ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 14, Issue 2, pp: (38-51), Month: April - June 2026, Available at: www.researchpublish.com

Community Perceptions and Participation in Mine Environmental Rehabilitation Programs: A Case Study of Trinity Nyakabingo Mines in Rulindo District, Rwanda

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DOI: https://doi.org/10.5281/zenodo.20541308

Published Date: 04-June-2026

Abstract: **This study examined community perceptions and participation in mine environmental rehabilitation programs at Trinity Nyakabingo Mines in Rulindo District, Rwanda. Mining activities in the area have created both socio-economic benefits and environmental challenges for surrounding communities, yet limited evidence existed on how local residents understand and engage in rehabilitation initiatives. The study aimed to assess community knowledge and perceptions of mine rehabilitation programs, identify factors influencing participation, and examine the relationship between community knowledge and participation. A descriptive cross-sectional design using mixed methods was employed. The study targeted 18,151 households surrounding the mining area, from which 391 respondents were selected using Yamane's formula. Quantitative data were collected through structured questionnaires and analyzed using descriptive and inferential statistics, including binary logistic regression and linear regression in IBM SPSS Statistics. Qualitative data from focus group discussions were analyzed thematically to support and triangulate quantitative findings. Results showed that while 70.6% of respondents were aware of rehabilitation programs, only 28.7% demonstrated good or very good knowledge. Respondents acknowledged significant environmental degradation caused by mining activities, whereas perceptions regarding the effectiveness and inclusiveness of rehabilitation programs were mixed. Participation in rehabilitation activities was relatively high at 62.1%, although 37.9% of respondents had never participated. The findings further revealed that socio-economic benefits, motivational factors, and institutional support significantly increased participation in rehabilitation programs, while barriers reduced community involvement. In addition, a statistically significant positive relationship was found between community knowledge and participation, indicating that increased awareness and understanding enhanced engagement in rehabilitation activities. The study concludes that strengthening community knowledge, improving institutional support, and promoting inclusive participation mechanisms are essential for enhancing community engagement and ensuring sustainable and effective mine rehabilitation programs in Rwanda.**

Keywords: **Community Perceptions, Mine, Environmental Rehabilitation, Trinity Nyakabingo Mines, Rwanda.**

1. INTRODUCTION

Mining is a major driver of the global economy, supplying essential raw materials for infrastructure, manufacturing, renewable energy, and digital industries. Despite its economic contribution, mining is also associated with serious environmental problems such as deforestation, soil erosion, water pollution, biodiversity loss, and land degradation

(Measham et al., 2024; Antwi-Agyei & Stringer, 2023). Poorly managed mining activities and abandoned mine sites can create long-term ecological damage, threaten public health, and reduce agricultural productivity.

Globally, environmental degradation linked to mining has intensified concerns about sustainable resource extraction. In countries such as Peru and Brazil, artisanal gold mining has caused severe mercury contamination in river systems, while large-scale mining in Indonesia and China has contributed to extensive deforestation and land degradation (Boutilier & Thomson, 2011; Withanachchi et al., 2018). These challenges have prompted stronger international governance frameworks, including the OECD Guidelines for Multinational Enterprises, the Extractive Industries Transparency Initiative (EITI), and the United Nations Sustainable Development Goals (SDGs 12, 13, and 15), all of which emphasize environmental responsibility, transparency, and community participation.

Consequently, modern mine rehabilitation approaches increasingly focus on ecological restoration, progressive rehabilitation, post-mining land-use planning, and inclusive stakeholder engagement (Fraser & Kunz, 2018; Alonzo et al., 2023). The concept of a "social license to operate" highlights the importance of trust, transparency, and active community involvement in environmental management. Countries such as Canada and Australia have institutionalized community participation through public consultations and local monitoring committees, improving rehabilitation outcomes and reducing conflicts.

In Africa, mining significantly contributes to employment, foreign exchange earnings, and economic growth. However, environmental degradation, abandoned mine sites, and weak community involvement remain major concerns in countries such as Ghana, South Africa, and the Democratic Republic of Congo (Hilson, 2017). Weak regulatory enforcement and limited technical capacity often undermine rehabilitation efforts. To address these challenges, the African Mining Vision (2009) advocates for environmentally sustainable mining and stronger community participation in governance and resource management.

In Rwanda, mining is a strategic sector contributing substantially to export revenues, particularly through the production of tin, tantalum, tungsten, and gold (Nziza & Ingabire, 2022). National policies, including the Mining and Quarry Operations Law and the Green Growth and Climate Resilience Strategy, promote responsible mining and environmental rehabilitation (REMA, 2019). However, although these frameworks recognize environmental sustainability, community participation in rehabilitation programs often remains limited to consultation rather than active involvement (Mukabayizere et al., 2025).

Rulindo District, located in Rwanda's Northern Province, hosts the Nyakabingo Mine operated by Trinity Metals, one of Africa's largest tungsten mines. While the mine contributes to employment and local economic development, surrounding communities continue to experience environmental challenges such as land degradation, water sedimentation, and safety risks. In response, rehabilitation measures including tree planting, slope stabilization, wastewater treatment, and alternative livelihood projects have been introduced (Rulindo District, 2025). Despite these interventions, limited empirical evidence exists regarding community perceptions of the effectiveness and inclusiveness of mine rehabilitation programs, as well as the extent of local participation in their implementation and monitoring. Understanding community perceptions and participation is therefore essential for promoting sustainable environmental restoration, strengthening trust between mining companies and local communities, and supporting long-term socio-economic development in Rulindo District.

2. METHODOLOGY

2.1 Research Design

The study adopted a mixed-methods approach, integrating both quantitative and qualitative data collection and analysis techniques

2.2 Study Area

Rulindo District is located in the Northern Province of Rwanda, approximately 60 kilometers from the capital city, Kigali.

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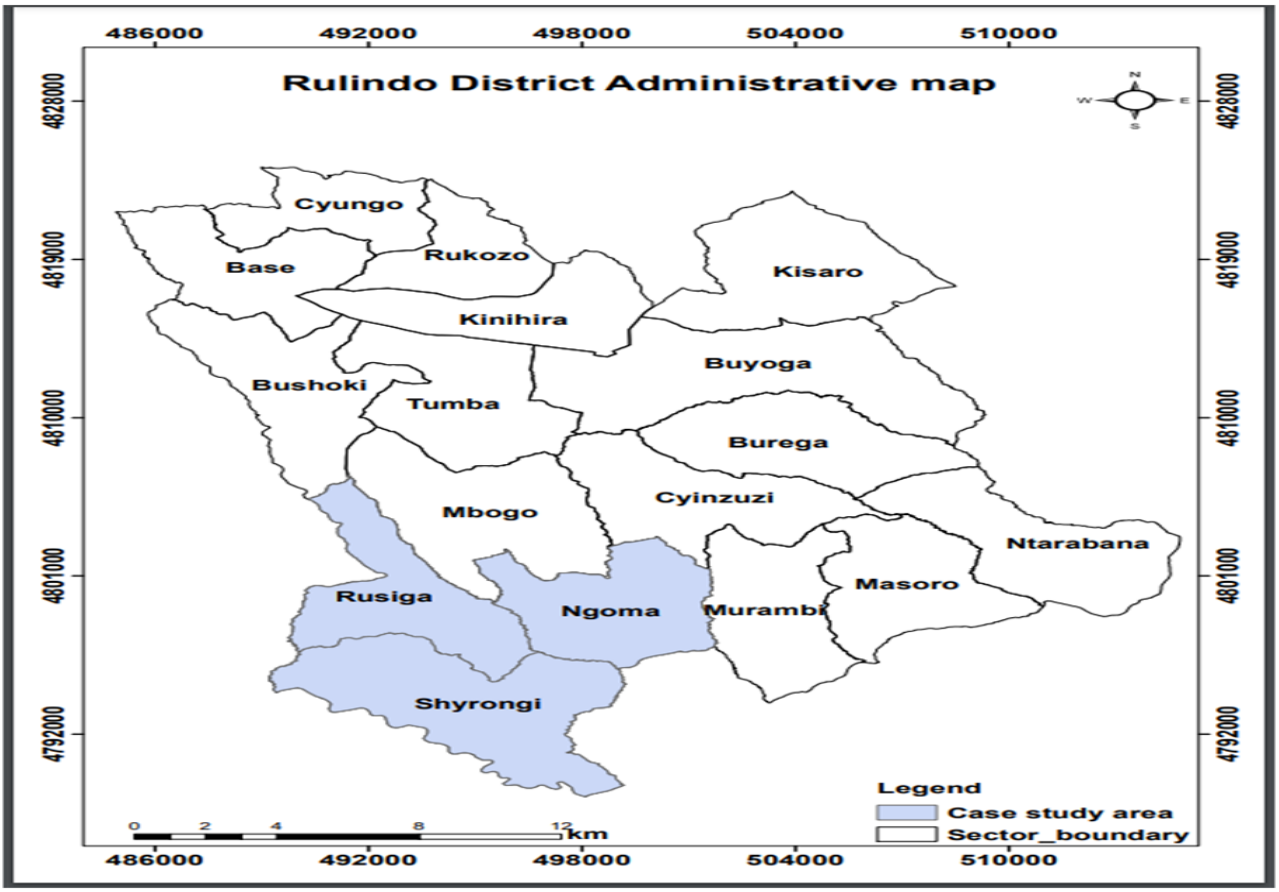

2.3 Sampling design

2.3.1 Target population

The target population for this study consisted of all households residing in the communities surrounding Trinity Nyakabingino Mines in Rulindo District, Rwanda. The target population for qualitative data included key stakeholders who have direct or indirect involvement with or knowledge of the mining activities and their impacts on surrounding communities

2.3.2 Sample Size

To determine the sample size, the study applied Yamane's (1967) formula, which provides a simplified and statistically valid method for calculating sample sizes with a specified level of precision. This approach ensured that the selected households accurately represent the broader population while maintaining the feasibility of data collection.

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

Where:

- n = required sample size
- N = total population 18,151 households
- e = level of precision (margin of error, 0.05)

$$n=n=\frac{18{,}151}{1+18{,}151(0.05)^2}=391.02=391$$

Therefore, the sample size is approximately 391 households.

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2.3.3 Sampling Techniques

The study used stratified random sampling for households. The sample allocation for each sector was calculated using proportional stratified sampling.

2.4 Data Collection Techniques

This study employed a mixed-methods approach, combining both quantitative and qualitative data collection techniques to obtain a comprehensive understanding of community perceptions and participation in mine rehabilitation programs at Trinity Nyakabingino Mines.

2.5 Data Analysis

Data analysis for this study was conducted using quantitative techniques. After data collection, all completed questionnaires were checked for completeness, coded, and entered into SPSS version 26 for analysis.

3. RESULTS AND DISCUSSIONS

3.1 Demographic details of Respondents

The demographic characteristics of the respondents are presented in Table 1. These characteristics include gender, age group, level of education, primary occupation, monthly household income, duration of residence near the mine, distance from the mine, and household dependency on mining activities.

Table 1: Demographic Characteristics of Respondents (n = 391)

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	210	53.7
	Female	181	46.3
Age Group	Below 25 years	58	14.8
	25–35 years	102	26.1
	36–45 years	95	24.3
	46–55 years	78	20.0
	Above 55 years	58	14.8
Education Level	No formal education	52	13.3
	Primary education	141	36.1
	Secondary education	118	30.2
	Vocational/Technical training	45	11.5
	University/College	35	9.0
Occupation	Mine employee	74	18.9
	Farmer	143	36.6
	Small business owner	68	17.4
	Casual laborer	61	15.6
	Unemployed	29	7.4
	Other	16	4.1
Monthly Income (RWF)	Below 30,000	96	24.6
	30,000–60,000	121	30.9
	61,000–100,000	88	22.5
	101,000–150,000	52	13.3
	Above 150,000	34	8.7
Length of Stay	Less than 5 years	49	12.5
	5–10 years	87	22.3
	11–15 years	96	24.6
	16–20 years	73	18.7

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Demographic Variable	Category	Frequency (n)	Percentage (%)
	More than 20 years	86	22.0
Distance from Mine	Less than 1 km	83	21.2
	1–2 km	109	27.9
	3–5 km	117	29.9
	More than 5 km	82	21.0
Dependency on Mining	Yes, directly employed	92	23.5
	Yes, indirectly	137	35.0
	No dependency	162	41.4

Source: Author's compilation, 2026

The findings in Table 1 show that a slightly higher proportion of respondents were male (53.7%) compared to female (46.3%), indicating a relatively balanced gender distribution. The majority of respondents were within the economically active age groups, particularly those aged 25–35 years (26.1%) and 36–45 years (24.3%), suggesting that most participants are actively engaged in livelihood activities.

In terms of education, most respondents had attained primary (36.1%) and secondary education (30.2%), while a smaller proportion had higher education, indicating moderate literacy levels within the study area. Regarding occupation, farming (36.6%) was the dominant activity, followed by mine employment (18.9%), highlighting the importance of both agriculture and mining in the local economy.

Income distribution shows that a large proportion of households earn below 60,000 RWF per month, reflecting relatively low-income levels among respondents. Additionally, many respondents had lived near the mine for over 10 years, indicating long-term exposure to mining activities and their environmental impacts.In terms of proximity, most households were located within 1–5 km of the mine, suggesting that they are directly affected by mining operations. Finally, while a considerable number of households (41.4%) reported no dependency on mining, a significant proportion depended on mining either directly or indirectly, demonstrating the economic relevance of mining activities in the area.

3.2 Community Knowledge and Perceptions of Mine Rehabilitation Programs

This section presents the findings related to the first research objective, which is to assess the level of community knowledge and perceptions regarding mine environmental rehabilitation programs around Trinity Nyakabingo Mines in Rulindo District.

3.2.1 Community Awareness of Rehabilitation Programs

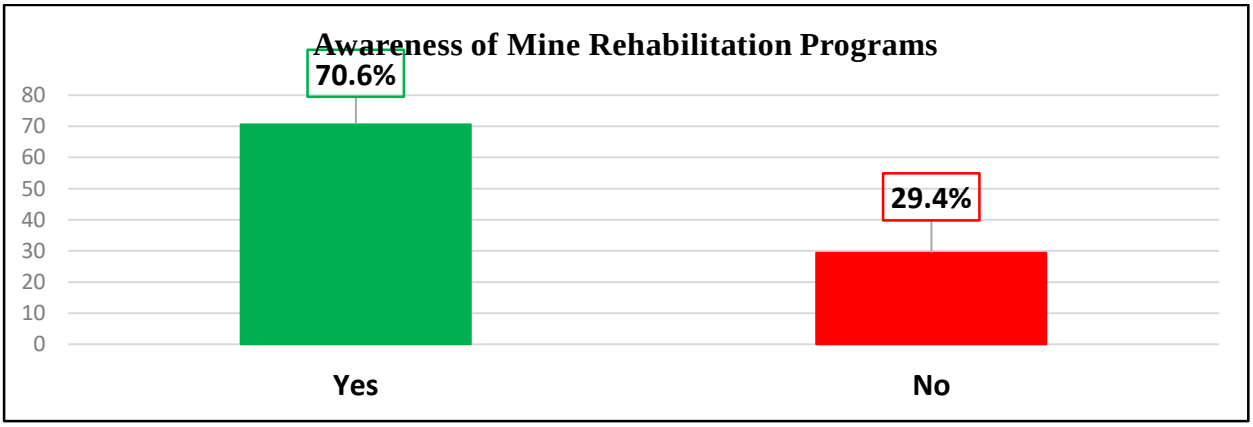

Figure 1 Awareness of Mine Rehabilitation Programs

Source: Author's compilation, 2026

The findings in Figure 1 indicate that the majority of respondents (70.6%) are aware of environmental rehabilitation programs implemented by Trinity Nyakabingo Mines, while 29.4% reported no awareness. This suggests a relatively high level of outreach, although a notable proportion of the community remains uninformed.

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Findings from the focus group discussions (FGDs) corroborate the quantitative results by indicating that community awareness of mine rehabilitation programs is generally high, although not uniformly distributed across all residents. Participants reported that information about these programs is mainly disseminated through community meetings and local leaders, but the level of understanding varies among individuals. One participant stated, *"Most of us are aware of the rehabilitation activities such as tree planting because we are informed during village meetings, but some people, especially those living farther away, are not fully aware."* Another participant added, *"Information does not reach everyone equally; some households miss out, particularly those who do not attend community gatherings."* These perspectives confirm the survey findings, highlighting that while awareness of rehabilitation initiatives is relatively widespread, gaps in information access and dissemination still exist within the community.

3.2.2 Sources of Information on Rehabilitation Programs

Table 2: Sources of Information about Rehabilitation Programs (Multiple Responses) (n = 391)

Source of Information	Frequency (n)	Percentage (%)
Community meetings	198	50.6
Mine employees/management	164	41.9
Local leaders	187	47.8
Neighbors/friends	143	36.6
Radio/media	119	30.4
Other	27	6.9

Source: Author's compilation, 2026

The findings in Table 2 indicate that community members rely on multiple sources of information to learn about mine rehabilitation programs. The most commonly reported source is community meetings (50.6%), followed closely by local leaders (47.8%) and mine employees or management (41.9%). Informal channels such as neighbors and friends also play a notable role, accounting for 36.6% of responses, while radio and other media sources contribute 30.4%. A small proportion of respondents (6.9%) reported obtaining information from other sources. Overall, these results suggest that interpersonal and community-based communication channels are the primary means through which information about rehabilitation programs is disseminated, highlighting the importance of local engagement structures in awareness creation.

3.2.3 Level of Community Knowledge

Table 3: Level of Knowledge about Rehabilitation Activities (n = 391)

Knowledge Level	Frequency (n)	Percentage (%)
No knowledge	49	12.5
Little knowledge	102	26.1
Moderate knowledge	128	32.7
Good knowledge	78	20.0
Very good knowledge	34	8.7

Source: Author's compilation, 2026

The findings in Table 3 show that the level of community knowledge about rehabilitation activities is generally moderate. The largest proportion of respondents (32.7%) reported having moderate knowledge, followed by those with little knowledge (26.1%). A smaller proportion indicated good knowledge (20.0%), while only 8.7% reported having very good knowledge. Notably, 12.5% of respondents stated that they had no knowledge at all. Overall, these results suggest that although awareness of rehabilitation programs exists within the community, in-depth understanding remains limited, with a significant proportion of respondents possessing only basic or moderate knowledge.

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3.2.4 Community Perceptions of Environmental Impact

Table 4: Perceptions of Environmental Impact of Mining (n = 391)

Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)
Mining negatively affects the environment	4.1	8.2	12.3	45.0	30.4
Water quality has deteriorated	5.6	10.2	14.1	42.5	27.6
Deforestation has increased	6.1	11.0	15.3	41.2	26.4
Soil degradation is visible	5.9	9.7	13.8	44.0	26.6
Biodiversity has decreased	6.4	10.5	16.1	40.7	26.3

Source: Author's compilation, 2026

The findings in Table 4 indicate that respondents generally perceive mining activities as having significant negative environmental impacts. A large majority agreed or strongly agreed that mining negatively affects the environment (75.4%), with similar perceptions observed across specific environmental indicators. For instance, 70.1% of respondents agreed or strongly agreed that water quality has deteriorated, while 67.6% reported increased deforestation. Additionally, 70.6% acknowledged visible soil degradation, and 67.0% believed that biodiversity has decreased due to mining activities. Only a small proportion of respondents expressed disagreement or neutrality across these statements. Overall, these results demonstrate a strong community consensus that mining operations have contributed to environmental degradation in the study area.

3.2.5 Perceptions of Rehabilitation Effectiveness

Table 5: Perceived Effectiveness of Rehabilitation Programs (n = 391)

Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)
Reforestation has improved forest cover	7.2	12.5	18.1	39.4	22.8
Water quality has improved	8.4	14.3	19.7	36.3	21.3
Programs address environmental damage	9.2	15.6	20.5	34.8	19.9
Company is committed to restoration	10.0	16.4	18.9	34.3	20.4
Programs improve livelihoods	9.7	15.1	21.0	33.8	20.4

Source: Author's compilation, 2026

The findings in Table 5 reveal generally moderate perceptions regarding the effectiveness of rehabilitation programs. A majority of respondents agreed or strongly agreed that reforestation has improved forest cover (62.2%) and that water quality has improved (57.6%), indicating some recognition of positive environmental outcomes. Similarly, 54.7% believed that the programs adequately address environmental damage, while 54.7% also perceived the mining company as being committed to environmental restoration. In terms of socio-economic outcomes, 54.2% agreed that rehabilitation programs have improved livelihoods. However, a considerable proportion of respondents remained neutral or expressed disagreement across all statements, suggesting that confidence in the effectiveness of these programs is not uniform. Overall, the findings indicate that while rehabilitation efforts are perceived to have some positive impacts, there is still skepticism and uncertainty among a significant segment of the community.

3.3 Factors Influencing Community Participation in Mine Rehabilitation Programs

This section presents the findings related to the second research objective, which is to identify the factors influencing community participation in mine environmental rehabilitation programs around Trinity Nyakabingo Mines in Rulindo District.

3.3.1 Level of Community Participation

The findings (Figure 4.2) show that a majority of respondents 243 (62.1%) reported having participated in mine rehabilitation activities, while 148 (37.9%) indicated that they had never participated. This suggests a relatively good level of community engagement in mine rehabilitation programs, although a considerable proportion of the community remains uninvolved.

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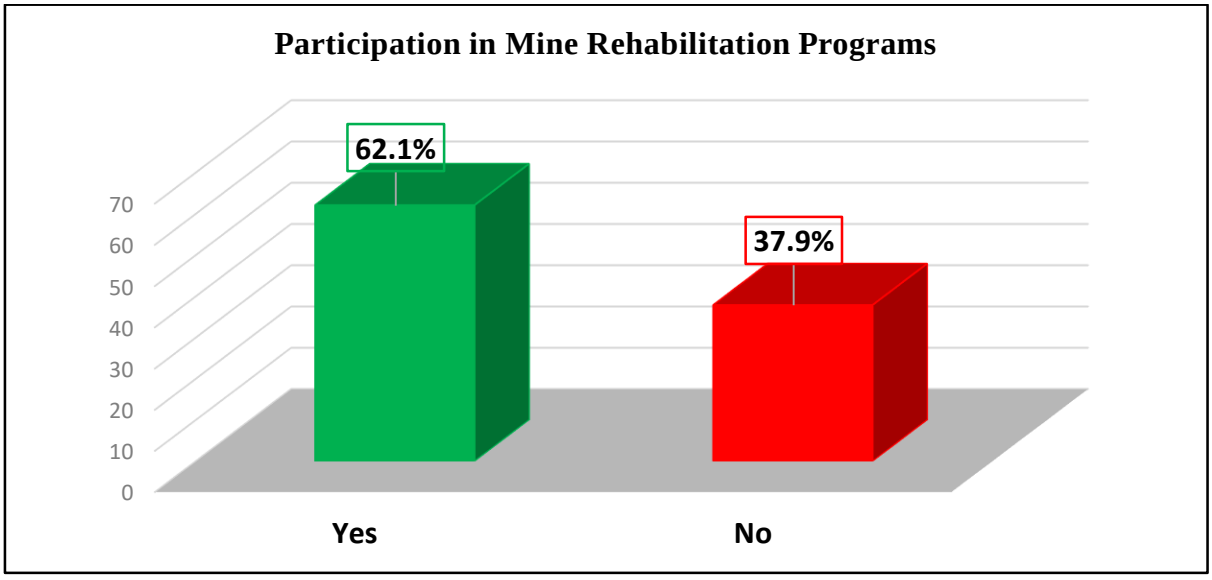

Figure 2: Participation in Mine Rehabilitation Programs (n = 391)

Findings from the focus group discussions further confirm that community participation in rehabilitation activities around Trinity Nyakabingo Mines is present but not universal. Participants reported that involvement is mainly seen in activities such as tree planting and community meetings, although participation is often irregular and depends on invitation or availability. One participant noted, *"Some of us take part in tree planting, but not all households are called or informed every time."* Others added that participation is sometimes limited to specific groups, with one respondent stating, *"You may want to participate, but you are only involved when the leaders select people."* These views reinforce the survey findings by showing that although participation exists, a considerable proportion of the community remains excluded or only partially engaged.

3.3.2 Motivational Factors Influencing Participation

Table 6: Motivational Factors (Mean Scores) (n = 391)

Statement	Mean	Std. Dev
Financial incentives motivate participation	3.92	1.12
Environmental concern motivates participation	4.15	0.98
Livelihood benefits motivate participation	4.03	1.05
Influence of community leaders	3.76	1.18
Sense of ownership/responsibility	4.08	1.01

Source: Author's compilation, 2026

The findings in Table 6 indicate that several motivational factors influence community participation in rehabilitation programs around Trinity Nyakabingo Mines. Overall, all the identified factors recorded mean scores above 3.5, suggesting general agreement among respondents. Environmental concern emerged as the strongest motivator (Mean = 4.15), followed closely by a sense of ownership and responsibility (Mean = 4.08) and livelihood benefits (Mean = 4.03). Financial incentives also play a significant role in encouraging participation (Mean = 3.92), while influence from community leaders, although still important, recorded the lowest mean score (Mean = 3.76). These findings suggest that participation is mainly driven by intrinsic motivations such as environmental awareness and responsibility, complemented by socio-economic incentives and community leadership influence.

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3.3.3 Barrier Factors Affecting Participation

Table 7: Barrier Factors (Mean Scores) (n = 391)

Statement	Mean	Std. Dev
Lack of information	3.87	1.14
Limited time	3.95	1.10
Lack of financial incentives	3.82	1.16
Exclusion from decision-making	3.90	1.12
Lack of trust in impact	3.78	1.19

Source: Author's compilation, 2026

The findings in Table 7 indicate that several barrier factors influence community participation in rehabilitation programs around Trinity Nyakabingo Mines. Overall, all the identified barriers recorded mean scores above 3.5, showing general agreement that they hinder participation. Limited time emerged as the most significant barrier (Mean = 3.95), followed by exclusion from decision-making processes (Mean = 3.90) and lack of information about rehabilitation programs (Mean = 3.87). Lack of financial incentives also represents an important constraint (Mean = 3.82), while lack of trust in the impact of participation recorded the lowest mean score (Mean = 3.78). These findings suggest that both structural and informational challenges significantly limit community engagement, with time constraints, weak inclusion mechanisms, and inadequate communication being the most influential barriers to participation.

3.3.4 Institutional Factors Influencing Participation

Table 8: Institutional Factors (Mean Scores) (n = 391)

Statement	Mean	Std. Dev
Adequate training provided	3.64	1.20
Government support	3.71	1.15
Feedback channels available	3.58	1.22
Company values community input	3.69	1.18

Source: Author's compilation, 2026

The findings in Table 8 indicate that institutional factors moderately influence community participation in rehabilitation programs around Trinity Nyakabingo Mines. All the assessed statements recorded mean scores slightly above 3.5, suggesting a generally moderate level of agreement among respondents. Government support emerged as the relatively strongest institutional factor (Mean = 3.71), followed by the perception that the company values community input (Mean = 3.69) and adequate training provided to community members (Mean = 3.64). Feedback channels available recorded the lowest mean score (Mean = 3.58), indicating comparatively weaker institutional communication mechanisms. Overall, these findings suggest that although institutional structures supporting community participation exist, they are perceived as only moderately effective, with room for improvement in training, feedback systems, and participatory governance mechanisms.

3.3.5 Socio-Economic Factors Influencing Participation

Table 9: Perceived Benefits from Mine Environmental Rehabilitation Programs (n = 391)

Statement	Mean	Std. Dev
Respondents have benefited from rehabilitation programs	2.57	0.75

Source: Author's compilation, 2026

The mean score of 2.57 indicates that slightly more than half of the respondents reported benefiting from mine environmental rehabilitation programs. However, the standard deviation of 0.50 suggests notable variation in responses, confirming that a substantial proportion of respondents did not experience benefits. This disparity may negatively influence community participation in rehabilitation activities.

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3.3.6 Binary Logistic Regression Results on Factors Influencing Community Participation in Mine Rehabilitation Programs

Table 10 presents the results of the binary logistic regression analysis examining the factors influencing community participation in mine rehabilitation programs in Trinity Nyakabingo Mines, Rulindo District. The model incorporates motivational, barrier, institutional, and socio-economic factors to determine their effect on the likelihood of community participation. The analysis is based on a sample of 391 respondents and identifies both the direction and strength of the relationships between the independent variables and participation in rehabilitation activities.

Table 10: Binary Logistic Regression Results on knowledge level and Sociodemographic Factors Influencing Community Participation in Mine Rehabilitation Programs (n = 391)

Variable	Coefficient (β)	Std. Error	t-value	Sig.
Constant	0.842	0.215	3.92	0.000
Knowledge level	0.356	0.048	7.42	0.000
Age	0.071	0.032	2.22	0.027
Gender	0.058	0.041	1.41	0.159
Education level	0.143	0.036	3.97	0.000
Occupation	0.089	0.029	3.07	0.002

$R^2 = 0.38$

$F = 47.63, p < 0.001$

Source: Author's compilation, 2026

The findings in Table 10 present the results of the logistic regression analysis examining the predictors of community participation in mine rehabilitation programs around Trinity Nyakabingo Mines. The model indicates that knowledge level has a positive and statistically significant effect on participation ($\beta = 0.356$, $p < 0.001$), meaning that higher levels of knowledge significantly increase the likelihood of participation. Education level ($\beta = 0.143$, $p < 0.001$) and occupation ($\beta = 0.089$, $p = 0.002$) are also significant predictors, showing that socio-economic characteristics influence participation behavior. Age has a small but significant positive effect ($\beta = 0.071$, $p = 0.027$), while gender is not statistically significant ($p = 0.159$), indicating that participation does not differ meaningfully between males and females. The model explains 38% of the variation in participation ($R^2 = 0.38$), and the overall model is statistically significant ($F = 47.63$, $p < 0.001$), confirming that the selected variables collectively provide a good explanation of participation in rehabilitation programs.

3.4 Relationship Between Community Knowledge and Factors Affecting Participation in Mine Rehabilitation Programs

This section presents the findings related to the third research objective, which is to examine the relationship between community knowledge and participation in mine environmental rehabilitation programs around Trinity Nyakabingo Mines in Rulindo District. The analysis of this relationship was conducted using regression analysis, which involved three key outputs: the Model Summary, ANOVA table, and Coefficients table. The Model Summary was used to determine the strength of the relationship, the ANOVA table assessed the overall significance of the model, while the Coefficients table determined the direction and statistical significance of the relationship between community knowledge and participation.

Table 11: Model Summary of the Relationship Between Knowledge and Participation

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.462	0.214	0.212	0.734

a. Predictors: (Constant), Community Knowledge

b. Dependent Variable: Community Participation in Mine Rehabilitation Programs

Source: Author's compilation, 2026

The model summary indicates a moderate positive relationship between community knowledge and participation in mine rehabilitation programs. The R value of 0.462 shows a moderate association, while the R Square value of 0.214 indicates that 21.4% of the variation in community participation is explained by knowledge levels. The adjusted R Square (0.212) confirms the stability of the model, and the standard error of 0.734 indicates a reasonable level of prediction accuracy.

Table 12: ANOVA Results

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	52.418	1	52.418	97.02	0.000
Residual	192.566	389	0.495		
Total	244.984	390			

Source: Author's compilation, 2026

The ANOVA results indicate that the regression model is statistically significant ($F = 97.02$, $p < 0.001$). This means that community knowledge significantly predicts participation in mine rehabilitation programs. The p-value being less than 0.05 confirms that the relationship between knowledge and participation is not due to chance, and therefore the model is a good fit for the data.

4. DISCUSSIONS OF FINDINGS

The findings of this study indicate that community participation in mine environmental rehabilitation is influenced by a combination of knowledge, access to information, socio-economic conditions, and institutional support. Although most community members were aware of rehabilitation activities and recognized the environmental impacts of mining, awareness alone did not guarantee active participation. This finding is consistent with previous studies (Alonzo et al., 2023; Fogarty et al., 2023; Mwanza, 2025), which argue that effective participation depends not only on awareness but also on the quality of communication, transparency, and opportunities for meaningful involvement in rehabilitation processes.

The study further revealed that participation is strengthened when communities perceive tangible benefits from rehabilitation programs and when institutions create enabling conditions for engagement. Similar findings have been reported by Nag (2025) and Sutrisno and Suryawan (2024), who found that stakeholder participation increases when communities receive adequate support, capacity-building opportunities, and socio-economic incentives. These results suggest that participation is not solely an individual choice but is significantly shaped by institutional responsiveness, inclusiveness, and the extent to which rehabilitation initiatives address local community interests and needs.

A key finding of the study is the existence of a significant positive relationship between community knowledge and participation in mine rehabilitation programs. This confirms the view that knowledge serves as a critical foundation for environmental stewardship and community engagement. Consistent with the findings of Mwanza (2025), Nag (2025), and Sutrisno and Suryawan (2024), the study demonstrates that informed community members are more likely to participate actively in rehabilitation activities. Therefore, sustainable mine environmental rehabilitation requires not only technical restoration measures but also continuous community education, effective information-sharing mechanisms, and inclusive governance approaches that empower local communities as active partners in environmental restoration and resource management.

5. CONCLUSION

This study concludes that community participation in mine environmental rehabilitation programs around Trinity Nyakabingo Mines is influenced by a combination of knowledge-related, socio-economic, and institutional factors that collectively determine the extent and quality of local engagement. While the findings reveal that community members generally possess awareness of environmental rehabilitation activities and acknowledge the environmental consequences of mining operations, this awareness does not necessarily translate into meaningful participation. The limited depth of knowledge regarding rehabilitation objectives, processes, and expected outcomes constrains active involvement and results in participation that is often irregular, consultative rather than collaborative, and insufficient to achieve long-term sustainability goals.

The study further establishes that community members demonstrate a positive attitude toward environmental restoration and express a willingness to contribute to rehabilitation initiatives. However, their participation is hindered by several

challenges, including inadequate access to relevant information, limited financial and time resources, insufficient technical understanding of rehabilitation practices, and restricted opportunities to participate in planning and decision-making processes. These barriers reduce the effectiveness of community contributions and weaken local ownership of rehabilitation programs. Importantly, the statistical analysis confirms a significant positive relationship between community knowledge and participation levels, indicating that individuals with greater understanding of environmental rehabilitation are more likely to engage actively in restoration activities.

The findings also suggest that institutional mechanisms designed to facilitate community involvement remain inadequate. Although rehabilitation programs are implemented with the intention of restoring degraded environments, limited stakeholder engagement and insufficient communication between mining authorities and local communities reduce the inclusiveness and effectiveness of such interventions. As a result, rehabilitation efforts risk being perceived as externally driven initiatives rather than shared community responsibilities.

Based on these findings, the study concludes that the success and sustainability of mine environmental rehabilitation programs depend not only on the availability of technical expertise and financial resources but also on the meaningful empowerment of local communities through continuous environmental education, transparent information sharing, capacity building, and inclusive governance structures. Strengthening community knowledge and ensuring active participation throughout the planning, implementation, monitoring, and evaluation stages of rehabilitation programs are essential for enhancing environmental outcomes and fostering a sense of ownership among stakeholders. Ultimately, sustainable mine environmental rehabilitation in Rulindo District requires a participatory approach that moves beyond passive consultation toward genuine community partnership. Local residents should be recognized as key actors in environmental restoration and natural resource management, whose knowledge, experiences, and contributions are indispensable for achieving lasting ecological recovery, social acceptance, and sustainable development in mining-affected communities.

6. ETHICAL CONSIDERATIONS

Ethical considerations were strictly observed throughout the study to protect the rights, dignity, and well-being of all participants. Prior to data collection, ethical clearance was obtained from the University of Lay Adventists of Kigali (UNILAK) to ensure that the study complies with established academic and research ethics standards.

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