



International Journal of Life Science Research Archive

ISSN: 0799-6640 (Online)

Journal homepage: <https://sciresjournals.com/ijlsra/>



(RESEARCH ARTICLE)



IMPACT OF COMMUNITY PARTICIPATION ON PERFORMANCE OF DRYLAND RESTORATION INITIATIVES: A CASE STUDY OF COMBIO AND TREPA PROJECTS IN RWAMAGANA DISTRICT, EASTERN RWANDA

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International Journal of Life Science Research Archive, 2026, 11(02), 020–031

Publication history: Received on 06 June 2026; revised on 15 October 2026; accepted on 17 October 2026

Article DOI: <https://doi.org/10.53771/ijlsra.2026.11.2.0056>

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ABSTRACT

This study examined the impact of community participation on the performance of dryland restoration initiatives implemented under the TREPA and COMBIO projects in Rwamagana District, Rwanda, since 2022. Despite increasing investments in dryland restoration, limited empirical evidence existed regarding how different levels and forms of community participation influence restoration outcomes in Rwanda. The existing literature showed that environmental constraints, particularly climate variability, can significantly impact forest cover dynamics and restoration success regardless of participation levels. The study adopted a mixed-methods cross-sectional descriptive-correlational research design. Data were collected from 245 respondents across four sectors of Rwamagana District (Nzige, Muyumbu, Munyaga, and Fumbwe) using structured questionnaires, field observations, 40 key informant interviews, and four focus group discussions. Quantitative data were analyzed using descriptive statistics, Pearson correlation, Independent Samples t-tests, ANOVA, and Multiple Linear Regression in SPSS Version 25, while qualitative data were analyzed thematically. The findings revealed that community participation varied across planning, implementation, and monitoring stages. Participation during planning was relatively low to moderate, whereas implementation participation was generally high, with more than 72% of respondents actively involved in restoration activities such as tree planting, maintenance, and site protection. Monitoring participation was moderate, with stronger engagement observed in interventions where communities demonstrated greater ownership and responsibility. Restoration performance was generally moderate to high, with most respondents estimating tree survival rates between 51% and 75%, while sites characterized by stronger community participation demonstrated comparatively better restoration outcomes. Pearson correlation analysis revealed a strong positive and statistically significant relationship between community participation and restoration performance ($r = 0.71$, $p < 0.001$). Multiple regression analysis further showed that participation in implementation strongly predicted tree survival and immediate benefits, while participation in monitoring significantly predicted community ownership and sustainability. The study concludes that meaningful and inclusive community participation is a key determinant of successful and sustainable dryland restoration outcomes.

Keywords: Community ownership, Community participation, Dryland restoration, Short-term restoration outcomes, Tree survival

1 INTRODUCTION

Dryland ecosystems cover approximately 41% of the Earth's land surface and support more than two billion people worldwide. These ecosystems are increasingly threatened by land degradation, deforestation, and climate variability, particularly in sub-Saharan Africa, where smallholder communities depend on ecosystem services for their livelihoods. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2018) estimates that land degradation affects 3.2 billion people globally, with dryland communities among the most severely impacted. At the global level, SDG 15 (Life on Land) calls for the protection and restoration of terrestrial ecosystems by 2030, while the UN Decade on Ecosystem Restoration (2021–2030) and the Bonn Challenge set ambitious targets to restore hundreds of millions of hectares of degraded landscapes.

Community participation, operationalized in this study through planning, implementation, and monitoring dimensions, is globally recognized as essential to achieving sustainable restoration outcomes. Evidence consistently demonstrates that communities meaningfully involved in planning, implementing, and monitoring restoration activities produce better ecological and social outcomes than externally managed, top-down approaches (Ocropom, 1990; Pretty, 1995). At the AU level, Agenda 2063 emphasizes green growth and environmental sustainability as central pillars of continental development. The African Forest Landscape Restoration Initiative (AFR100) commits African nations to restoring 100 million hectares of degraded land by 2030, with community participation explicitly recognized as a cornerstone of regional restoration strategies.

Research across sub-Saharan Africa demonstrates that restoration performance measured through indicators such as tree survival rates, community ownership of restored sites, and immediate benefits from restoration activities varies significantly based on the depth and quality of community participation across project phases (Reij & Winterbottom, 2015).

In Rwanda, specifically, forest landscape restoration efforts have demonstrated significant socio-economic and environmental benefits, including erosion control and soil protection, with community-based tree selection practices playing a crucial role (Kubwimana & Ndokoye, 2025). Such localized strategies are particularly vital for reforestation initiatives, where community involvement significantly influences planning, planting, and monitoring activities, thereby enhancing program effectiveness (Ali et al., 2025). Rwanda's commitment to restoring two million hectares of degraded land by 2030 under the Bonn Challenge is fundamentally anchored in the GGCRS, the NST2 (2024–2029), and the National Land Use and Development Master Plan. These frameworks prioritize community-based environmental management and the empowerment of smallholder farmers as central drivers for achieving a net-zero pathway (Mugabowindekwe et al., 2023).

Rwamagana District, located in Rwanda's Eastern Province, is characterized by semi-arid to sub-humid dryland conditions that are typical of the region. The area experiences highly variable rainfall, generally lower and less reliable compared to other parts of Rwanda, contributing to periodic dry spells, reduced vegetation cover, and increasing soil degradation risks, particularly erosion on cultivated hillsides (MINAGRI, 2018; REMA, 2019; Meteo Rwanda, 2022). These environmental challenges have necessitated the implementation of ecosystem restoration and climate resilience interventions, including the COMBIO and TREPA projects. Both initiatives were introduced in Rwamagana District in 2022 and are planned to continue through 2027, with the aim of restoring degraded landscapes and enhancing biodiversity and climate resilience.

The TREPA project focuses on integrated dryland restoration approaches, including agroforestry systems, restoration of degraded state forests, buffer zone protection around water bodies such as lakes, rivers, and dams, roadside tree plantation programs, and the establishment of Private Forest Management Units (PFMUs), all designed to improve ecosystem services and sustainable land management (REMA, 2022; TREPA Project Document, 2022). Similarly, the COMBIO project emphasizes biodiversity conservation and ecological restoration through Sancta biodiversity enrichment sites, roadside plantation initiatives, and the integration of native tree species within agroforestry systems implemented under TREPA, thereby strengthening ecosystem connectivity and biodiversity outcomes (REMA, 2022). Both projects are implemented across selected sectors of Nzige, Muyumbu, Munyaga, and Fumbwe and are grounded in the principle that meaningful community participation in planning, implementation, and monitoring is essential for achieving sustainable dryland restoration and long-term environmental performance (World Bank, 2021; UNCCD, 2022).

Despite these significant investments, a critical implementation challenge persists, referred to in this study as the "participation–performance gap." Although project monitoring systems commonly report high levels of community participation based on indicators such as attendance in meetings and involvement in planting activities, these measures often fail to capture the depth and quality of participation. In many cases, community involvement may be limited to

labor contribution rather than meaningful engagement in decision-making processes, planning, and resource management (REMA, 2022).

This distinction is important because previous studies have shown that superficial or tokenistic participation does not necessarily lead to improved environmental outcomes or sustainability of restoration efforts (Agrawal & Chhatre, 2006). However, in the context of COMBIO and TREPA projects in Rwamagana District, there remains limited empirical evidence on whether the level of community participation translates into improved restoration performance, particularly in terms of tree survival, site maintenance, and long-term ownership.

Furthermore, the specific challenges that may hinder effective community participation and restoration performance, such as climate variability, weak local leadership structures, limited technical support, and resource constraints, have not been sufficiently examined in this context. Without a clear understanding of how the quality of participation influences restoration outcomes, policymakers and implementers risk continuing to invest in interventions that appear participatory in design but may not achieve sustainable ecological and community benefits in practice.

2 RESEARCH METHODOLOGY

2.1 Description of the Study Area

Rwamagana District is located in the Eastern Province of Rwanda between latitudes $1^{\circ}35'S$ and $2^{\circ}05'S$ and longitudes $30^{\circ}01'E$ and $30^{\circ}30'E$. The district covers approximately 674 km², with altitudes ranging from 1,400 to 1,800 meters above sea level, and had a population of 484,953 people in 2022. It is bordered by Kayanza District, Bugesera District, Kigali City, and Gatsibo District. The district contains important water bodies such as Lake Muhazi, which contributes to ecological and hydrogeological functions (NISR, 2022).

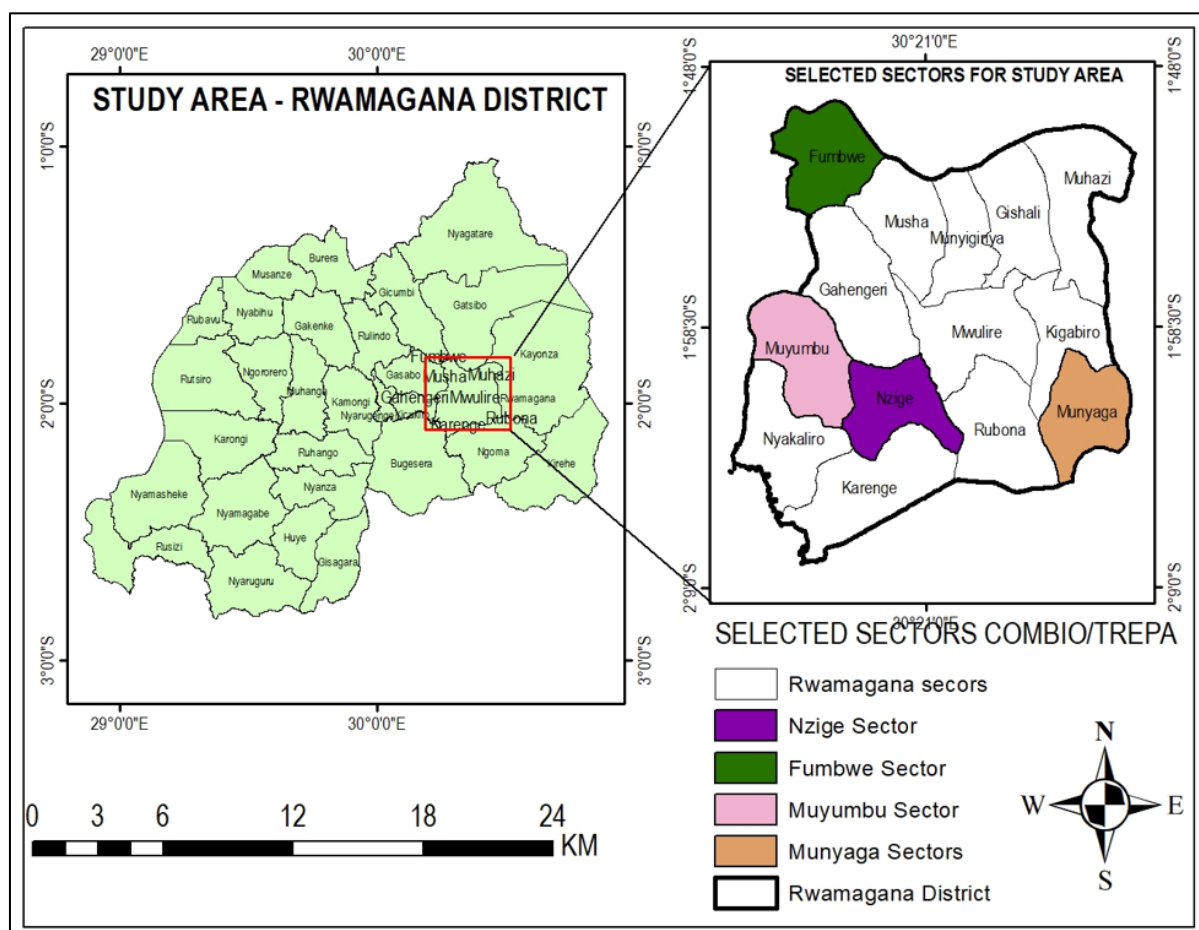


Figure 1: Map of Rwamagana District Showing Selected Study Sectors and Project Site

Rwamagana District is characterized by diverse agro-ecological zones, especially dryland lowlands that are vulnerable to land degradation and ecological deterioration. The area experiences a bimodal rainfall pattern with annual rainfall ranging from 900–1,100 mm and temperatures between 19°C and 23°C. Rainfall seasons occur from March to May and

October to November, separated by dry periods that often result in drought stress, declining soil moisture, and vegetation degradation.

The district's economy mainly depends on subsistence agriculture, agroforestry, and smallholder livestock farming, with major crops including maize, cassava, and sorghum. High population density, small landholdings, and intensive agricultural activities increase pressure on natural resources and contribute to land degradation. Due to these environmental challenges, Rwamagana has been identified as a priority area for Rwanda's national land restoration initiatives (NISR, 2022).

2.2 Research Design

This study employs a mixed-methods research design, combining quantitative and qualitative approaches within a cross-sectional descriptive-correlational framework.

2.3 Population of the study

The study population comprises all stakeholders directly involved in the COMBIO and TREPA projects across the four selected sectors of Nzige, Muyumbu, Munyaga, and Fumbwe in Rwamagana District since their inception in 2022. According to COMBIO and TREPA project records obtained from the Rwamagana District project coordination office (2025), the total number of beneficiary households directly participating in both projects across the four sectors is 1,248 households. In addition to beneficiary households, the study population includes project staff from both COMBIO and TREPA (10 individuals), local government officials with direct oversight of restoration activities in the selected sectors (8 individuals)

Table 1: Study Population by Category

Respondent Category	Exact Sample	Instrument
Community members (beneficiary households)	245	Structured questionnaire
Community members for FGDs	40 (4 FGDs × 10 participants)	FGD guide
Project staff (COMBIO and TREPA)	10	KII guide
Local government officials	8	KII guide
Total	303	

Source: COMBIO and TREPA Project Records, 2025; NISR (2022)

2.4 Sample Size Determination

Stratified random sampling is applied to select beneficiary household respondents for the structured questionnaire, stratifying by sector (Nzige, Muyumbu, Munyaga, Fumbwe) and by intervention type within each sector to ensure representative coverage of all COMBIO and TREPA restoration activities. Within each stratum, respondents are selected through simple random sampling from project household beneficiary lists maintained by COMBIO and TREPA project offices. Purposive sampling is applied to select project staff, local government officials, and extension workers for key informant interviews and focus group discussions, given their specialized knowledge of project processes and restoration outcomes since 2022.

The sample size for the questionnaire survey is determined using Yamane's (1967) formula applied to the community member population of 1,248 beneficiary individuals:

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

Where: **n** = required sample size

N = total number of beneficiary households in the selected study sites (Obtained from COMBIO and TREPA project records and local administrative data)

e = level of precision (margin of error), set at 0.05 (Gota *et al.*, 2022).

$$n = \frac{1248}{1 + 1248 (0.05)^2} = 302.9 \cong 303$$

The exact sample size is allocated by sector and respondent category as presented in Tables 2

Table 2: Sample Size Allocation by Sector

Sector	Population (Beneficiary Individuals)	Sample size per sector $ni = \frac{Ni * n}{N}$	Responded Questionnaire Sample Size
Nzige	348	85	68
Muyumbu	315	76	62
Munyaga	329	80	65
Fumbwe	256	62	50
Total	1248	303	245

2.5 Data Collection Methods and Instruments

The study used four main data collection instruments: a structured questionnaire, a key informant interview guide, a focus group discussion guide, and a field observation checklist. These instruments were designed to collect both quantitative and qualitative data related to community participation and restoration performance in the COMBIO and TREPA projects in Rwamagana District.

The structured questionnaire was the primary quantitative instrument used to collect data from 245 community members selected from four sectors. Respondents were drawn from COMBIO and TREPA beneficiary household registers because they directly participated in project planning, implementation, and monitoring activities. The questionnaire consisted of six sections covering sociodemographic characteristics, participation in planning, implementation, and monitoring, restoration performance indicators, and intervening variables. Participation and performance indicators were measured using a five-point Likert scale ranging from Strongly Disagree to Strongly Agree. The questionnaire was translated into Kinyarwanda and pilot-tested among 30 community members from non-selected sectors before the main survey.

A semi-structured key informant interview guide was used to collect qualitative data from 20 purposively selected respondents, including 10 COMBIO and TREPA project staff and 8 local government officials. Project staff provided expert information on participation mechanisms, restoration outcomes, and project implementation experiences, while local government officials contributed institutional perspectives on restoration activities and ecological performance. The interviews explored community participation practices, restoration performance indicators such as tree survival and immediate benefits, challenges encountered, and the relationship between participation and restoration outcomes.

Focus group discussion (FGD) guides were used to facilitate four FGDs involving 40 community members, with two discussions conducted for COMBIO communities and two for TREPA communities. Participants were purposively selected from questionnaire respondents to ensure representation of gender, project experience, and intervention types. FGDs enabled participants to collectively discuss their experiences in project planning, implementation, and monitoring, as well as their perceptions of restoration performance and immediate benefits. Discussions were conducted in Kinyarwanda, audio-recorded with consent, translated, and transcribed for thematic analysis.

In addition, a field observation checklist was used to collect objective ecological data on tree survival rates at COMBIO and TREPA restoration sites. The researcher conducted field surveys using at least ten sample plots measuring 20m × 20m per restoration site across the selected sectors. The checklist recorded tree species planted, number of trees planted and surviving, tree health condition, and evidence of immediate benefit activities such as harvesting or grazing. These observations helped validate and triangulate self-reported restoration performance data collected through the questionnaire.

2.6 Data Analysis Methods

Data for Objective 1 were obtained from questionnaire Sections B, C, and D, together with focus group discussions and key informant interviews. Quantitative data were analyzed using SPSS Version 25 through descriptive statistics, including frequencies, means, and standard deviations, to determine levels of community participation. Participation levels were categorized as low (1.0–2.4), moderate (2.5–3.4), and high (3.5–5.0). The forms of participation were classified into five typologies: manipulation, informing, consultation, partnership, and citizen control. Qualitative data from FGDs and KIIs were analyzed using thematic analysis based on Braun and Clarke (2006) to identify recurring themes and assess the depth of community involvement and power-sharing within the projects.

Data for Objective 2 were collected from questionnaire Section E, field observation checklists, and key informant interviews. Quantitative questionnaire data were analyzed using descriptive statistics to assess restoration performance indicators, including tree survival rates, community ownership, and immediate benefits such as economic gains, employment, and technical skills. Performance levels were categorized as low, moderate, or high using mean score ranges. Field observation data were analyzed using ecological statistics, where the tree survival rate was calculated as the percentage of surviving trees relative to the total number planted according to project records. Restoration performance was compared between COMBIO and TREPA sites and across the four sectors using Independent Samples t-tests and one-way ANOVA. Qualitative interview data were analyzed thematically and triangulated with quantitative findings.

Data for Objective 3 were derived from combined community participation and restoration performance scores from 245 respondents, supported by qualitative data from FGDs and KIIs. Quantitative analysis involved Pearson's Correlation Coefficient to determine the strength and significance of relationships between community participation and restoration performance indicators. Statistical significance was assessed at $p < 0.05$ and $p < 0.01$. Multiple Linear Regression analysis was then conducted to evaluate the predictive influence of participation dimensions on restoration performance while controlling for intervening variables. Three regression models were developed using tree survival rate, community ownership, and immediate benefits as dependent variables. Qualitative data were analyzed using thematic analysis and integrated with quantitative findings through triangulation to provide a comprehensive understanding of the relationship between community participation and restoration outcomes.

2.7 Ethical Considerations

All participants were informed about the purpose of the study, its objectives, and the procedures involved in data collection. Information provided by participants was treated as strictly confidential. Prior to data collection, authorization was sought from relevant local authorities in Rwamagana District. The study also complied with institutional ethical guidelines for research involving human subjects.

3 FINDINGS

Table 3: Level of Community Participation in Dryland Restoration Initiatives (n = 245)

Level of Participation	Frequency (n)	Percentage (%)
Manipulation	18	7.3
Informing	52	21.2
Consultation	74	30.2
Partnership	71	29.0
Citizen control	30	12.2

Source: Author's compilation (2026)

The findings in Table 4 indicate that the overall level of community participation in dryland restoration initiatives was predominantly concentrated at the levels of consultation (30.2%) and partnership (29.0%). This suggests that, in many cases, community members were consulted and involved in project activities, although full decision-making authority was not always shared equally. A considerable proportion of respondents (21.2%) perceived participation to be at the informing level, implying that some communities were mainly informed about project activities without meaningful involvement in decision-making processes. A smaller proportion of respondents (7.3%) viewed participation as manipulation, indicating that in certain cases, community members were used primarily to implement activities while major decisions remained under the control of project leaders. On the other hand, 12.2% of respondents reported experiencing citizen control, where communities exercised substantial authority over restoration management and maintenance activities.

Table 4: Tree Survival Rate and Health Condition of Restoration Sites (n = 245)

Variable	Category	Frequency (n)	Percentage (%)
Estimated Tree Survival Rate	Less than 25%	24	9.8
	25–50%	58	23.7
	51–75%	97	39.6
	More than 75%	66	26.9
General Health Condition of Surviving Trees	Very poor	16	6.5
	Poor	42	17.1
	Fair	71	29.0
	Good	82	33.5
	Very good	34	13.9

Source: Author's compilation (2026)

The findings in Table 5 indicate that the performance of dryland restoration initiatives in terms of tree survival was generally positive. The majority of respondents (39.6%) estimated that between 51–75% of planted trees were still surviving, while 26.9% reported survival rates of more than 75%. Only a small proportion of respondents indicated survival rates below 25% (9.8%), suggesting that most restoration sites achieved moderate to high levels of tree survival.

Regarding the health condition of surviving trees, the largest proportion of respondents described the trees as being in good condition (33.5%), followed by fair condition (29.0%). Additionally, 13.9% rated tree health as very good, while relatively few respondents perceived tree health as poor or very poor.

Table 5: Independent Samples t-test Comparing Restoration Performance between COMBIO and TREPA Projects

Project	N	Mean Performance Score	Std. Deviation	t-value	p-value
COMBIO	98	3.71	0.64	2.487	0.014
TREPA	86	3.49	0.68		

Source: Author's compilation (2026)

The findings in Table 6 indicate that respondents participating in the COMBIO project reported a higher mean performance score ($M = 3.71$, $SD = 0.64$) compared to those participating in the TREPA project ($M = 3.49$, $SD = 0.68$). The Independent Samples t-test revealed that the difference was statistically significant ($t = 2.487$, $p = 0.014$), since the p-value was less than 0.05. This implies that the level of restoration performance differed significantly between the two projects.

Table 6: One-Way ANOVA Comparing Restoration Performance across Sectors

Sector	N	Mean Performance Score	Std. Deviation
Nzige	68	3.78	0.61
Muyumbu	62	3.38	0.66
Munyaga	65	3.54	0.63
Fumbwe	50	3.69	0.71
ANOVA Statistics		Value	
F-value		4.316	
p-value		0.006	

Source: Author's compilation (2026)

The findings in Table 6 show variations in restoration performance across the four sectors. Nzige sector recorded the highest mean performance score ($M = 3.78$), followed by Fumbwe ($M = 3.69$), Munyaga ($M = 3.54$), and Muyumbu ($M = 3.38$). The ANOVA results indicate that the differences in performance across sectors were statistically significant ($F = 4.316$, $p = 0.006$), as the p-value was below the 0.05 level of significance. This suggests that restoration performance varied meaningfully across geographical locations.

Table 7: Pearson Correlation between Overall Community Participation and Overall Restoration Performance (n = 245)

Variables	Mean	Std. Deviation	Pearson Correlation (r)	p-value
Overall Community Participation	3.34	0.58	0.684**	0.000
Overall Restoration Performance	3.57	0.61		

Correlation is significant at the 0.01 level (2-tailed).; Source: Author's compilation (2026)

The findings in Table 7 reveal a strong positive and statistically significant relationship between overall community participation and overall restoration performance ($r = 0.684$, $p < 0.01$). This indicates that higher levels of community participation are associated with improved performance of dryland restoration initiatives. The positive correlation suggests that communities that actively participate in planning, implementation, and monitoring activities tend to experience better restoration outcomes, including higher tree survival rates, stronger community ownership, and greater socio-economic and environmental benefits.

Table 8: Pearson Correlation between Participation Dimensions and Performance Indicators (n = 245)

Variables	Tree Survival Rate	Community Ownership & Sustainability	Immediate Benefits
Participation in Planning	0.521**	0.648**	0.474**
Participation in Implementation	0.693**	0.601**	0.638**
Participation in Monitoring	0.611**	0.719**	0.582**

Note: Correlation is significant at the 0.01 level (2-tailed).; Source: Author's compilation (2026)

The findings in Table 8 indicate that all dimensions of community participation were positively and significantly correlated with the key performance indicators of dryland restoration initiatives. Participation in planning showed a moderate positive relationship with tree survival rate ($r = 0.521$, $p < 0.01$), community ownership and sustainability ($r = 0.648$, $p < 0.01$), and immediate benefits ($r = 0.474$, $p < 0.01$). These findings suggest that involving communities during planning contributes positively to restoration outcomes, particularly by strengthening ownership and long-term commitment toward restoration sites.

Table 9: Challenges Affecting Community Participation and Restoration Performance (n = 245)

No.	Statement	SD (%)	D (%)	N (%)	An (%)	SA (%)	Mean
G1	Pests, diseases, and livestock damage frequently destroy planted trees	12 (4.9)	24 (9.8)	38 (15.5)	102 (41.6)	69 (28.2)	3.78
G2	Unpredictable climate and prolonged droughts significantly hinder restoration success	10 (4.1)	18 (7.3)	30 (12.2)	110 (44.9)	77 (31.4)	3.92
G3	Local leadership sometimes fails to enforce community protection rules fairly	24 (9.8)	40 (16.3)	52 (21.2)	82 (33.5)	47 (19.2)	3.36
G4	Low community participation is caused by limited awareness and understanding of project activities	18 (7.3)	32 (13.1)	44 (18.0)	96 (39.2)	55 (22.4)	3.56
G5	Inadequate communication between project staff and the community reduces active participation	20 (8.2)	36 (14.7)	46 (18.8)	92 (37.6)	51 (20.8)	3.48

Source: Author's compilation (2026)

Participation in implementation demonstrated the strongest relationship with tree survival rate ($r = 0.693$, $p < 0.01$) and immediate benefits ($r = 0.638$, $p < 0.01$). This implies that active community involvement in practical restoration activities such as tree planting, maintenance, and mobilization of local resources contributes substantially to ecological performance and livelihood-related benefits. Similarly, participation in monitoring exhibited the strongest correlation with community ownership and sustainability ($r = 0.719$, $p < 0.01$), indicating that continuous community engagement in monitoring, reporting, and protection activities enhances long-term responsibility and sustainability of restoration initiatives.

The findings in Table 10 indicate that respondents experienced several significant challenges affecting both community participation and the performance of dryland restoration initiatives. Mean scores ranged from 3.36 to 3.92, suggesting that most respondents agreed that the listed factors negatively influenced restoration outcomes. The most serious challenge identified was unpredictable climate and prolonged droughts (G2), which recorded the highest mean score (3.92). A large majority of respondents agreed that climate variability significantly hindered tree survival and restoration success. This finding highlights the vulnerability of dryland restoration initiatives to environmental and climatic conditions.

Similarly, respondents strongly agreed that pests, diseases, and livestock damage (G1) frequently affected planted trees, resulting in reduced restoration performance. These biological and physical disturbances were identified as major threats to the sustainability of restoration efforts. The findings also indicate that limited awareness and understanding of project activities (G4) contributed to low community participation in some intervention sites. This suggests that insufficient sensitization and community education may reduce local engagement and commitment toward restoration activities.

Inadequate communication between project staff and community members (G5) was also identified as an important challenge. Poor communication may limit information sharing, weaken coordination, and reduce opportunities for meaningful participation in planning and decision-making processes. Although comparatively lower than other challenges, respondents also agreed that local leadership sometimes failed to enforce protection rules fairly (G3). This may contribute to weak compliance with restoration regulations and reduced trust among community members.

3.1 Qualitative Findings Supporting Quantitative Results

Key informants reported that community participation varied across project phases. Participation was strongest during implementation, moderate during monitoring, and weakest during planning. Most respondents explained that planning processes mainly involved local leaders, committee members, and selected representatives, while ordinary community members were often excluded from decision-making, especially in roadside plantation and buffer zone interventions. One informant stated that *"communities were only informed after major decisions had already been made."* However, more inclusive participation was observed in PFMU and Sancta sites, where communities contributed to site identification and management decisions. Participants explained that *"being involved from the beginning increased our sense of ownership and responsibility."*

Key informants described restoration performance as generally moderate to good, depending on community participation and environmental conditions. They reported that tree survival rates were higher in PFMU and Sancta sites where maintenance and participation were stronger. According to respondents, *"well-managed sites recorded higher survival rates because communities protected and maintained them regularly."* FGD participants also observed positive restoration outcomes, including improved vegetation cover, reduced soil erosion, and better soil fertility. Nevertheless, they emphasized that drought, livestock grazing, pests, and diseases continued to threaten restoration success. One participant explained that *"during dry seasons many trees fail to survive because water is limited and animals destroy unprotected areas."*

Field observations confirmed variations across sites. PFMU and Sancta interventions generally showed healthier vegetation and better maintenance, while some agroforestry, roadside plantation, and buffer zone sites exhibited dead trees, drought stress, and livestock-related damage. Despite these challenges, visible environmental improvements such as erosion control and increased vegetation cover were evident in several sites.

4 DISCUSSION OF FINDINGS

The findings revealed that community participation in dryland restoration initiatives was mainly concentrated at the levels of consultation (30.2%) and partnership (29.0%), while a smaller proportion of respondents reported citizen control (12.2%) and manipulation (7.3%). These findings are consistent with Arnstein's ladder of participation, which distinguishes between tokenistic participation (informing, consultation, manipulation) and meaningful participation (partnership and citizen control). The dominance of consultation and partnership levels suggests that COMBIO and TREPA projects partially achieved participatory approaches, but full empowerment of communities remains limited.

The findings align with Handberg (2018), who emphasized that weak participation, where stakeholders have limited influence over rules, fails to generate ownership or improve outcomes. Similarly, Agrawal and Chhatre (2006) highlighted that effective governance depends on meaningful local engagement and enforcement rather than mere presence in project activities. In the case of Rwamagana, limited involvement in planning reduces long-term ownership, while stronger participation in implementation enhances short-term engagement but may not guarantee sustainability.

The study found that restoration performance was generally moderate to good, with 39.6% of respondents reporting tree survival rates between 51–75% and 26.9% reporting survival above 75%. Similarly, most respondents described tree health as good (33.5%) or fair (29.0%), indicating relatively positive ecological outcomes.

These results are consistent with Silva et al. (2025), who found that higher community participation is generally associated with improved ecological and social outcomes in restoration projects. The findings also support Mansourian et al. (2022), who emphasized that local communities play a critical role in the success of restoration initiatives, especially in rural and resource-dependent contexts.

The findings demonstrate a strong positive relationship between community participation and restoration performance. Sites with higher levels of participation, particularly PFMU and Sancta interventions, showed better tree survival, improved maintenance, and stronger ownership. Regression results further confirmed that participation in implementation significantly predicted immediate benefits ($\beta = 0.418$, $p < 0.001$), explaining 63.7% of the variation in benefits.

Qualitative findings reinforced this relationship, as participants consistently reported that involvement in planning and implementation increased ownership and encouraged protection of restoration sites. This finding supports the “sense of ownership” theory proposed by Handberg (2018), which argues that strong participation fosters psychological commitment and improves resource management outcomes.

Similarly, Agrawal and Chhatre (2006) found that institutional strength and local engagement are key determinants of forest condition. In the context of Rwamagana, the findings suggest that participation enhances not only ecological outcomes but also socio-economic benefits such as employment, skills development, and environmental awareness.

5 CONCLUSION

The study concludes that community participation plays a critical role in determining the performance and sustainability of dryland restoration initiatives under the COMBIO and TREPA projects in Rwamagana District. Restoration interventions characterized by inclusive participation across planning, implementation, and monitoring stages demonstrated stronger tree survival, better maintenance, stronger community ownership, and greater socio-economic and environmental benefits. However, participation remained uneven across intervention types, with some projects limiting broader community involvement during planning and decision-making processes. The study further concludes that environmental challenges, particularly climate variability and drought, continue to threaten restoration performance despite community efforts. Overall, the findings demonstrate that meaningful and sustained community participation, supported by effective institutional support, strong local leadership, continuous awareness creation, and adaptive restoration strategies, is essential for achieving successful and sustainable dryland restoration outcomes in Rwanda.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

The principal author appreciates the guidance and support of UNILAK lecturers. He wants to express his heartfelt thanks, particularly to his supervisor, Jean Baptiste NSENGIYUMVA, as well as to everyone else who contributed to the completion and value of this work.

Funding Source

This study did not receive any financial support from any governmental, non-governmental, or private organization. The research was conducted using the authors' personal resources.

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.”

Author Contributions

- **Conceptualization:** Christophe TUYISENGE
- **Data curation:** Christophe TUYISENGE
- **Formal analysis:** Christophe TUYISENGE
- **Methodology:** Christophe TUYISENGE
- **Writing – original draft:** Christophe TUYISENGE
- **Writing – review & editing:** Jean Baptiste NSENGIYUMVA
- **Funding:** There was no financial support provided for conducting this study.
- **Competing interests:** This study declared no competing interests.

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