source: Primary data, 2026

The results show that all Sustainable Land Management (SLM) practices have a positive and significant effect on household income ($p < 0.05$). Terracing had the strongest influence ($\beta = 0.312$), followed by agroforestry ($\beta = 0.268$) and crop rotation ($\beta = 0.241$). This indicates that increased adoption of SLM practices leads to higher household income among smallholder farmers. Overall, the findings confirm that SLM practices significantly improve farmers' economic well-being.

The multiple linear regression model estimating the effect of Sustainable Land Management (SLM) practices on household income is specified as follows:

$$Y=0.845+0.312\ \text{Terracing}+0.268\text{Agroforestry}+0.241\ \text{Crop rotation}+0.215\ \text{Organic Feltilizer}+0.198\ \text{Mulching}+\varepsilon$$

IV.CONCLUSIONS RECOMMENDATIONS

The study revealed that the adoption of Sustainable Land Management (SLM) practices among members of Abizeranye and Abanyamurava Kinyinya cooperatives in Kayonza District is generally moderate, with terracing being the most widely adopted practice, while irrigation remains the least adopted. The findings indicate that farmers are increasingly implementing SLM practices to improve agricultural productivity and manage land resources sustainably. The study further found that household income among respondents is mainly derived from crop production, livestock farming, and diversified income-generating activities. Respondents strongly agreed that income diversification contributes to financial stability, reduces income risks, and supports household livelihoods. In addition, SLM practices have contributed to increased agricultural income, asset accumulation, and reduced production costs.

The regression analysis confirmed a strong and statistically significant positive relationship between SLM practices and household income. Terracing, agroforestry, crop rotation, organic fertilizer use, and mulching all had positive effects on household income, with terracing showing the strongest contribution. The results further revealed that SLM practices explain a substantial proportion of the variation in household income, demonstrating their important role in improving farmers' economic well-being. Overall, the study concludes that Sustainable Land Management practices significantly increase household income and strengthen livelihood resilience among smallholder farmers in Kayonza District. Therefore, promoting wider adoption of SLM practices through technical support, capacity building, and investment in agricultural infrastructure can further enhance farmers' income and sustainable rural development.

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