JRIIE Journal of Research Innovation and Implications in Education
Center for Research Implications & Practice

Website:www.jriiejournal.com ISSN 2520-7504 (Online) Vol.9, Iss.1, 2025 (pp. 316 – 330)

Influence of Community Engagement on the Sustainability of Borehole Projects in Ruhango District, Rwanda

Sandrine Mutuzo & Wabala Samuel
University of Kigali
Email: sandrinemutuzo@gmail.com

Abstract: *This study investigates the influence of community engagement in capacity-building initiatives on the sustainability of borehole projects in Ruhango District, Rwanda. Employing a descriptive research design, the study examines how community involvement in technical training, leadership development, and financial literacy programs impacts the long-term effectiveness and operational success of borehole water systems. The research is anchored in the Capacity-Building and Sustainability theories, which emphasize the importance of empowering local communities to effectively manage resources for sustainable development. A sample size of 269 respondents, including community members, local authorities, and project manager, was selected using stratified purposive sampling. Data were collected through structured questionnaires and interviews, and the analysis was conducted using SPSS version 21. Correlation analysis revealed a positive but moderate correlation of 0.693 ($p < 0.01$) between community engagement in capacity-building initiatives and project sustainability, indicating that increased community participation in these initiatives is linked to greater project sustainability. The regression analysis further confirmed the statistically significant effect of capacity-building initiatives on project sustainability. Despite the positive relationship, the study identifies gaps in the effectiveness of the training programs, particularly in leadership and financial literacy, which are crucial for the long-term sustainability of borehole projects. In conclusion, while community engagement plays an important role in the sustainability of borehole projects, more targeted training in leadership and financial management is recommended to ensure long-term success.*

Keywords: *Community Engagement, Project Sustainability, Borehole Project, Capacity-building initiative, Ruhango District*

How to cite this work (APA):

Mutuzo, S. & Wabala, S. (2025). Influence of community engagement on the sustainability of borehole projects in Ruhango District, Rwanda. *Journal of Research Innovation and Implications in Education, 9*(1), 316 – 330. **https://doi.org/10.59765/57ge7.**

1. Introduction

Community engagement plays a critical role in ensuring the sustainability of development projects (World Bank, 2020). When local communities are actively involved in the planning, implementation, and management of projects, they are more likely to take ownership, ensuring the long-term success and upkeep of the project. This involvement can range from decision-making to the maintenance of infrastructure. For example, in many rural areas, the maintenance of water systems such as boreholes is often handled by the local community (UNDP, 2021). When communities are trained to care for these systems, they ensure that the infrastructure continues to meet local needs, making it less reliant on external support (IIED, 2019). This participatory approach fosters responsibility and ensures that the projects remain functional for years, rather than deteriorating due to lack of attention or resources.

Globally, the role of community engagement in sustainable development has been recognized as a key factor in the success of various projects (Steve, 2022). Across many regions, particularly in rural and underserved areas, projects are more likely to be sustainable when local populations are directly involved in their design and

management. For instance, in India, community-based management models like the "Pani Panchayat" in Maharashtra have empowered local communities to manage water systems, leading to improved maintenance and equitable access to water (Sharma, 2021). Similarly, countries in Latin America, such as Brazil and Colombia, have also adopted community-driven water management strategies. In Colombia, water user committees have taken on the responsibility of maintaining rural water systems, leading to more efficient and sustainable water distribution in remote areas. (Colombia, Ministry of Environment and Sustainable Development, 2022).

In developed countries, community engagement has long been part of the framework for managing public services such as water systems (Toroide, 2020). Countries like Denmark and the Netherlands have successfully integrated local participation into their water management systems. In the Netherlands, the concept of Water Boards, which are self-governing bodies consisting of local stakeholders, ensures that water management is closely aligned with the needs of the community (Wilson, 2021). These local bodies are responsible for the maintenance and management of water systems, making the entire process more efficient and responsive to the needs of residents. Similarly, in the United Kingdom, local authorities work with community groups to ensure that water infrastructure projects are aligned with local needs, ensuring sustainability and effective management.

Across Africa, the importance of community engagement in water projects has gained significant attention. In countries like Kenya, Ghana, and Tanzania, participatory water management has led to greater success and sustainability in rural water projects (Steve, 2022). In Kenya, for example, water committees are responsible for managing boreholes, ensuring that they are maintained by local residents rather than relying on external agencies. This model has proven to be effective in increasing access to clean water while also ensuring that systems are maintained over time. Similarly, in Ghana, rural communities are actively involved in both the planning and maintenance of water systems. This model has not only improved water access but also reduced water-related diseases, as communities are more invested in ensuring the cleanliness and functionality of their water sources (Smith and Jones, 2020). These African examples emphasize that when communities are engaged, they take ownership of water projects, ensuring that these resources are sustainable and effective in the long term.

In East Africa, community engagement in water projects has shown promising results, with countries such as Tanzania, Uganda, and Rwanda leading the way. In Tanzania, village water committees are responsible for managing local water resources, including boreholes, and ensuring that they are kept in working condition (Oliva, 2020). These community-led initiatives have helped maintain the sustainability of water systems, especially in rural areas. Uganda has also adopted decentralized models for water management, where local communities have a say in decision-making and are actively involved in managing water points. In Rwanda, the emphasis on community-driven projects has been particularly successful, with local populations playing a key role in the maintenance of boreholes and other water infrastructure (Mutiso & Nyang'oro, 2019). This approach has helped ensure that water systems remain operational, reducing the dependence on external aid and fostering local empowerment.

In Rwanda, community engagement has proven to be a key driver in the sustainability of infrastructure projects, particularly in the water sector (Nshimiyimana, 2021). In districts like Ruhango, local communities are involved from the planning stage all the way through to the ongoing management and maintenance of water systems. By focusing on training and empowering local residents, Rwanda has developed a model where communities take full ownership of boreholes, ensuring their continued functionality. This hands-on involvement not only guarantees the availability of clean water but also fosters stronger community bonds and promotes collective responsibility. The success of Rwanda's approach is evident in its ability to address water challenges using locally driven solutions, reducing reliance on external aid (Rwanda Ministry of Infrastructure, 2020). The experience in Ruhango District, where community members play an active role in managing water systems, highlights how community participation can result in more sustainable and lasting outcomes (Kagabo & Uwimana, 2022).

1.1 Problem statement

In Rwanda, community engagement plays a vital role in ensuring the sustainability of development projects, particularly in rural water interventions like boreholes (Terry, 2020). By involving local communities in decision-making, implementation, and ongoing management, projects are better aligned with community needs and priorities, leading to stronger ownership and more effective maintenance (Rwanda Water and Sanitation Corporation, 2023). However, while community engagement is crucial, many borehole projects face significant challenges in sustaining local involvement after the initial phases. Once external funding or technical support is withdrawn, many projects struggle to maintain functionality due to declining community engagement, particularly in the operation and maintenance stages. As a result, rural communities often continue to experience water access issues, with boreholes frequently falling into disrepair and being abandoned.

Existing research highlights the importance of community engagement for the long-term success of water projects.

Studies such as Mubangizi et al. (2022) show that community-managed systems in Rwanda are more likely to remain operational due to local ownership and active participation in decision-making. Musoni et al. (2020) also emphasize that water management committees involving local people in ongoing maintenance result in fewer breakdowns and better project sustainability. However, studies like Niyonsaba et al. (2023) highlight that community involvement tends to fade after the initial project phases, resulting in poor maintenance and eventual failure of the project. Mushobozi et al. (2021) argue that while participation is encouraged during the planning and implementation phases, there is insufficient focus on empowering communities to take responsibility for ongoing management once external support ends. Additionally, Habyarimana et al. (2024) point out that weak local governance and lack of technical capacity hinder the effective engagement needed for sustaining these water systems in rural areas.

Despite the known benefits of community engagement, there remains a gap in understanding how to ensure sustained involvement, particularly in the post-implementation phase. While initial engagement is often prioritized, few studies have examined how ongoing community participation in water projects affects their long-term maintenance and sustainability. Moreover, there is limited research on the role of local leadership, governance structures, and capacity-building efforts in sustaining community engagement and ensuring the continued operation of borehole projects. This study aimed to address this gap by exploring how sustained community engagement influences the sustainability of borehole water projects in rural Rwanda, focusing on the mechanisms that support or hinder long-term success.

This study sought to achieve the following Research objective:

To examine the influence of community engagement in capacity-building initiatives for enhancing the sustainability of borehole projects in Ruhango District.

2. Literature Review

2.1 Community Engagement

Community engagement has emerged as a central element in the success and sustainability of development projects globally. When local communities participate actively in the design, implementation, and management of projects, they are more likely to take ownership of the initiative, leading to improved outcomes and longevity (Schneider, 2021). This approach fosters responsibility and ensures that the project continues to meet local needs, reducing the risk of abandonment once external support is withdrawn. In the context of water projects like boreholes, engaging communities ensures that the systems are maintained and protected, especially in rural and underserved areas where external interventions are limited (Johnson, 2022). As such, community involvement is not just a means of improving project relevance but also a strategy to empower local populations to manage their resources effectively (Foster, 2023).

One of the key benefits of community engagement is the creation of social cohesion, where local residents collaborate to achieve common goals. This is particularly important in rural settings where resources and expertise may be limited. Involving community members in the decision-making process helps build trust and encourages collective action, which is crucial for ensuring the sustainability of infrastructure projects like boreholes (Hansen, 2021). For example, the “Pani Panchayat” system in India, where local communities manage water systems, has been successful due to strong community participation in both the planning and management phases (Müller, 2020). Similarly, in rural Rwanda, water projects have benefited from local engagement, where communities participate in maintaining and protecting water systems (Rwanda Water and Sanitation Corporation, 2023). These efforts highlight the importance of involving local communities in decision-making to ensure the long-term success of development projects.

Additionally, when communities are empowered to take on roles in decision-making, they are better positioned to sustain projects over time. Studies have shown that in areas where communities are directly involved in managing resources, the projects are more likely to succeed and endure (Thomson, 2021). This is particularly evident in the case of water projects in rural Africa, where community involvement has led to better-maintained systems and reduced failure rates (Terry, 2022). Through active participation, communities not only improve the management of resources but also build the necessary skills and knowledge to handle challenges that arise over time, contributing to the overall sustainability of the projects (Smith & Jones, 2020).

2.1.2 Community engagement in Capacity Building Initiatives

Capacity building initiatives are essential in ensuring the sustainability of community-driven development projects. By equipping local communities with the necessary skills and knowledge, capacity building ensures that they are prepared to manage, operate, and maintain infrastructure like boreholes effectively (Hansen, 2021). In water projects, this may involve training community members in technical tasks such as repairing and maintaining water pumps, managing water resources, and overseeing finances

for project upkeep. In Rwanda, for instance, the training of local community members in water management and repair has led to the continued functionality of boreholes, reducing dependence on external support (Mushobozi et al., 2021). This approach has proven successful in various global contexts, where capacity building has helped rural communities sustain infrastructure in the long term (Baker, 2020).

Building local capacity also ensures that communities can address challenges as they arise. In countries like Kenya, where water projects have incorporated capacity-building components, local communities have been able to manage water systems effectively without external intervention (UNICEF, 2022). By providing technical training, local residents gain the skills necessary to identify and solve problems, such as pump breakdowns or water contamination, ensuring that the infrastructure remains operational and accessible for years (Wilson, 2021). Such initiatives contribute not only to the success of the project but also to the development of local leadership and management skills, which can be used in other areas of community development (Thomson, 2022).

Furthermore, capacity building initiatives often include education on environmental sustainability, teaching communities about the long-term impact of their actions on the environment and water resources. In countries such as Uganda and Rwanda, where such training has been integrated into water management programs, communities are more likely to adopt sustainable practices, such as water conservation and pollution prevention (Müller, 2022). This broader approach to capacity building helps ensure that communities are not only able to manage infrastructure but also understand the environmental factors that influence its sustainability. By fostering both technical and environmental knowledge, capacity-building initiatives contribute to the long-term sustainability of water projects (Smith & Jones, 2020).

2.1.3 Project Sustainability

Project sustainability is a key aspect of ensuring that the benefits of development projects are sustained over the long term. For water projects such as boreholes, sustainability encompasses financial sustainability, technical sustainability, and social sustainability (Schneider, 2021). Financial sustainability refers to the ability of a project to generate enough resources for its continued maintenance, while technical sustainability involves the functionality of the infrastructure over time. Social sustainability, on the other hand, emphasizes the active participation of the community in the management and upkeep of the project. All three dimensions are crucial for ensuring that the project continues to provide benefits to the community even after the initial implementation phases (Henry, 2022).

In rural water projects, financial sustainability is often achieved through local contributions or tariffs, which provide the necessary funds for maintenance and repairs. For example, in Kenya, community-managed water systems that charge small fees for water usage have been able to sustain themselves financially, ensuring that the infrastructure remains functional (UNICEF, 2022). Similarly, in Rwanda, water user committees have been set up to manage local water resources and generate funds for ongoing maintenance (Rwanda Water and Sanitation Corporation, 2023). These examples highlight the importance of establishing financial systems that allow communities to maintain and manage their water projects effectively over the long term.

Moreover, the technical sustainability of water systems relies on the capacity of the community to manage, maintain, and repair the infrastructure. In countries like Uganda, where communities are trained in water system maintenance, technical sustainability is enhanced, and the need for external support is reduced (Müller, 2022). By building local capacity and ensuring that communities have the skills to handle maintenance tasks, water projects are able to remain operational without relying on external interventions. In Rwanda, technical sustainability has been achieved through capacity-building programs that train local communities to repair and maintain boreholes, ensuring the long-term functionality of water systems (Theobald, 2021). These efforts contribute to the overall success and sustainability of water projects, demonstrating the critical role of local engagement and capacity building.

2.2 Theoretical Review

In order to understand the dynamics of community engagement and its impact on the sustainability of borehole projects in Ruhango District, it is essential to explore relevant theories that underpin the concepts of community involvement, development, and sustainability. These theories provide frameworks for understanding how communities participate in development projects and the factors that influence the long-term success of these projects. This section discusses three key theories that are integral to this study: Community-Based Development Theory, Social Capital Theory, and Sustainability Theory. Each of these theories offers unique insights into how community engagement can contribute to the sustained success of water infrastructure projects, particularly in rural areas.

2.2.1 Community-Based Development Theory

Community-Based Development Theory was introduced by Robert Chambers in the 1980s and later expanded by several scholars, including Amartya Sen and Michael Cernea. Chambers, in particular, focused on the empowerment of local communities and their active participation in development processes, emphasizing that community involvement should be at the heart of development interventions (Sandra, 2023). Over time, this theory has become an important framework for understanding how local knowledge and grassroots engagement contribute to the success of development projects. It shifted the perspective from top-down to bottom-up approaches, challenging the conventional reliance on external experts to dictate community development (Mansuri & Rao, 2021).

Community-Based Development Theory essentially posits that the success of development projects hinges on the active participation of local communities (Toroid, 2020). It asserts that communities should not just be the recipients of development aid, but should have a central role in designing, implementing, and managing projects. By doing so, projects are more likely to be sustainable and aligned with the actual needs and priorities of the community (Gael, 2021). This participation fosters a sense of ownership, which in turn enhances the longevity of the project. For example, in water systems such as boreholes, when local communities are involved in decision-making and maintenance, they are more likely to ensure that the system remains operational over time.

This theory directly supports the objective of the study, which focuses on the influence of community engagement in decision-making on the sustainability of borehole projects in Ruhango District. By involving local communities in decisions such as the location, design, and management of boreholes, the theory suggests that communities will feel a sense of ownership and responsibility for these projects, leading to better maintenance and longer-lasting outcomes.

2.2.2 Sustainability Theory

Sustainability Theory emerged from the Brundtland Report published by the World Commission on Environment and Development (WCED) in 1987, under the leadership of Gro Harlem Brundtland. The report defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Kate, 2020). The theory has since evolved to include not only environmental concerns but also social and economic dimensions of sustainability, stressing the importance of inclusivity, equity, and long-term resource management (Kakooza,2019). It has become a foundational principle in international development and environmental policy, guiding both large-scale and community-based projects toward more sustainable outcomes (Sachs, 2019).

Sustainability Theory advocates for the design of projects that can continue to meet the needs of the community over the long term without depleting resources or causing harm to future generations (Oliva, 2022). This involves integrating environmental, social, and economic factors into the development process to ensure that projects are not only effective but also resilient and enduring. In the context of borehole projects, Sustainability Theory suggests that water systems must be managed in a way that allows them to function for many years, with ongoing support and community involvement, to ensure they continue to meet local needs without exhausting resources or requiring constant external intervention (Huth, 2021).

This theory is relevant in demonstrating that the sustainability of the borehole systems in Ruhango hinges not only on the initial construction but also on the active, ongoing engagement of the community in its maintenance and use. Social mobilization, therefore, plays a critical role in educating and empowering the community, fostering the collective action needed to sustain these water systems. By mobilizing social resources and creating awareness, the project ensures that the local population continues to view the water systems as a shared responsibility, crucial for their daily lives and future well-being (Kates et al., 2005; Sachs, 2019). This approach underlines the importance of social participation in enhancing the long-term viability and success of water projects.

2.3 Empirical Literature

The empirical review examines how community engagement affects the sustainability of borehole projects in various global contexts, focusing on three key areas: decision-making, capacity-building, and social mobilization and awareness. It compares the impact of community participation in water projects across developed countries, Africa, East Africa, and Rwanda. The review highlights a positive relationship between community engagement and project sustainability but also identifies gaps in the literature, particularly regarding the mechanisms of engagement and challenges faced in rural areas.

2.3.1 Community engagement in Capacity-Building Initiatives and Project Sustainability

Globally, capacity-building initiatives have shown to significantly impact the sustainability of water projects.

The World Bank's (2021) study across several developing countries revealed that projects with strong community capacity-building programs had a 40% higher sustainability rate. Training local communities in water system management and maintenance led to a 35% reduction in system failures. Regression analysis indicated a positive correlation ($r = 0.61$) between capacity-building and the operational sustainability of these systems. These findings suggest that when local communities are equipped with the necessary skills to manage and maintain infrastructure, projects are more likely to be sustained in the long term. However, a gap exists in research on the specific types of training that are most effective for different communities, such as technical training versus managerial training.

In developed countries, capacity-building initiatives have also been integral to ensuring the sustainability of water systems. A study in the United Kingdom by Roberts et al. (2020) found that when local communities were provided with training on water management, project sustainability improved by 25%. Regression analysis showed that capacity-building efforts explained 22% of the variance in the long-term sustainability of water systems ($R^2 = 0.22$). The study demonstrated that local communities who were empowered with technical skills could reduce their reliance on external agencies and take full ownership of the maintenance and management of water infrastructure. However, the research does not explore the specific barriers faced by different socioeconomic groups in accessing capacity-building programs, which represents a gap in the existing literature.

In Africa, capacity-building initiatives have been essential for the sustainability of water projects. In Ghana, Osei et al. (2021) found that water projects that included local capacity-building programs experienced a 35% reduction in failure rates. The regression analysis showed a positive correlation ($r = 0.74$) between community training and the sustainability of water systems. This study emphasized that when communities were trained in system maintenance, the projects were more resilient and had a higher chance of remaining operational in the long term. However, the study does not address the challenge of scalability for capacity-building programs, particularly in remote rural areas where infrastructure and resources may be limited.

In East Africa, capacity-building programs have proven to be critical for the success of water projects. In Uganda, a study by Turyahikayo et al. (2019) revealed that communities trained in water system management experienced a 40% improvement in the sustainability of borehole projects. Regression analysis showed a strong positive correlation ($r = 0.80$) between capacity-building initiatives and the continued functionality of water systems. The study highlighted that training local communities in both technical and managerial aspects of water systems led to reduced breakdowns and a more efficient use of resources. However, there is a gap in understanding how the integration of gender perspectives into these capacity-building programs impacts the sustainability of the projects.

In Rwanda, capacity-building programs are central to the success of rural water projects. A study by the Rwanda Water and Sanitation Corporation (2023) found that local training initiatives in Ruhango District increased the sustainability rate of borehole projects by 50%. Regression analysis indicated that these capacity-building efforts explained 30% of the variance in the operational success of the water systems ($R^2 = 0.30$). The findings suggest that when local communities are trained to manage and repair water systems, they are better equipped to maintain their infrastructure without depending on external agencies. However, a gap exists in research regarding the impact of community ownership of the capacity-building process itself and how this affects the success of these initiatives.

3. Methodology

Saylor (2020) defines a research design as the blueprint for conducting a research study that outlines the procedures for collecting, measuring, and analyzing data. It provides the overall structure for the research process, ensuring that the study is systematic, organized, and capable of addressing the research questions. A well-defined research design is essential for ensuring that the study produces valid, reliable, and meaningful results.

For this study, a descriptive research design was adopted, as it is well-suited to examine the relationship between community engagement and the sustainability of borehole water projects in Ruhango District, Rwanda. Descriptive research aims to provide a detailed account of the characteristics of the population or phenomenon being studied. This design allowed the researcher to capture both the quantitative and qualitative aspects of community engagement and its impact on water project sustainability. By combining both quantitative and qualitative methods, the study provided a comprehensive understanding of how community involvement in decision-making, capacity-building, and social mobilization contributes to the long-term success of water systems. Descriptive research allowed for the collection of rich, detailed data, offering insights into the factors that influence sustainability and the challenges faced by local communities in managing their water resources.

For this study, the target population consisted of community members, local leaders, and key stakeholders involved in the management and implementation of

borehole water projects in the Byimana sector of Ruhango District. This includes 3,152 local community members who directly benefit from the water systems, as well as 1 project manager, 18 water user committees, 3 local government officials, and 3 community-based organizations that oversee the implementation and sustainability of these projects. In total, the target population comprised 3,177 individuals, representing the various stakeholders associated with the 9 boreholes located in Byimana sector. The following gives details on target population.

Table 1: Table representing target population

Category	Total Population
Project manager	1
Local government officials	3
Representatives of community-based organizations	3
Community members (direct beneficiaries)	3,152
Members of water user committees	18
Total	**3177**

Source: Ruhango District Report, 2025

For this research, a stratified random sampling technique was employed to ensure that different subgroups within the target population are adequately represented. Stratified random sampling involves dividing the population into distinct strata or categories, and then randomly selecting participants from each group. This method is particularly useful when there are distinct subgroups within the population, ensuring that the sample reflects the diversity of the population with respect to key characteristics such as community members, local leaders, water management committee members, and community-based organizations. In this study, the population was divided into five main categories: project manager, community members, local leaders, water user committees, and representatives from community-based organizations (CBOs). A random selection was made from each stratum to ensure that each group contributes proportionally to the sample size.

To determine the appropriate sample size for this study, the researcher used the formula for sample size estimation, as provided by Krejcie and Morgan (1970). Given the target population of 3177 individuals, the sample size was 342 to ensure that the results are statistically significant while balancing resource constraints. This approach allowed for reliable and valid conclusions about the relationship between community engagement and the sustainability of borehole water projects. A stratified random sampling technique was employed to ensure that the sample accurately represents the diversity within the population. The community was divided into strata based on key characteristics such as roles in water project management (e.g., community members, local leaders, project staff), and participation in decision-making activities. Random sampling was then used within each stratum to select participants. This ensured that the sample is both representative and diverse, capturing insights from different segments of the population. Additionally, key informant interviews were conducted with selected leaders involved in the management of water systems.

The data collection methods for this study involved both primary and secondary data. Primary data was gathered through structured surveys, semi-structured interviews, and direct observations. Surveys provided quantitative data on community engagement, while interviews offered deeper insights into stakeholder experiences. Observations at water project sites helped assess the impact of community engagement activities on the sustainability of water systems. Secondary data was collected from project reports, evaluations, and maintenance logs from both governmental and non-governmental organizations to provide additional context and triangulate the primary data. The data collection aimed to capture a comprehensive understanding of the factors affecting the sustainability of water projects.

To ensure reliable and valid data, several instruments were used, including questionnaires, interview guides, and documentary reviews. The questionnaire contained both open-ended and Likert scale questions to assess community participation in decision-making, capacity-building, and social mobilization. A semi-structured interview guide was used for in-depth interviews with key informants such as project managers and local government officials. The documentary review analyzed project documents to assess the effectiveness of community engagement over time. A pilot study was conducted to test the instruments, and feedback led to revisions. The validity of the instruments was established using the Content Validity Index (CVI), and reliability was assessed using Cronbach's Alpha, which showed the questionnaire had sufficient reliability for data collection.

Data analysis involved both quantitative and qualitative methods. Quantitative data were analyzed using descriptive

statistics to summarize basic characteristics, followed by regression analysis to examine the relationships between community engagement and the sustainability of water projects. The qualitative data were analyzed through thematic analysis, where key themes were identified from interview responses to complement the quantitative findings. Ethical considerations included obtaining informed consent, ensuring confidentiality, and maintaining transparency in reporting the research findings, with all data securely stored and anonymized to protect participants' privacy.

4. Results and Discussion

This section presents the findings from both quantitative and qualitative data analysis. Descriptive and inferential statistics were used to analyze the data, with the findings presented through frequency distributions, means, and standard deviations, displayed in tables for clarity. The section begins with an overview of the response rate, followed by a detailed presentation of the results derived from both descriptive and inferential statistical methods. The findings are then discussed in relation to the research objectives and existing literature, providing a comprehensive interpretation of how community engagement impacts the sustainability of water projects.

4.1 Findings

This section presents the key findings derived from the data analysis conducted during the study, including both the results from the pilot test and the main data collection

4.1.1 Pilot Test Results

The pilot test was conducted to assess the reliability and validity of the research instrument (questionnaire) used in this study. A total of 25 participants, randomly selected from the target population at Rwanda Energy Group, participated in the pilot test. The feedback and data obtained from this group were analyzed to ensure the questionnaire was effective in measuring the intended constructs and to identify any areas that needed adjustment before the main data collection

Table 2: Cronbach's Alpha Reliability Test for Key Variables

Variables	N (Number of Items)	C (Average Inter-Item Covariance)	V (Average Variance of Items)	Cronbach's Alpha (α)
Capacity Building Initiative	6	0.44	0.8	0.8
Project Sustainability	6	0.48	0.77	0.84

Source: Primary data, 2025

Table 2 presents the results of the Cronbach's Alpha reliability test for key variables used in the study. The table shows that the Capacity Building Initiative variable, consisting of 6 items, had an average inter-item covariance of 0.44, an average variance of 0.8, and a Cronbach's Alpha value of 0.8, indicating good internal consistency. Similarly, the Project Sustainability variable, with 6 items, had an average inter-item covariance of 0.48, an average variance of 0.77, and a Cronbach's Alpha value of 0.84, which also reflects strong reliability. These results confirm that the instruments used to measure these constructs were reliable for data collection in the study.

4.1.2 Response Rate

The study targeted a total population of 3,177 individuals and sampled 342 respondents. Of these, 337 respondents were given questionnaires, representing 98.5% of the sample. Additionally, 5 individuals were selected for interviews, which included 1 project manager, 1 local government official, 1 representative from a community-based organization, and 2 members of water user committees. Out of the 337 distributed questionnaires, 269 were returned, yielding a return rate of approximately 79.8%. Adding the 5 interviewees (which accounts for 1.5% of the total sample), the total number of responses for the study was 274, which represents a total response rate of approximately 80.2%. This high response rate reflects strong participation and indicates that the study's findings are both reliable and representative of the target population, providing solid grounds for analysis and conclusions.

Table 3: Distribution of Questionnaires and Response Rate

Category	Frequency	Percentage (%)
Total Sample	342	100
Questionnaires Distributed	337	98.5
Questionnaires Returned	269	79.8

Source: Primary data, 2025

Table 3 shows that out of the 342 respondents targeted in the study, 337 questionnaires were distributed, representing 98.5% of the total sample. Of these distributed questionnaires, 269 were successfully returned, resulting in a response rate of 79.8%. According to Mugenda & Mugenda (2003), a response rate below 40% is considered unreliable, 40%-50% as poor, 50%-60% as acceptable, 60%-70% as good, 70%-80% as very good, and above 80% as excellent. With a response rate of 79.8%, the study falls within the very good category. This indicates strong participation, ensuring that the findings are both reliable and representative of the target population. The 79.8% response rate reflects a high level of engagement, making the results robust for analysis and providing a solid foundation for drawing conclusions.

4.1.3 Descriptive Statistics of capacity-building initiatives

The objective of this study was to examine the influence of community engagement in capacity-building initiatives on enhancing the sustainability of borehole projects in Ruhango District. Specifically, this objective sought to explore how the involvement of the community in training programs, skills development, and knowledge sharing impacts the long-term effectiveness and operational success of borehole water systems. A Likert scale ranging from 1 to 5 was employed to measure the respondents' level of agreement with several statements related to community engagement and project sustainability. The scale was structured as follows: 1-5 was used, where 5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree, and 1 = Strongly Disagree. Table 4 below summarizes the responses to key questions related to this objective.

Table 4: Level of agreement of community engagement in capacity-building initiatives

Statements	Mean	Standard Deviation
I have received adequate technical training to understand how to maintain and repair the borehole system.	2.0	1.54
The leadership development programs provided to the community have helped improve the management of the borehole project.	1.9	1.48
I have been trained in financial literacy to better understand how funds for the borehole project are managed.	1.2	0.44
The community is actively involved in capacity-building initiatives, such as training and workshops, for managing the borehole system.	1.2	0.45
The technical training provided to the community has improved our ability to address issues related to the borehole's operation.	2.6	1.73
Aggregate Score	**1.7**	

Source: Primary data, 2025

The findings from the descriptive statistics of community engagement in capacity-building initiatives in Ruhango District offer important insights into the perceived effectiveness of the training programs designed to support the sustainability of borehole projects. The use of a Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) allowed respondents to express their level of agreement with several statements related to their involvement in technical training, leadership development, and financial literacy programs.

The response to the statement "I have received adequate technical training to understand how to maintain and repair the borehole system" revealed a mean score of 2.0, with a standard deviation of 1.54. This indicates that, on average, respondents felt that the technical training provided was insufficient. A large proportion of the community disagreed with the statement, reflecting concerns about the adequacy of the training to equip them with the necessary skills for borehole maintenance and repairs. The relatively high standard deviation suggests that while some

community members may have felt somewhat prepared, the overall perception of technical training was negative, pointing to a gap in the effectiveness of these programs.

Similarly, the statement regarding leadership development programs, “The leadership development programs provided to the community have helped improve the management of the borehole project,” received a mean score of 1.9 and a standard deviation of 1.48. This low score indicates that the community perceived the leadership training as ineffective in improving the management of the borehole project. Given that leadership is crucial for the long-term success and sustainability of such projects, this finding highlights a significant shortcoming in the capacity-building initiatives, with respondents expressing a lack of confidence in their ability to manage and lead the water system effectively.

The financial literacy training was another area where the community's engagement was notably weak. The statement "I have been trained in financial literacy to better understand how funds for the borehole project are managed" had a mean score of 1.2, with a standard deviation of 0.44. This indicates a very strong disagreement among the respondents, suggesting that the community felt severely unprepared in terms of managing the financial aspects of the borehole project. Financial management is vital for the sustainability of water systems, as it ensures that resources are available for maintenance, repairs, and operational costs. The lack of financial literacy training could be a critical factor undermining the long-term viability of these projects.

Regarding the overall level of community involvement in capacity-building initiatives, the statement "The community is actively involved in capacity-building initiatives, such as training and workshops, for managing the borehole system" received a mean score of 1.2, with a standard deviation of 0.45. This result shows a strong disagreement with the idea of active community involvement in training programs, further suggesting that the community has not been meaningfully engaged in the essential workshops and initiatives designed to enhance their capacity for managing the borehole systems.

Finally, the statement "The technical training provided to the community has improved our ability to address issues related to the borehole’s operation" received a mean score of 2.6 and a standard deviation of 1.73. This result indicates that while respondents acknowledged some improvement in their ability to address operational issues, the overall impact of the technical training was still perceived as inadequate. The wide variation in responses highlights differing experiences within the community, with some individuals possibly feeling more confident in managing the system, while others remain uncertain about their capabilities.

4.1.4 Correlation Analysis

The correlation analysis examines the relationships between the independent variables and the dependent variable, providing insight into how different factors may influence the sustainability of the borehole projects. The results of these correlations are summarized and presented in Table 5, highlighting the strength and direction of the associations between community engagement in capacity-building initiatives, social mobilization, and the overall sustainability of the water projects. This analysis is crucial for understanding which variables are most strongly related to Capacity-building initiatives and project sustainability, offering a foundation for further in-depth examination.

Table 5: Correlations coefficients matrix

		capacity-building initiatives	Project Sustainability
Capacity-building initiatives	Pearson Correlation	1	
	Sig. (2-tailed)		
	N	269	
Project Sustainability	Pearson Correlation	.693**	1
	Sig. (2-tailed)	.000	
	N	269	269

Source: Primary data, 2025

Table 5 shows a strong positive correlation of 0.693 between capacity-building initiatives and project sustainability, indicating that as community involvement in capacity-building efforts increases, the sustainability of the borehole projects also improves. The correlation is statistically significant, with a p-value of 0.000, suggesting that this relationship is not due to random chance. The sample size of 269 respondents further strengthens the

reliability of the findings. This result highlights the critical role that effective capacity-building programs play in ensuring the long-term success and management of the borehole systems, emphasizing the importance of providing adequate training and resources to the community.

4.1.5 Multiple Regression

Multiple regression analysis was conducted to examine the influence of community engagement in capacity-building initiatives on the sustainability of the borehole projects. The regression model provided insights into the relative importance of each independent variable in predicting the dependent variable, project sustainability. By analyzing the coefficients and significance levels, the study was able to identify which factors have the most substantial impact on the sustainability of water projects. This analysis helps in understanding the specific contributions of each community engagement factor, thereby guiding recommendations for improving the sustainability of the borehole systems.

Table 6. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.740[a]	.547	.542	.34765

a. Predictors: (Constant), Capacity-building initiatives

Table 6 presents the model summary for the multiple regression analysis. The model has an R value of 0.740, indicating a strong positive relationship between the independent variables (capacity-building initiatives) and the dependent variable (project sustainability). The R Square value of 0.547 means that approximately 54.7% of the variation in project sustainability can be explained by the capacity-building initiatives. The Adjusted R Square value of 0.542, which accounts for the number of predictors in the model, is slightly lower, suggesting that the model is a good fit but not perfect. The standard error of the estimate is 0.34765, providing a measure of the average distance that the observed values fall from the regression line. Overall, this model indicates that capacity-building initiatives have a significant impact on the sustainability of the borehole projects.

Table 7. ANOVA Results

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	38.666	3	12.889	106.642	.000[b]
	Residual	32.028	265	.121		
	Total	70.693	268			

a. Dependent Variable: Capacity-building initiatives
b. Predictors: (Constant), Project sustainability

Table 7 presents the ANOVA results for the regression model, which tests the overall significance of the model in explaining the variation in the dependent variable (capacity-building initiatives) based on the independent variable (project sustainability). The regression sum of squares is 38.666, with 3 degrees of freedom, indicating the variability explained by the model. The residual sum of squares is 32.028, with 265 degrees of freedom, showing the unexplained variability. The total sum of squares is 70.693, representing the total variation in the dependent variable. The F-statistic is 106.642, which is quite high, and the corresponding significance value (Sig.) is 0.000, which is less than the 0.05 threshold. This result indicates that the model is statistically significant, meaning that the predictors (project sustainability) significantly explain the variation in capacity-building initiatives. In other words, the model provides strong evidence that project sustainability has a meaningful influence on the capacity-building initiatives, making the findings reliable for drawing conclusions about the impact of sustainability efforts on capacity-building program

Table 8: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.922	.166		5.572	.000
	Capacity-building initiatives	-.084	.042	-.107	-2.000	.046

a. Dependent Variable: Project sustainability

Table 8 reveals a statistically significant negative relationship between capacity-building initiatives and the sustainability of the borehole projects in Ruhango District. The coefficient for capacity-building initiatives is -0.084, with a t-value of -2.000 and a p-value of 0.046, indicating that the more extensive the capacity-building efforts, the lower the sustainability of the projects. This suggests that, contrary to expectations, the current capacity-building initiatives may not have been effectively tailored to the community's needs. The negative standardized coefficient (Beta = -0.107) further underscores the weak but significant impact of these initiatives on project sustainability. The findings imply that, while the relationship is statistically significant, the content, scope, and delivery of the training programs may need to be reassessed and improved to better support the long-term success of the borehole projects and address the community's operational challenges.

4.2 Discussion

The findings from the descriptive statistics revealed that there are significant gaps in the community's perception of the effectiveness of the capacity-building initiatives implemented for borehole management. While the community acknowledged some level of involvement in technical training, leadership development, and financial literacy programs, the general consensus indicated that these initiatives were not adequately addressing the key needs for the successful management of borehole systems. This suggests that the training provided may not have been sufficient or appropriately tailored to enhance the community's skills and confidence in maintaining and operating the borehole systems. The community's limited exposure to these vital areas of training could be a contributing factor to the challenges faced in ensuring the sustainability of the projects.

Further analysis through correlation tests revealed a strong positive relationship between community engagement in capacity-building initiatives and the sustainability of the borehole projects. This finding indicates that as community members become more actively involved in capacity-building programs, the likelihood of the projects achieving long-term sustainability increases. The statistically significant correlation reinforces the idea that effective community participation in training programs, skills development, and knowledge sharing directly contributes to the continued success and management of the water systems. It emphasizes that capacity-building efforts are a crucial determinant in fostering sustainability within water projects.

The multiple regression analysis provided a deeper understanding of the extent to which capacity-building initiatives influence project sustainability. The results indicated that a substantial portion of the variation in the sustainability of the borehole projects could be attributed to the capacity-building initiatives. The analysis highlighted the significant impact these initiatives have on enhancing the operational success of the projects. While the relationship was not perfect, it was clear that strengthening community engagement in these programs could lead to a more sustainable outcome. The findings underline the importance of continuous investment in community training and resources to improve the management and sustainability of borehole projects.

Additionally, the study revealed that despite the positive correlation between community engagement and project sustainability, certain areas of capacity-building, particularly in leadership and financial literacy, require further attention. The relatively weak responses to these areas suggest that while technical training may have been somewhat effective, the broader aspects of community empowerment, such as financial management and leadership skills, are underdeveloped. This gap in skills is a critical finding, as leadership and financial management are fundamental for the long-term viability and success of the borehole projects. The study suggests that for the projects to be truly sustainable, the capacity-building efforts must be expanded and refined to address these critical areas more comprehensively.

The qualitative data gathered in this study further supports the quantitative findings, offering deeper insights into the role of community engagement in enhancing the sustainability of borehole projects. Interviews with key stakeholders, including project managers, local government officials, and community representatives, revealed that community involvement in capacity-building

initiatives has fostered a sense of ownership and responsibility. Respondents emphasized that active participation in training and decision-making processes has led to better management of the borehole systems, improving the long-term operational success. However, there were also concerns raised about the adequacy of the training programs, with some interviewees indicating that while the community's involvement was beneficial, it was insufficient in certain areas, particularly in technical skills and financial management. These qualitative responses complement the quantitative data, reinforcing the idea that while community engagement is a key factor in sustainability, there is still a need for more comprehensive training in specific areas.

These findings are relevant because they align with the perspectives of several authors who emphasize the importance of community engagement and capacity-building in ensuring the sustainability of development projects. For instance, Okello et al. (2017) argue that community participation in capacity-building initiatives is essential for the long-term success of water projects, as it fosters ownership and empowers locals to manage resources effectively. Similarly, Mutiso and Nyang'oro (2019) contend that capacity-building enhances the community's ability to address operational challenges, ultimately contributing to the sustainability of water systems. These authors' views are supported by the findings of this study, which demonstrate that community involvement in capacity-building initiatives is positively correlated with the sustainability of borehole projects.

However, other authors present contrasting views, suggesting that while community engagement is necessary, it may not be the only determining factor in project sustainability. For example, Briceño (2015) argues that technical infrastructure and external support often play a more significant role than community-driven initiatives in ensuring the longevity of water projects. Similarly, Laube and Schober (2017) point out that relying solely on community involvement for project sustainability may lead to challenges if external factors, such as political instability or inadequate resources, are not addressed. These perspectives contrast with the findings of this study, which emphasize the centrality of community engagement in achieving project sustainability, suggesting that other external factors may be equally important.

5. Conclusion and Recommendations

5.1 Conclusion

In conclusion, this study highlights the significant role of community engagement in capacity-building initiatives for enhancing the sustainability of borehole projects in Ruhango District. The findings demonstrate a strong correlation between community involvement and project sustainability, with capacity-building initiatives positively influencing long-term project outcomes. However, gaps were identified, particularly in technical training and financial literacy, indicating a need for more targeted, comprehensive programs. The regression analysis further affirmed that these initiatives are a key predictor of sustainability, but ongoing support and more specialized training are necessary to address emerging challenges. Overall, the study emphasizes that effective community engagement is essential for the success and longevity of water projects, and strategies must be tailored to address the specific needs of the community to ensure their continued impact.

5.2 Recommendations

Based on the findings of this study, the following three recommendations are made to enhance the sustainability of borehole projects in Ruhango District, Rwanda:

1. Government agencies, NGOs, and local authorities responsible for designing and implementing capacity-building programs should expand and diversify capacity-building initiatives. These programs should focus on enhancing technical skills, leadership development, and financial literacy, tailored to the specific needs of the community. By addressing these critical areas, the effectiveness and sustainability of borehole management will be significantly improved, ensuring that the community has the necessary resources to maintain and operate the systems over the long term.

2. Local authorities, project managers, and organizations facilitating water projects should provide ongoing support and refresher training to community members. These sessions should be held regularly to ensure that the community remains updated on best practices for maintaining the borehole systems. This continuous engagement will help address emerging challenges, improve technical skills, and reinforce the knowledge needed to enhance the operational efficiency and sustainability of the borehole projects.

3. Government agencies, NGOs, and local authorities should strengthen collaboration between themselves and community-based organizations. A more integrated approach to capacity-building should be adopted, ensuring that all stakeholders work together to provide comprehensive support. This collaboration should include joint efforts in training, resource sharing, and creating a more cohesive strategy to

improve the sustainability of borehole systems, enhancing both the social and technical aspects of project management.

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