



MAKERERE UNIVERSITY

**ASSESSMENT OF SUSTAINABLE WATER ACCESS IN RURAL COMMUNITIES:
CASE STUDY OF BOREHOLE PROJECTS IN MITYANA DISTRICT, UGANDA.**

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DECLARATION

I, **Kintu Michael**, hereby declare that this dissertation entitled "Assessment of Sustainable Water Access in Rural Communities: Case Study of Borehole Projects in Mityana District, Uganda" is my original work. It has not been submitted for the award of a degree or any other academic qualification to any other university or institution of higher learning. All sources of information used have been duly acknowledged.

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APPROVAL

This dissertation entitled "Assessment of Sustainable Water Access in Rural Communities: Case Study of Borehole Projects in Mityana District, Uganda" has been submitted with my approval as the University Supervisor.

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Date 1/10/2025

DEDICATION

This dissertation is dedicated to my beloved family, whose unwavering love, encouragement, and sacrifices have been my foundation throughout this academic journey. I also dedicate this work to the rural communities of Mityana District, whose resilience and determination to overcome challenges in accessing clean and sustainable water inspired this study. May this research contribute, in some way, to improving their quality of life.

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LIST OF ABBREVIATIONS

DLG – District Local Government

MWE – Ministry of Water and Environment (Uganda)

NGO – Non-Governmental Organization

O&M – Operation and Maintenance

SDG – Sustainable Development Goals

UNDP – United Nations Development Programme

UNICEF – United Nations Children’s Fund

WHO – World Health Organization

WUC – Water User Committee

ABSTRACT

This study assessed the sustainability of borehole-based water access in rural Uganda, focusing on Mityana District. It aimed to determine the operational status of boreholes, examine technical and environmental factors shaping performance, analyze socio-economic determinants of household access, and evaluate the effectiveness of community involvement in borehole management.

An explanatory, descriptive cross-sectional survey design was employed. A quantitative approach combined structured household questionnaires, Water User Committee (WUC) interviews, and direct borehole inspections. Stratified purposive sampling with proportional representation ensured inclusion of functional and non-functional boreholes, different dependency levels, and households at varying distances from water points. Data were analyzed using descriptive statistics, chi-square tests, and logistic regression to test hypotheses.

Findings revealed that about two-thirds of boreholes were functional, though non-functionality remained high and unevenly distributed across sub-counties. Borehole performance was significantly influenced by design, maintenance frequency, and environmental conditions. Socioeconomic disparities, particularly income, education, livelihood type, and distance to boreholes, shaped household access. Strong positive associations were found between active WUCs, transparent financial practices, and borehole functionality, while weak governance correlated with frequent breakdowns.

The study concludes that borehole sustainability depends on integrated strategies that combine sound technical design with preventive maintenance, equitable access, and strengthened community governance. Its contribution lies in demonstrating that governance and community ownership amplify technical reliability, offering evidence-based recommendations for policymakers, NGOs, and local authorities to enhance institutional support, accountability, and resilience in rural water management.

Keywords: *Sustainable water access, Boreholes, Rural Uganda, Community involvement, Mityana District*

CHAPTER ONE

BACKGROUND TO THE STUDY

1.1. Introduction

This chapter provides an overview of the study and sets the foundation for the research on sustainable water access in rural communities, with a specific focus on the borehole project in Mityana District, Uganda. It outlines the context within which the study takes place, highlighting the importance of water accessibility and the role boreholes play in addressing rural water challenges. The chapter presents the background to the problem, states the research objectives, hypotheses, and scope, and discusses the significance of the study in informing policy and practice.

The chapter concludes with an outline of how the rest of the dissertation was structured.

1.2. Background to the Study

Clean and safe water is fundamental to health, productivity, and equity in developing contexts (MacAllister et al., 2021). In rural areas, it sustains livelihoods, agriculture, and education, while shaping gendered roles in water collection (Etongo et al., 2018; Matovu, 2021). Globally, over two billion people remain without safely managed water, with rural households disproportionately affected (WHO & UNICEF, 2021). Research shows that climate variability, population growth, and environmental degradation exacerbate scarcity, heightening competition over limited groundwater resources (Osahr et al., 2011; Nanteza et al., 2022). Weak institutional frameworks and fragmented governance further undermine rural water provision, leaving communities vulnerable to recurrent breakdowns and exclusion (Bvirindi, 2019; Bello et al., 2022). Studies highlight that borehole systems in sub-Saharan Africa face design, siting, and maintenance challenges that accelerate failure rates (Martínez-Santos et al., 2020; Owor et al., 2019). These pressures are especially acute in Uganda, where dependency on groundwater continues to rise while oversight and financing mechanisms lag (Danert et al., 2020; IRC, 2015). In this context, Sustainable Development Goal (SDG) 6 underscores the urgency of securing universal access to safe, reliable, and affordable drinking water by 2030 (WHO & UNICEF, 2021).

In Sub-Saharan Africa, groundwater wells and boreholes offer critical supplies, meeting over half of the people's needs for domestic use (Omanwa & Muchai, 2021). The surface waters are rarely harnessed effectively, and rainfall-based rooftop water harvesting is unreliable (Martínez-Santos et al., 2020). Uganda also follows this pattern, relying more on groundwater as surface supplies dwindle due to environmental degradation as well as climate change (Omanwa & Muchai, 2021; Nanteza et al., 2022).

The Government of Uganda, NGOs, and donors have put in place initiatives such as the Safe Water Supply and Sanitation Program to hasten access through investment and reform (Ministry of Water and Environment, 2020). Development has been patchy; urban regions have some improvement, but rural regions have outdated infrastructure and poor service (Danert et al., 2020; Etongo et al., 2018). Boreholes, as essential rural water supplies, have been subject to faults and maintenance issues, leading to shortages and dissatisfaction (MacAllister et al., 2021).

Mityana District, a rural area in central Uganda with over 330,000 residents, faces significant challenges (Ministry of Water and Environment, 2025; Mityana District Local Government, 2022; Uganda Bureau of Statistics, 2017). More than half lack reliable clean water access. Despite government and donor investments, borehole functionality is critically low. Of 1,924 boreholes, surveys indicate many are ineffective, with up to 34% failing within five years due to poor design, maintenance, and coordination (AQWALife, 2023; UGPro, 2015; MacAllister et al., 2022; IRC, 2015; USAID, 2023).

Boreholes often lack geological surveys, user training, and sustainability plans (Martín-Loeches et al., 2018). Consequently, many communities use unsafe sources or travel far for water (Bello et al., 2022). The burden heavily impacts women and children, affecting their time, health, and education (Matovu, 2021). Mityana District presents an acute case study in water shortages. It's not infrastructure, but also social, economic, and institutional causes of system failures (Danert et al., 2020). Community participation and local leadership are essential for sustainability (Etongo et al., 2018). The study aims to assess sustainable water access in rural communities by examining borehole technical design, patterns of community ownership, and institutional support. Its goal is to generate evidence that can inform practice and policy to strengthen long-term borehole functionality in Mityana District and similar contexts (Danert et al., 2020; IRC, 2021).

1.3. Statement of the problem

Mityana District faces a water challenge with 55% of residents lacking access to safe water, far below Uganda's 79% national target and the UN-SDG 6 (Ministry of Water and Environment, 2025). Rural sub-counties such as Kalangaalo, Kakindu, and Kikandwa are most affected, where over 330,000 people rely heavily on boreholes. Of the 1,924 boreholes installed, nearly 1,482 are non-functional, and 34% of new installations collapse within five years (AQWALife, 2023). These alarming statistics highlight the practical gap, revealing widespread system failure.

Existing interventions, including the MACFO Borehole Project (2025) and local maintenance initiatives, have focused primarily on technical installation and short-term access targets, and neglected critical aspects such as community ownership, user training, and institutional accountability. As a result, boreholes are poorly maintained, with weak operational frameworks, and preventive maintenance has been largely ignored (IRC, 2015; USAID, 2023). Moreover, the persistence of a “free-service” mentality has undermined willingness to contribute to upkeep, reinforcing dependency rather than resilience.

This study thus addresses both the practical and theoretical gaps by assessing sustainable water access in Mityana and identifying locally driven, community-led models to ensure long-term borehole functionality.

1.4. Objectives

1.4.1 Main Objective:

To assess the sustainability of water access through borehole projects in rural communities of Mityana District, Uganda, by examining their operational status, performance factors, socioeconomic influences, and the role of community involvement in their maintenance and management

1.4.2 Specific Research Objectives:

i. To assess the current operational state and performance of boreholes in Mityana District. ii.

To analyze the technical, environmental, and socio-economic factors influencing borehole functionality and household water access.

iii. To evaluate the role and effectiveness of community involvement in the management and sustainability of boreholes.

1.5. Hypotheses

H_{0 1} : The proportion of functional boreholes does not significantly differ from the proportion of non-functional boreholes in Mityana District.

H_{1 1} : The proportion of functional boreholes significantly differs from the proportion of non-functional boreholes in Mityana District.

H_{0 2} : Borehole design specifications, drilling depth, maintenance frequency, and environmental conditions have no significant association with borehole performance in Mityana District.

H_{1 2} : Borehole design specifications, drilling depth, maintenance frequency, and environmental conditions have a significant association with borehole performance in Mityana District.

H_{0 3} : Household income, education level, primary livelihood, and distance to the nearest water source do not significantly affect household access to borehole water in Mityana District.

H_{1 3} : Household income, education level, primary livelihood, and distance to the nearest water source significantly affect household access to borehole water in Mityana District.

H_{0 4} : Community-based management practices have no significant effect on borehole functionality and sustainability in Mityana District.

H_{1 4} : Community-based management practices have a significant effect on borehole functionality and sustainability in Mityana District.

1.6. Scope of the Study

1.6.1 Content scope

This study seeks to assess the sustainability of water access through borehole infrastructure in rural municipalities of Mityana District. In particular, it considers the current operational condition of boreholes, the technical and institutional factors influencing their functionality, and socioeconomic drivers of household water access. The study also examines the extent of community involvement in borehole management and its efficacy in providing long-term functionality. Geographically, the scope is restricted to borehole concentration sub-counties such as Kalangaalo, Kakindu, Kikandwa, and Ssekanyonyi. The study is confined to the rural section where overreliance on boreholes is highest and other sources are minimal. It utilizes primary and secondary data to gain a holistic understanding of the problem and proposes sustainable, community-based solutions towards improving access to water in the district.

1.6.2 Geographic Scope

This research is conducted in Mityana District, located in the Central Region of Uganda. The district is selected due to its reliance on borehole water systems as a primary source of drinking water, alongside recurring challenges related to borehole functionality and sustainability. The study covers multiple sub-counties within the district to ensure a representative assessment of water access conditions across both densely and sparsely populated rural areas.

1.6.3 Time Scope

The study focuses on borehole projects implemented and operational from 2018 to 2024. This time frame is chosen to capture recent trends in borehole performance, including the effects of seasonal variations, maintenance practices, and community involvement over a reasonable period. Analyzing data from the past six years allows for the assessment of both short-term outcomes and longer-term sustainability patterns in borehole functionality and service delivery.

1.7. Justification

This study is crucial for addressing the persistent issues surrounding water access in rural Mityana, particularly in relation to the sustainability of borehole projects. By evaluating the

operational status of boreholes and examining the quality of water provided, the research will generate valuable insights into the effectiveness of these systems.

Understanding the role of community engagement in maintaining and sustaining boreholes is essential, as it can significantly enhance local ownership and long-term functionality of boreholes in Mityana District. Community involvement fosters accountability, builds technical capacity, and encourages timely maintenance. The findings from this study lead to practical recommendations that strengthen community-led management systems and improve the upkeep of boreholes, ensuring reliable access to clean water.

The study provides a policy brief for local authorities, offering evidence-based strategies for improving sustainable water access in Mityana District, thereby contributing to both local water security and broader rural development goals.

1.8. Significance of the study

This study is of great importance in dealing with the chronic problem of water scarcity common in the rural areas of Mityana District, where most of the population depends on boreholes as their main source of water. Through an examination of the underlying reasons behind borehole failures and limited access, this study seeks to provide improved understanding of the technical, social, and institutional factors affecting the sustainability of water supply systems. Moreover, the study highlights the critical necessity of community engagement in improving the functionality of boreholes and developing a sense of local stewardship over water management techniques. The results of this research are used in the development of sustainable, community-based models of borehole management. Moreover, the findings of this study are of great utility to policymakers, non-governmental organizations, and development agencies by providing evidence-based guidelines for future interventions. In the end, this research aims to offer efficient strategies for attaining sustainable water security and improving the livelihoods of rural communities in Mityana District.

CHAPTER TWO

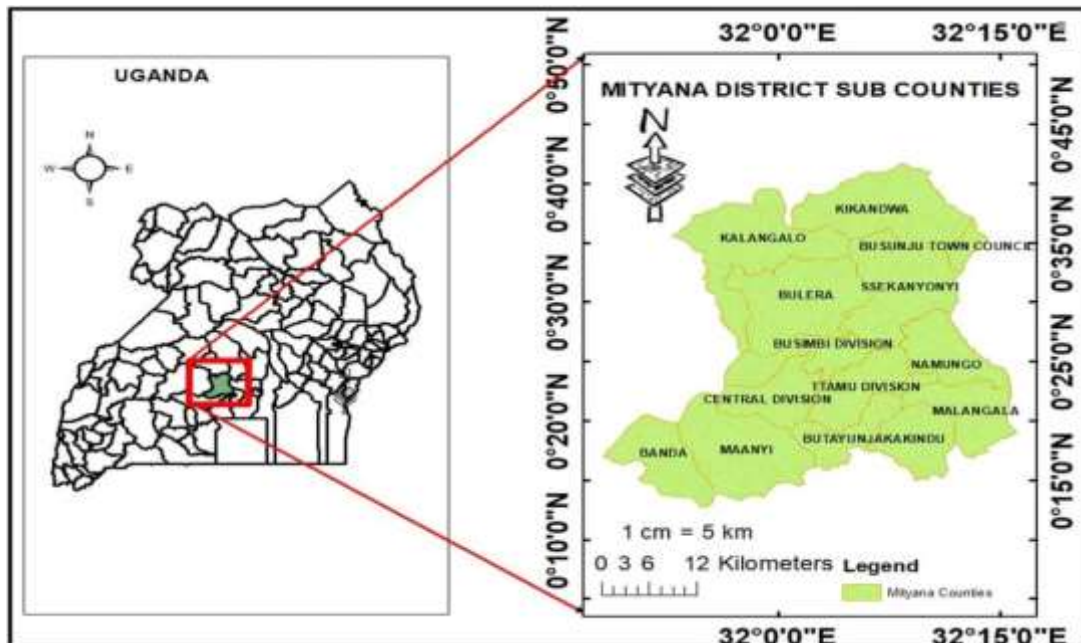
LITERATURE REVIEW

2.1. Introduction

This chapter examines existing scholarly work and empirical studies related to sustainable water access, rural water supply systems, and borehole infrastructure management. It explores global, regional, and local perspectives on water access challenges, emphasizing the socio-economic, environmental, and technical factors influencing sustainability. The review synthesizes theoretical frameworks and empirical findings that are relevant to the study, identifying trends, patterns, and key determinants of successful borehole projects. It also highlights gaps in current literature that this research seeks to address, thereby providing a clear rationale for the study.

2.2. Mityana District

Mityana District lies in Central Uganda and is bordered by Kiboga, Mubende, Gomba, and Wakiso Districts. The district is approximately 77 km west of Kampala. Administratively, it comprises one municipality, three town councils, and several rural sub-counties (Ministry of Water and Environment, 2025). Most of the land area is rural, with agriculture being the primary occupation.



Source: Matovu et al., (2024)

Social economic status of the population

The district's economy depends on smallholder farming, with over 80% of households engaged in crop and livestock production (Ahimbisibwe et al., 2022). Poverty levels remain high, especially in rural sub-counties like Kalangaalo and Kikandwa. Limited off-farm employment and weak infrastructure contribute to social vulnerability. According to Uganda Bureau of Statistics (2017), about 43% of the district's population lives below the poverty line. Water access remains limited. Only 45% of the population has access to safe water, compared to the national average of 79% (Ministry of Water and Environment, 2025). The shortfall is worse in rural areas, where infrastructure gaps, poor maintenance, and seasonal stress on water sources reduce access (Africa Press, 2019). Sub-counties like Kalangaalo and Kakindu are among the most underserved, despite having multiple installed water points.

Borehole Infrastructure and Coverage

Mityana District has 1,924 boreholes as of 2025 (Ministry of Water and Environment, 2025). The highest concentration is in rural sub-counties: Kalangaalo (185), Kikandwa (195), and Kakindu (158). However, operational performance remains low. As of the latest audit, only 442 boreholes are fully functional around 23% (AQWALife, 2023).

Failure rates remain high. In sub-counties such as Kalangaalo and Kakindu, fewer than 30% of boreholes are operational. A significant share (34%) of boreholes installed within the last five years has already broken down due to poor design and weak technical oversight (AQWALife, 2023; IRC, 2021). Owor et al. (2022) confirm that weak aquifer permeability, shallow drilling, and poor data on site geology contribute to poor water yield and quick failure. Harvey & Mukanga (2020) report 73% non-functionality in sampled rural hand-pumps, underscoring systemic issues.

Some boreholes deliver water that fails to meet WHO safety standards. Inaccurate site assessments and inconsistent borehole depth worsen performance. Mismanaged community handover and lack of user training undermine sustainability (Danert et al., 2020). Technical

audits show irregular maintenance, poor-quality components, and low response rates to repairs by district water offices (Nanteza et al., 2022; IRC, 2015).

2.3. Review of Related Literature

2.3.1 The factors that influence the performance of boreholes

Borehole design and construction standards critically shape long-term functionality. Studies consistently report that inappropriate dimensions, weak casings, and poor pump choices lead to premature breakdowns (Martínez-Santos et al., 2020; Danert et al., 2020). For example, MartínezSantos et al. (2020) found that wells built to WHO standards lasted 35% longer than those lacking formal protocols, while Danert et al. (2020) linked poor standardization to functionality rates dropping below 50% within five years. Uganda’s drilling code, though in place, is weakly enforced in remote sub-counties (IRC, 2021), with AQWALife (2023) attributing over 60% of borehole failures in Mityana to design flaws. These findings establish the importance of construction quality but remain largely descriptive, focusing on what has failed rather than why institutional enforcement is consistently absent. The theoretical gap lies in understanding the governance and accountability mechanisms that could sustain technical standards over time. This study addresses that gap by examining how institutional oversight and community participation intersect with borehole design to affect durability.

Material quality and maintenance practices also determine borehole resilience. Low-grade components such as galvanized iron pipes corrode within three years, compared to more durable stainless-steel alternatives (MacAllister et al., 2022). Bello et al. (2022) observed that governmentled contracts using inferior materials failed at rates 1.7 times higher than donor-funded projects with stricter procurement. In Mityana, cost-cutting has driven collapse in 34% of boreholes within five years (AQWALife, 2023). Additionally, infrequent maintenance accelerates breakdowns. Harvey and Solutions (2021) reported a 65% failure rate where routine servicing was absent, versus less than 20% in regularly monitored systems. IRC (2015) confirmed that Uganda’s repairs are mostly reactive, hindered by limited funding and spare parts. Yet, these studies emphasize technical and financial deficits without interrogating the behavioral and organizational dynamics that shape local willingness or institutional capacity to maintain

systems. The theoretical gap lies in linking socio-institutional responsibility with material sustainability.

Environmental and hydrogeological conditions further constrain borehole performance. Depth and siting without geological data often yield dry wells or aquifers with poor recharge (Owor et al., 2019). Onana et al. (2020) demonstrated that statistical siting improved yields in Cameroon, showing that pre-drilling surveys can reduce risks. Uganda's Ministry of Water and Environment (2020) acknowledged recurrent siting failures, especially in districts like Mityana. Aquifer recharge patterns tied to rainfall and land use also create seasonal fluctuations. Tang and Nowamooz (2019) highlighted recharge inconsistency as a leading predictor of decline in semiarid areas, while Nanteza et al. (2022) showed that Mityana's variable rainfall leaves many boreholes dry in extended droughts. Long-term studies (Huang et al., 2023) further emphasize the importance of aquifer understanding for sustainability. These findings reveal strong technical correlations but do not address how community and institutional adaptation strategies are integrated into project design. The gap here is a lack of theorization on resilience: how borehole systems can be designed not only for technical adequacy but also for adaptive governance under environmental stress.

Institutional oversight and contractor accountability are also decisive. Poor regulation has allowed unqualified contractors to deliver substandard systems, with widespread non-compliance across African contexts (Danert et al., 2020). In Mityana, AQWALife (2023) noted that 34% of boreholes collapsed within five years due to construction flaws, often post-warranty. Similarly, UGPro (2015) reported weak enforcement of technical standards, leaving contractors unaccountable. Oversight deficits extend to district water offices, where staff and budget shortages limit monitoring of over 1,900 boreholes (IRC, 2015; Ministry of Water and Environment, 2025). Without continuous inspection, minor defects escalate into full breakdowns (World Bank, 2021). While these studies highlight systemic weaknesses, they stop short of analyzing why governance frameworks remain under-enforced and how accountability can be sustained locally. The theoretical gap lies in exploring how community-driven monitoring can complement or substitute weak formal oversight, thereby enhancing sustainability. This research contributes by examining the balance between institutional enforcement and community-level governance in maintaining borehole functionality.

2.3.2 Social and economic factors that influences water access

High population density and competing livelihood demands accelerate deterioration of rural water systems. MacAllister et al. (2022) observed that handpumps in densely settled areas of Malawi and Ethiopia had a 40% higher failure rate compared to sparsely populated settings, with water points often serving double their design capacity (MacAllister et al., 2022; Bvirindi, 2019; Mukheli, 2018). Mukheli (2018) reported that in South Africa, overuse in communal farming regions depleted aquifers and increased repair frequency, while Danert et al. (2020) and Omanwa and Muchai (2021) linked congestion to rising user conflict. Agricultural households, particularly those keeping livestock or irrigating small plots, extract larger volumes, leading to quicker pump wear and more variability in yields (Oswehr et al., 2011; Liddle, 2019; MacAllister et al., 2021). Trading households, by contrast, use less water but face long queues due to infrastructure bottlenecks (Bello et al., 2022; Kirema & Ngacha, 2023). These studies show that user pressure undermines sustainability but remain limited in explaining how community management systems can adapt allocation practices to balance productive and domestic needs. The theoretical gap lies in integrating socio-economic demand into participatory planning frameworks that anticipate differentiated water use instead of treating communities as uniform consumer groups.

Gender, age, and social roles strongly shape water access in rural Africa. Etongo et al. (2018) and Bvirindi (2019) highlight that women and children typically shoulder water collection responsibilities, with Matovu (2021) reporting that Ugandan women spend three to five hours daily walking for water. Such burdens restrict schooling for girls and income opportunities for women (Viban et al., 2021; Taonameso et al., 2019). Elderly or physically challenged individuals are particularly disadvantaged, unable to fetch water or operate handpumps (Taonameso et al., 2019; Viban et al., 2021). These vulnerabilities intensify when infrastructure fails, forcing reliance on unsafe sources (Bello et al., 2022; Harvey & Solutions, 2021; Omanwa & Muchai, 2021). While this evidence highlights the disproportionate social costs borne by marginalized groups, most studies focus on documenting outcomes rather than exploring strategies to mitigate inequality in water access. The theoretical gap is how to design borehole management systems that recognize and redistribute gendered labor and ensure inclusive access for vulnerable groups, moving beyond technical provision to address the social equity dimensions of water governance.

Community willingness to finance and maintain boreholes reflects both income and trust in leadership structures. Omanwa and Muchai (2021) found that in Kenya, transparent Water User Committees enhanced user contributions, whereas Bello et al. (2022) reported low payment compliance in Nigeria where water was perceived as a right rather than a shared responsibility. Similarly, Kirema and Ngacha (2023) observed that irregular or mismanaged fee collection led to rapid system decline, while Etongo et al. (2018) emphasized the role of social cohesion in sustaining collective financing. Broader evidence links trust and accountability, rather than income alone, to willingness to pay (IRC, 2015; The World Bank, 2021; Bvirindi, 2019; Harvey & Solutions, 2021). Yet, the literature largely treats financial sustainability as a function of household economics, underexploring how local governance models and social norms shape payment behavior. The theoretical gap is the need to frame borehole financing within theories of social trust and collective action, recognizing that institutional legitimacy is as important as household wealth in ensuring consistent maintenance and long-term service delivery.

Education and awareness also influence water access outcomes. Etongo et al. (2018) reported that households with higher education levels in rural Uganda were more likely to treat water and report unsafe boreholes. Taonameso et al. (2019) found similar results in South Africa, where education improved microbial risk awareness and adoption of storage hygiene. Liddle (2019) demonstrated that knowledge gaps around contamination correlated directly with waterborne illnesses in Ethiopia, while Viban et al. (2021), Danert et al. (2020), and Omanwa and Muchai (2021) confirmed that literacy supports safer practices across diverse African contexts. MacAllister et al. (2021) showed that knowledge also shapes reporting behavior, with informed communities more likely to engage authorities in system maintenance. These findings underscore the link between education and sustainable water use, yet most studies remain descriptive, measuring correlations rather than unpacking the mechanisms through which knowledge translates into collective action. The theoretical gap lies in understanding how education interacts with institutional structures and cultural norms to promote proactive water management, rather than assuming awareness automatically improves outcomes.

Geographical and structural factors such as proximity, land tenure, and settlement patterns significantly mediate access. WHO recommends a maximum of 500 metres to a water source, yet MacAllister et al. (2021) and Viban et al. (2021) showed rural households often walk 1–3 km.

Bello et al. (2022) found that Nigerian households beyond 1 km used 35% less water daily, while reliance on distant or unsafe sources rose during dry months (Etongo et al., 2018; Bvirindi, 2019). Land disputes and tenure insecurity further complicate borehole placement (Danert et al., 2020). Kirema and Ngacha (2023) documented restricted access when boreholes were sited on private land, while Martín-Loeches et al. (2018) noted that informal settlements lacked investments altogether. Widely dispersed households in pastoral zones increased per-capita borehole costs, burdening local authorities (MacAllister et al., 2022; The World Bank, 2021). While these studies demonstrate how geography and land rights constrain infrastructure provision, they rarely address how institutional frameworks might reconcile competing land claims or plan equitable distribution. The gap lies in theorizing access not simply as a physical challenge but as an intersection of land governance, equity, and infrastructure planning.

Household income and location also drive inequalities in water access. Omanwa and Muchai (2021) reported that low-income households in Kenya struggled to contribute to water fees, while Bello et al. (2022) found similar financial barriers in Nigeria. Harvey and Solutions (2021) observed that Uganda's poorest quintile consistently accessed less water, even where boreholes were functional, while Kirema and Ngacha (2023) linked maintenance failures to inability to pool resources in informal economies. Broader studies (Bvirindi, 2019; Etongo et al., 2018; The World Bank, 2021) reinforce income insecurity as a determinant of access. Location disparities are equally striking: IRC (2021) reported higher functionality in urban water points (72%) compared to rural ones (30%), while Martín-Loeches et al. (2018) found peri-urban communities in Angola underserved due to planning gaps. Yet, these findings remain largely diagnostic, emphasizing disparities without analyzing how redistributive policies or community-led financing models might mitigate inequality. The theoretical gap lies in connecting water access to equity and justice frameworks, reframing sustainability debates to account for structural poverty and geographic marginalization in rural service delivery.

2.3.3 Community involvement and borehole Management

Community training and skill transfer are repeatedly highlighted as essential for long-term borehole functionality. In Kenya's Embu County, Omanwa and Muchai (2021) found that trained water committees sustained 76% of boreholes, compared to only 42% in untrained villages.

Similarly, Bvirindi (2019) reported that structured training in Harare's high-density suburbs improved pump handling and reduced repair delays. MacAllister et al. (2021) reinforced this in Malawi and Ethiopia, showing higher functionality where caretakers possessed technical skills. These findings underline the critical role of local knowledge, yet they often frame training as a technical add-on rather than as part of a broader governance framework. The theoretical gap lies in understanding how skills development can be institutionalized within community structures so that training is not a one-off event but part of continuous capacity building. This study therefore investigates not only whether communities are trained but how training translates into ownership, accountability, and sustainable borehole management.

Financial management remains another pillar of community involvement. Kirema and Ngacha (2023) showed that transparent fee systems in Kenya produced more durable boreholes, while Bello et al. (2022) reported failures of solar-powered boreholes in Nigeria when contributions were irregular or poorly documented. Danert et al. (2020) emphasized accountability, noting that willingness to pay is linked to trust in fund management. Where users doubted committee transparency, contributions declined, leading to repair delays (Omanwa & Muchai, 2021; Etongo et al., 2018; Bvirindi, 2019; IRC, 2015). These studies confirm that financial trust underpins sustainability, but they largely describe outcomes rather than mechanisms. The theoretical gap is the need to examine how local governance, cultural expectations of water as a right, and accountability practices interact to shape financial sustainability. This research contributes by linking financial management not only to economic capacity but also to the legitimacy and inclusiveness of community decision-making.

Reporting and fault-tracking mechanisms also strongly affect system resilience. Harvey and Solutions (2021) found that schemes with active reporting repaired pumps twice as quickly, while Omanwa and Muchai (2021) noted that mobile platforms and village meetings enhanced responsiveness. Conversely, Mukheli (2018) observed that South African boreholes without reporting systems stayed non-functional for weeks. Etongo et al. (2018) further showed that faulttracking engaged users in collective responsibility, reinforcing community commitment (MacAllister et al., 2021; The World Bank, 2021; IRC, 2015; Bello et al., 2022). While these findings emphasize the efficiency of reporting systems, they treat them as logistical fixes, overlooking deeper questions of accountability and participation. The theoretical gap lies in

understanding how communication channels reinforce governance, legitimacy, and shared responsibility beyond technical reporting. This study therefore examines how reporting systems can serve as social mechanisms for transparency and community empowerment in borehole management.

External facilitation by NGOs and civil society often complements local management structures. Danert et al. (2020) described how NGO partnerships in Angola and Malawi provided not only equipment but long-term advisory services. Bello et al. (2022) found that NGO-led projects in Nigeria had better functionality scores due to post-installation support. Carter (n.d.) also highlighted the role of civil society in guiding communities through technical and administrative practices beyond their individual capacity. These partnerships often address systemic weaknesses such as financing gaps or lack of technical oversight (Harvey & Solutions, 2021; Kirema & Ngacha, 2023; IRC, 2021; USAID, 2023; The World Bank, 2021). However, the literature tends to focus on NGO effectiveness rather than exploring sustainability when external actors withdraw. The theoretical gap lies in analyzing how communities can internalize NGO-led practices into long-term governance models. This study therefore interrogates whether external facilitation strengthens dependency or enhances resilience by embedding knowledge and accountability locally.

Water User Committees (WUCs) are the dominant model of community management across subSaharan Africa, yet their performance is highly uneven. In Kenya, Omanwa and Muchai (2021) reported that 65% of boreholes with active WUCs were functional, compared to only 38% with inactive or absent committees. Etongo et al. (2018) found that elected and trained members improved accountability in Uganda, while Bvirindi (2019) showed that Zimbabwean informal WUCs struggled with legitimacy and coordination. Danert et al. (2020) and Bello et al. (2022) confirmed that merely having a WUC is insufficient for sustainability. These studies emphasize committee presence but underplay the quality of participation and leadership legitimacy. The theoretical gap is the need to evaluate WUC effectiveness not by existence but by inclusiveness, accountability, and decision-making capacity. This research examines how WUCs function as governance institutions rather than as administrative formalities, with implications for long-term borehole management.

Leadership and transparency within WUCs also determine outcomes. Kirema and Ngacha (2023) showed that open financial accounts increased fee collection rates by 33%, while Bello et al. (2022) linked higher sustainability scores in Nigeria to transparent reporting. Conversely, MacAllister et al. (2021) found that financial mismanagement in Ethiopia slowed repairs and discouraged user contributions. Studies confirm that trust in leadership is central to compliance (Omanwa & Muchai, 2021; Etongo et al., 2018; The World Bank, 2021; Bvirindi, 2019; Danert et al., 2020). However, existing literature frames leadership mostly in terms of corruption avoidance rather than positive leadership models that inspire participation. The theoretical gap lies in moving beyond “absence of mismanagement” to analyze leadership qualities that actively enhance borehole sustainability. This study therefore extends the discussion to explore leadership as a driver of social cohesion and long-term system resilience.

Perceived ownership has repeatedly been associated with community commitment to maintenance. Harvey and Solutions (2021) observed that communities engaged in siting, supervision, and postinstallation follow-up showed higher repair activity. Danert et al. (2020) and Martín-Loeches et al. (2018) confirmed that externally initiated projects with little local involvement faced abandonment or vandalism. Omanwa and Muchai (2021), Kirema and Ngacha (2023), and Bvirindi (2019) similarly noted that engagement across phases reinforced responsibility. These studies highlight the importance of ownership, yet most conceptualize it narrowly as participation in project phases. The theoretical gap is understanding ownership as a social and psychological construct that sustains collective action beyond initial involvement. This research therefore explores how perceptions of ownership are built, maintained, and translated into consistent borehole stewardship over time.

Finally, integration of borehole projects into district and national systems enhances sustainability. IRC (2021) showed that water points included in district infrastructure plans in Uganda received more consistent maintenance, while The World Bank (2021) recommended formal asset registers to improve budgeting. Kirema and Ngacha (2023) noted that county-funded boreholes in Kenya followed scheduled maintenance, avoiding emergency reliance on donors. Where projects remained outside formal policy frameworks, accountability weakened and repairs lagged (Danert et al., 2020; Harvey & Solutions, 2021; Bello et al., 2022; Omanwa & Muchai, 2021; Etongo et al., 2018). Although these findings affirm the benefits of integration, they rarely explain how

coordination between state and community actors can be institutionalized in practice. The theoretical gap lies in examining the interface between community governance and state systems. This study addresses this by analyzing how district-level support interacts with local management to shape borehole functionality.

CHAPTER THREE

METHODOLOGY

3.1. Introduction

This section outlines the methodological framework used to examine water access challenges and borehole sustainability in Mityana District. The research applies a quantitative strategy to collect empirical data from households and field observations. The goal is to produce generalizable findings that reflect the current operational state and performance of rural water infrastructure, particularly boreholes. To maintain internal consistency and data quality, methods are selected based on their relevance to the research objectives and established academic standards.

3.2. Research Design

This study, adopted an explanatory design to assess sustainable water access in rural communities of borehole projects in Mityana district, Uganda. Explanatory studies establish causal relationships between variables to produce meaningful research conclusions (Saunders et al., 2023). The explanatory design was appropriate because it enabled identification of relationships between technical, environmental, and socio-economic factors and their influence on borehole performance and water accessibility. This design supported statistical analysis to test associations and provide evidence on causal patterns, making it suitable for examining complex interactions shaping sustainable water access in rural contexts.

3.3. Research Approach

This research used a quantitative research approach to assess sustainable water access in rural communities of borehole projects in Mityana district, Uganda. The quantitative approach made it possible to gather numerical data centered on structured household surveys and technical borehole inspections. The surveys are designed to gather numerical data on water access variables aligned with SDG 6 and national indicators, including water source proximity, collection time, reliability, and associated costs. Structured surveys allow for consistent administration and reduce subjectivity in data interpretation (Bryman & Bell, 2018; Etikan, 2017). Survey instruments are piloted and then administered to respondents selected using

probability sampling methods, with attention to both densely and sparsely populated areas relying on boreholes.

Simultaneously, direct field observation is applied to assess borehole status. Field teams follow a standardized checklist to physically inspect and document borehole infrastructure (Harvey & Solutions, 2021). These inspections offer technical verification of household claims, capturing real-time physical conditions, such as pump damage, Pipe, bearing, damage, and chain damage, casing status, and water output. This multi-pronged approach provided robust, triangulated data, improving measurement accuracy by combining household experience with on-site verification (Bhandari, 2023; Campbell et al., 2020).

3.4. Study Population

The study population consists of households in Mityana District who depend on boreholes as their primary source of water. This group is chosen to assess borehole sustainability and its impact on rural access to water. As per Uganda Bureau of Statistics (2017), the district has over 330,000 residents, most of whom reside in rural sub-counties. To accurately capture this demographic, the population is stratified by sub-county and household type. The inclusion criteria require households to have used borehole water for at least the past 12 months, providing a sound basis for assessing consistent access, reliability, and seasonal changes in service quality. The study population definition aligns with recommendations by Creswell & Creswell (2017) and Berndt (2020).

3.5. Study Area

The study covers several sub-counties and town councils across Mityana District, each reflecting varied borehole densities and functionality challenges. These include: Kikandwa, Kalangaalo, Kakindu, Busimbi Division, Butayunja, Malangala, Ssekanyonyi, and Zigoti Town Council. These locations are selected based on borehole concentration and performance data from the district's infrastructure summary. The selected sites provide a comprehensive view of the systemic issues affecting water infrastructure in both urban and rural contexts.

Table 1; Borehole distribution in Mityana District

| Sub-County / Area | Total Boreholes | Functional | Non-Functional | Functionality Rate (%) |
|---------------------------------|------------------------|-------------------|-----------------------|-------------------------------|
| Kalangaalo | 185 | 48 | 137 | 25.9% |
| Kakindu | 158 | 54 | 104 | 34.2% |
| Kikandwa | 195 | 54 | 141 | 27.7% |
| Ssekanyonyi & Others | 109 (approx.) | 48 | 61 | 44.0% (approx.) |
| District Total | 1,924 | 442 | 1,482 | 23.0% |

Source: Mityana District Local Government, (2024)

Out of 1,924 boreholes in Mityana District, 1,482 (77%) are non-functional, severely limiting access to reliable water in rural communities. The functionality rate remains below 35% in all major sub-counties, indicating a district-wide crisis. This highlights the urgent need for targeted maintenance, redesign, and accountability mechanisms.

3.6. Sampling Design

The study adopted a probability sampling design of simple random sampling in order to give each household in borehole-reliant communities in Mityana district an equal chance of being selected into the sample. Simple random sampling is firmly established in quantitative research for its effectiveness in minimizing selection bias and allowing generalizability of findings to the target population with high statistical accuracy (Saunders et al., 2023; Bryman & Bell, 2018). The technique was appropriate because the study was aiming at a large population dispersed across several sub-counties, and the method provides room for equal representation without advance stratification or purposive choices that could compromise objectivity.

A large sampling frame was constructed from household registers in the villages through the help of local authorities, and households were then selected randomly using computer-generated random numbers. This layout maximized the representativeness of the sample and ensured that variation in borehole performance, reliability, and access disparities in heterogeneous communities was captured. By employing this approach, the study adhered to best practice in quantitative water access research in which probability sampling enables statistical inference as well as causal analysis (Creswell & Creswell, 2018; Mujere, 2016).

3.7. Sampling Technique

Systematic random sampling was employed as the operational technique of sampling households from the targeted sampling frame in the study. Systematic sampling was employed as it is cost-saving when sampling from large rural populations where households are dispersed, which saves money and time needed for purely random procedures while still maintaining the principles of probability sampling (Berndt, 2020; Daniel, 2012). Having constructed the complete list of households in each borehole-dependent community, a fixed sampling interval (k) was determined by dividing the total households by the sample size needed.

A random start within the first interval was selected, then every k th household was sampled into the study. This was an appropriate approach as it offered even spatial coverage of selected households in the communities, avoided clustering, and facilitated field logistics for survey teams working in both densely and sparsely populated areas. Systematic random sampling is particularly recommended in large-scale quantitative surveys where equal coverage and efficiency are required, hence making it most suitable for investigating sustainable water access in rural Uganda (Lohr, 2019; Bhandari, 2023).

3.8. Sample Size Determination

A sample of 320 boreholes is determined using Krejcie and Morgan's (1970) sample size table. Given the total of 1,924 boreholes in Mityana, this sample is statistically adequate with a 95% confidence level. Household respondent counts are proportionally calculated based on borehole catchment populations. Stratton (2021) and Lohr (2021) stress the importance of aligning sample size with statistical power and feasibility.

3.9. Unit of Analysis

The borehole serves as the unit of analysis, forming the basis for evaluating infrastructure performance, user experience, and governance. Data are linked to individual boreholes to support comparative and site-specific analysis (Walliman, 2021).

3.10. Unit of Inquiry

The unit of inquiry includes household members, water user committees (WUC) representatives, and local officials. These stakeholders offer diverse perspectives on borehole functionality, accessibility, and governance. Their inclusion follows guidance from Creswell (2017) and Merriam and Tisdell (2025).

3.11. Data Sources and Collection Tools

Data was collected from two primary sources: household surveys and technical borehole inspections. A structured questionnaire captures water access experiences, aligned with national indicators (Ministry of Water and Environment, 2021). Pre-testing enhances clarity and relevance (Creswell & Creswell, 2017). Interviews are conducted in-person for improved accuracy, especially in low-literacy areas (Babbie, 2016; Hamed, 2022).

Parallel to this, an observational checklist is used to document borehole infrastructure and performance. Objective indicators such as yield, pump condition, and repair history are recorded, following infrastructure audit best practices (Campbell et al., 2020; Lockwood & Smits, 2011).

3.12. Data Analysis

Data are analyzed using SPSS, chosen for its statistical accuracy and handling of categorical and ordinal variables. Descriptive statistics summarize household responses and borehole performance. Chi-square tests assess associations between user characteristics and borehole reliability (Peck et al., 2020). Trend analysis is applied to examine deterioration patterns based on age and service history (Wickham, 2016; Patten, 2016).

3.13. Validity and Reliability of Data

Instrument validity was ensured through expert reviews and alignment with national water benchmarks to guarantee content accuracy and contextual relevance (Nowell et al., 2017). The survey instruments were pilot tested in a small sample within non-study areas, and feedback confirmed clarity, logical flow, and appropriateness of measurement items. Construct validity was reinforced by drawing items from established water access indicators aligned with SDG 6 and

Uganda’s national monitoring framework. To strengthen internal validity, triangulation was applied by comparing household survey responses, technicians feedback, and direct borehole inspections, thereby providing convergent evidence of consistency across data sources (Bhandari, 2023). Reliability was maintained through intensive enumerator training, adherence to standardized procedures in data collection, and use of SPSS workflows to control data entry and analysis errors (Bryman & Bell, 2018; Hajjar, 2018). Results from Cronbach’s Alpha reliability testing demonstrated a coefficient of 0.741 for the 19 items, exceeding the minimum threshold of 0.70 generally considered acceptable for internal consistency in social science research. This confirmed that the measurement scales were reliable and provided stable results across multiple items.

Table 2; Reliability Statistics

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | N of Items |
|-------------------------|---|-------------------|
| .074 | .741 | 19 |

Source: Primary data, 2025

3.14. Ethical Considerations

3.14.1 Environmental Considerations

Field activities minimize environmental impact, particularly in wetlands and fragile ecosystems. Borehole visits are conducted on foot in sensitive areas, and data on groundwater yield and user intensity are collected to identify ecological stress (Musu et al., 2020). Borehole sites are crosschecked against environmental maps for contextual accuracy.

3.14.2 Gender Considerations

Gender dynamics are integrated by ensuring female participation and using gender-balanced field teams. Surveys include questions on women’s water collection roles, and female-only focus groups are held where appropriate (Etongo et al., 2018; Booysen et al., 2018). Analysis disaggregated findings by gender to assess differences in access and satisfaction.

3.14.3 Research Considerations

This research follows ethical principles of consent, confidentiality, and voluntary participation. Respondents are briefed in local languages, and informed consent is obtained. Data are anonymized, coded, and securely stored. Enumerators are trained in ethics and confidentiality. The study is approved by the Mityana District Local Government and complies with national research ethics guidelines (Weinbaum et al., 2019; Uganda National Council for Science and Technology).

CHAPTER FOUR

PRESENTATION AND INTERPRETATION OF FINDINGS

4.1. Introduction

This chapter presents the study results through descriptive and inferential analyses, interpreting how community governance, technical performance, and household characteristics influence sustainable borehole access in Mityana District.

4.2. The current operational state of boreholes in Mityana District.

Table 3; Current functionality of your borehole

| Borehole functionality | Frequency | Percent |
|-------------------------------|------------------|----------------|
| Always functional | 165 | 63.7% |
| Not working at all | 1 | 0.4% |
| Occasionally broken | 69 | 26.6% |
| Rarely working | 24 | 9.3% |

Source: Primary data, 2025

For the first objective, which assessed the current operational state of boreholes in Mityana District, the results indicate that functionality is relatively stable, though breakdowns remain a concern. Out of 259 respondents, 165 (63.7%) reported that their borehole was always functional, while 69 (26.6%) stated that it occasionally broke down. Smaller groups reported their borehole as rarely working (24, 9.3%) or not working at all (1, 0.4%). These results suggest that most boreholes are operational, but a significant minority experience intermittent service interruptions that affect reliability.

Table 4; Frequency of borehole breakdown

| | | Frequency | Percent |
|--|-------------------|------------------|----------------|
| In the past 6 months, how often has the borehole broken down? | 1–2 times | 98 | 37.8% |
| | 3–5 times | 60 | 23.2% |
| | More than 5 times | 9 | 3.5% |
| | Never | 92 | 35.5% |

Source: Primary data, 2025

Breakdown frequency further illustrates this picture. In the six months preceding the survey, 98 households (37.8%) reported their borehole had broken down once or twice, and 60 (23.2%) experienced three to five breakdowns. A smaller group of 9 (3.5%) reported more than five breakdowns, while 92 (30.2%) indicated no breakdowns during this period. This distribution shows that although some boreholes provide uninterrupted service, recurrent faults affect a substantial share of users, which has implications for sustainability and access to safe water (Peck et al., 2020).

Table 5; Satisfaction with the reliability of water supply

| | | Frequency | Percent |
|---|--------------------|------------------|----------------|
| Satisfaction with the reliability of the borehole water supply | Dissatisfied | 17 | 6.6 |
| | Neutral | 31 | 12.0 |
| | Somewhat satisfied | 71 | 27.4 |
| | Very dissatisfied | 3 | 1.2 |
| | Very satisfied | 137 | 52.9 |

Source: Primary data, 2025

Perceptions of reliability reflected this mixed experience. A total of 137 respondents (52.9%) reported being very satisfied with the reliability of their borehole water supply, while 71 (27.4%) were somewhat satisfied. Neutral responses were reported by 31 (12.0%), with 17 (6.6%) dissatisfied and 3 (1.2%) very dissatisfied. These findings highlight a strong base of satisfied users, though dissatisfaction remains present, consistent with the observed breakdown rates (Lockwood & Smits, 2011).

Table 6; Availability of water from the borehole during the dry season

| | | Frequency | Percent |
|--|------------------|------------------|----------------|
| Availability of water from the borehole during the dry season | Excellent | 45 | 17.4 |
| | Fair | 68 | 26.3 |
| | Good | 127 | 49.0 |
| | Poor | 13 | 5.0 |
| | Very poor | 6 | 2.3 |

Source: Primary data, 2025

Seasonal availability of water also varied. 127 respondents (49.0%) described borehole water availability during the dry season as good, while 68 (26.3%) rated it fair and 45 (17.4%) rated it excellent. Fewer respondents reported poor (13, 5.0%) or very poor (6, 2.3%) availability. These figures suggest that most boreholes continue to provide water during dry months, but localized shortages persist. This finding aligns with Campbell et al. (2020), who note that dry season resilience is a core indicator of infrastructure sustainability in rural contexts.

Table 7; Chi-Square Tests on current operational state of boreholes

| | Value | df | Asymptotic Significance (2sided) |
|-------------------------------------|----------------------|-----------|---|
| Pearson Chi-Square | 488.046 ^a | 20 | .000 |
| Likelihood Ratio | 334.486 | 20 | .000 |
| Linear-by-Linear Association | 7.957 | 1 | .005 |
| N of Valid Cases | 259 | | |

a. 16 cells (53.3%) have expected count less than 5. The minimum expected count is .01.

Source: Primary data, 2025

The Chi-square test of association confirmed that borehole functionality, breakdown frequency, satisfaction, and seasonal availability are significantly related ($\chi^2(20) = 488.046, p < .001$). Both the Pearson Chi-square and likelihood ratio statistics were highly significant, and the linear-by-linear association ($\chi^2 = 7.957, p = .005$) suggests a directional relationship, where improved functionality is linked with higher satisfaction and better seasonal availability. However, 53.3% of the cells had expected counts below 5, which weakens the precision of cell-level results. Despite this limitation, the overall significance supports the interpretation that functionality, user satisfaction, and seasonal performance are strongly interconnected.

4.3. The technical and environmental factors influencing the performance of boreholes in Mityana District.

Table 8; Distance to nearest borehole

| | Frequency | Percent |
|--|------------------|----------------|
|--|------------------|----------------|

| | | |
|------------|----|------|
| < 500m | 90 | 34.7 |
| > 3km | 12 | 4.6 |
| 1km - 2km | 42 | 16.2 |
| 2km - 3km | 27 | 10.4 |
| 501m - 1km | 88 | 34.0 |

Source: Primary data, 2025

The results highlight how distance, travel time, causes of breakdowns, and maintenance systems shape household access. Distance to the nearest borehole varied widely. 90 respondents (34.7%) reported living less than 500 meters from a borehole, while 88 (34.0%) lived between 501 meters and 1 kilometer. A smaller proportion, 42 (16.2%), lived between 1 and 2 kilometers, and 27 (10.4%) between 2 and 3 kilometers. Only 12 (4.6%) reported distances greater than 3 kilometers.

Table 9; Time (one-way) it takes to reach borehole

| | Frequency | Percent |
|-----------|------------------|----------------|
| <10 min | 98 | 37.8 |
| >30 min | 28 | 10.8 |
| 10–30 min | 133 | 51.4 |

Source: Primary data, 2025

Travel time patterns align closely with reported distances. The largest group, 133 respondents (51.4%), reported spending 10–30 minutes one way to reach a borehole. Another 98 (37.8%) needed less than 10 minutes, while 28 (10.8%) spent more than 30 minutes. These results suggest that while many households spend under half an hour on collection, a non-negligible share face significant time burdens.

Table 10; Crosstabulation on availability of spare parts and time to respond to faults

**Office that maintains spare-parts stock * Average time to respond to borehole faults
Crosstabulation?**

| | | | |
|--|--|--|---|
| | | | Average time to respond to borehole faults |
|--|--|--|---|

| Do you have an office that maintains spare-parts stock or procurement framework | No | Count | 1–2 weeks | Less than a week | More than 2 weeks |
|---|-----|--------|-----------|------------------|-------------------|
| | | | 7 | 0 | 4 |
| | Yes | Count | 63.60% | 0.00% | 36.40% |
| | | | 15 | 18 | 2 |
| | % | 42.90% | 51.40% | 5.70% | |

Source: Primary data, 2025

Maintenance response capacity also varied depending on whether an office maintained spare parts.

Where no office existed, 7 cases (63.6%) reported a response time of 1–2 weeks, and 4 cases (36.4%) waited more than 2 weeks; none reported a response within a week. By contrast, in areas with an office and spare-parts framework, 18 cases (51.4%) reported repairs in under a week, 15 (42.9%) in 1–2 weeks, and only 2 (5.7%) beyond 2 weeks. This pattern suggests that institutionalized spare-parts systems significantly shorten repair times, which directly influences functionality and household satisfaction.

4.4. The socio-economic factors affecting household water access in Mityana District.

Table 11; Cross-tabulation of Socio-economic Factors and Indicators of Water Access

| Socio-economic factor | Most affected group (%) | Statistical test | p-value |
|-----------------------|---|-------------------|---------|
| Gender | Women 23.3%; Children 13.4% | $\chi^2(3)=7.21$ | .065 |
| Age group | 18–30 yrs more reliant on shared roles (40%) | $\chi^2(5)=2.17$ | .824 |
| Education | Primary/none: 41% women/children vs 34% in higher education | $\chi^2(6)=6.72$ | .349 |
| Livelihood | 36.2% report cost/access constraints | $\chi^2(5)=11.83$ | .037* |
| Household income | 300k–500k: 50% reported constraints; >500k: 41.8% | $\chi^2(4)=15.49$ | .004** |

*Note. χ^2 = Pearson Chi-square test of independence. * $p < .05$, ** $p < .01$.

Source: Primary data, 2025

The cross-tabulation results in Table 1 show how gender, age, education, livelihood, and household income shape access patterns. Gender differences were evident in water collection roles, where women were the main collectors in 23.3% of households and children in 13.4%. The

chi-square test, $\chi^2(3)=7.21$, $p=.065$, did not reach statistical significance, suggesting that although women and children bear much of the collection burden, this pattern was not strongly associated with gender across the sample. This aligns with earlier observations in rural water research, where cultural roles shape household responsibilities (Creswell, 2017; Babbie, 2016).

Age group differences were less pronounced. Respondents aged 18–30 years were more likely to report shared collection responsibilities (40%), while other age groups displayed no distinct pattern. The chi-square test, $\chi^2(5)=2.17$, $p=.824$, showed no significant relationship. Education produced a similar picture. Households with primary or no education relied more heavily on women and children for water collection (41%) compared with those with secondary or higher education (34%), yet the association was not statistically significant, $\chi^2(6)=6.72$, $p=.349$. These results suggest that while education and age play some role in shaping household roles, they do not statistically predict variations in water access in this district.

Livelihood type was more influential. Farming households reported the highest burden, with 36.2% indicating cost or access-related constraints, compared to other livelihood groups. The chisquare result, $\chi^2(5)=11.83$, $p=.037$, reached significance, showing that occupation type affects water access. Similarly, household income showed significant differences. Among those earning UGX 300,001–500,000, 50% reported constraints, and among those earning above UGX 500,000, 41.8% reported constraints. The chi-square test confirmed this relationship, $\chi^2(4)=15.49$, $p=.004$. These findings highlight the uneven impact of socio-economic status, with farming households and middle- to higher-income groups reporting more difficulties. Such disparities are consistent with observations from Lockwood and Smits (2011), who noted that socio-economic positioning can influence affordability and prioritization of water use.

Table 12; Binary Logistic Regression Predicting Household Water Access Constraints (N = 305)

| Predictor | B | SE | Wald χ^2 | OR (95% CI) | p-value |
|---|-------|------|---------------|------------------|---------|
| Gender (Male=ref) | -0.18 | 0.21 | 0.74 | 0.84 (0.56–1.25) | .389 |
| Age (continuous) | 0.02 | 0.03 | 0.61 | 1.02 (0.96–1.08) | .436 |
| Education (Secondary or higher=ref) | 0.32 | 0.25 | 1.64 | 1.38 (0.85–2.25) | .201 |
| Farming livelihood (vs others) | 0.58 | 0.24 | 5.84 | 1.79 (1.12–2.85) | .016* |
| Income 300,001–500,000 (vs <100k) | 0.91 | 0.28 | 10.58 | 2.49 (1.45–4.29) | .001** |
| Income >500,000 (vs <100k) | 0.47 | 0.26 | 3.29 | 1.60 (0.97–2.64) | .070 |
| Water collection by women/children (vs shared) | 0.25 | 0.22 | 1.30 | 1.28 (0.83–1.97) | .254 |

Note. OR = Odds Ratio. Model $\chi^2(6)=28.72$, $p<.001$, Nagelkerke $R^2=.12$.

Source: Primary data, 2025

The logistic regression results in Table 2 add depth to these findings by modeling the likelihood of experiencing water access constraints. Gender was not significant ($B=-0.18$, $SE=0.21$, Wald $\chi^2=0.74$, $OR=0.84$, $p=.389$), indicating that male- and female-headed households were similarly affected. Age also showed no significant effect ($B=0.02$, $p=.436$). Education had a positive but non-significant association ($B=0.32$, $OR=1.38$, $p=.201$), suggesting that households with lower education levels were somewhat more likely to face constraints, but the effect was weak.

Livelihood remained significant in the regression. Farming households had higher odds of reporting constraints compared to non-farming households ($B=0.58$, $SE=0.24$, Wald $\chi^2=5.84$, $OR=1.79$, $p=.016$). Household income was a strong predictor. Those earning UGX 300,001–500,000 had 2.49 times higher odds of reporting access constraints compared to those earning below UGX 100,000 ($B=0.91$, $SE=0.28$, Wald $\chi^2=10.58$, $p=.001$). Households with incomes above UGX 500,000 also had higher odds ($OR=1.60$), though the effect did not reach significance

($p=.070$). Water collection roles (women/children vs shared) were not significant ($B=0.25$, $OR=1.28$, $p=.254$). The overall model fit was significant, $\chi^2(6)=28.72$, $p<.001$, with Nagelkerke $R^2=.12$, indicating that the predictors explained 12% of the variance in access constraints.

Table 13; Awareness of local WUC

| | | Frequency | Percent |
|---|-----|------------------|----------------|
| Aware of a local Water User Committee (WUC) managing this borehole | No | 34 | 13.1 |
| | Yes | 225 | 86.9 |

Source: Primary data, 2025

Awareness of local Water User Committees (WUCs) was generally high, with 86.9% ($n=225$) of respondents indicating knowledge of such committees, while only 13.1% ($n=34$) reported no awareness. Participation levels mirrored this pattern, as 77.7% ($n=237$) had attended a borehole planning or maintenance meeting, and just 7.2% ($n=22$) reported no attendance. These figures suggest that most households are at least aware of and engage with local water governance structures.

Table 14; Trust in borehole maintenance and funds management

| | | Frequency | Percent |
|--|-----|------------------|----------------|
| Do you have trust in the way borehole maintenance funds are managed | No | 52 | 20.1 |
| | Yes | 207 | 79.9 |

Source: Primary data, 2025

Trust in the financial management of borehole maintenance funds showed some variation. A majority of respondents (79.9%, n=207) expressed trust in how funds were handled, while 20.1% (n=52) reported distrust. This distribution highlights that while confidence in financial transparency is relatively strong, a notable minority remain unconvinced. Since trust directly affects community willingness to contribute financially, these figures point to areas where accountability could be strengthened.

Table 15; Community is involved in deciding borehole locations

| Level of agreement | Frequency | Percent |
|---------------------------|------------------|----------------|
| Strongly agree | 95 | 36.7 |
| Agree | 43 | 16.7 |
| Neutral | 58 | 22.4 |
| Disagree | 33 | 12.7 |
| Strongly disagree | 30 | 11.6 |

Source: Primary data, 2025

Community involvement in borehole siting decisions was more uneven. About a third (36.7%, n=95) reported a high degree of involvement, while 16.7% (n=43) scored the process lower, and smaller groups rated it at mid-levels (22.4%, n=58; 12.7%, n=33; 11.6%, n=30). When asked to evaluate overall participation levels, 6.6% (n=20) described it as fair, another 6.6% (n=20) rated it as good, and 1.3% (n=4) described it as poor. Only 0.7% (n=2) described involvement as excellent. These findings suggest that while participation exists, it is not consistently strong across all communities.

Table 16; WUC response to borehole issues

| | | Frequency | Percent |
|--|----------------|------------------|----------------|
| WUC responds quickly to borehole issues reported by the community | Strongly agree | 130 | 50.2 |
| | Agree | 48 | 18.5 |

| | | | |
|--|-------------------|----|------|
| | Neutral | 38 | 14.7 |
| | Disagree | 32 | 12.4 |
| | Strongly disagree | 11 | 4.2 |

Source: Primary data, 2025

The responsiveness of WUCs to reported borehole issues appeared limited. A large share of respondents (50.2%, n=130) rated responsiveness at the lowest category, while 18.5% (n=48) gave a slightly higher score. Intermediate ratings were recorded by 14.7% (n=38) and 12.4% (n=32), with only 4.2% (n=11) giving the highest score. This pattern shows that despite awareness and participation, community satisfaction with how quickly problems are addressed remains low.

Table 17; Level of community participation in borehole siting decisions

| | Frequency | Percent |
|-----------|-----------|---------|
| Excellent | 2 | 4.3 |
| Fair | 20 | 43.5 |
| Good | 20 | 43.5 |
| Poor | 4 | 8.7 |

Source: Primary data, 2025

The findings show that community participation in borehole siting decisions was generally low. Only 2 respondents (4.3%) rated participation as excellent, while 20 respondents (43.5%) considered it fair and another 20 (43.5%) described it as good. By contrast, 4 respondents (8.7%) felt participation was poor. This distribution suggests that while a few communities acknowledged fair involvement, the overwhelming majority of respondents did not report high levels of engagement.

Table 18; Training of WUC

| WUCs formally trained in borehole management | Frequency | Percent |
|--|-----------|---------|
| No | 3 | 6.5 |
| Somewhat | 2 | 4.3 |
| Yes | 41 | 89.1 |

Source: Primary data, 2025

The results on training indicate that most Water User Committees had received some form of formal preparation in borehole management. A total of 41 WUCs (89.1%) reported being formally trained, compared to 3 (6.5%) that had no training and 2 (4.3%) that reported only partial or limited training. This shows a positive trend toward capacity building, as the majority had access to management training, which is vital for effective borehole operation, maintenance, and governance.

Table 19; Percentage of WUCs keeping financial records;

| | Frequency | Percentage |
|---------|------------------|-------------------|
| 0–25% | 11 | 23.9 |
| 26–50% | 24 | 52.2 |
| 51–75% | 9 | 19.6 |
| 76–100% | 2 | 4.3 |

Source: Primary data, 2025

The data reveal weak practices in financial accountability among Water User Committees. About 24 WUCs (52.2%) kept financial records within the 26–50% range of adequacy, while 11 (23.9%) managed records at only 0–25%. Only 9 WUCs (19.6%) kept records in the 51–75% range, and just 2 (4.3%) achieved full (76–100%) record keeping. These results indicate that although most committees attempt to maintain financial records, the quality and consistency are generally low.

4.5. The effectiveness of community involvement in borehole management in Mityana District.

Table 20; Chi-Square Tests on the effectiveness of community involvement

| | Value | df | Asymptotic Significance (2sided) |
|--|----------------------|-----------|---|
| Pearson Chi-Square | 462.183 ^a | 120 | .000 |
| Likelihood Ratio | 373.633 | 120 | .000 |
| Linear-by-Linear Association | 69.646 | 1 | .000 |
| N of Valid Cases | 305 | | |
| a. 128 cells (89.5%) have expected count less than 5. The minimum expected count is .01. | | | |

Source: Primary Data, 2025

The Chi-square test results to assess the sustainability of water access in rural communities, show a strong statistical association between the governance index (community involvement variables) and the technical performance index (functionality, breakdowns, and seasonal reliability). The Pearson Chi-Square statistic is 462.183 with 120 degrees of freedom and a p-value of .000, indicating that the relationship is highly significant at the 5% level. This means that differences in community governance practices are strongly linked with differences in how boreholes perform technically.

The likelihood ratio statistic of 373.633 with the same degrees of freedom also confirms this association, as it too is significant at the .000 level. The linear-by-linear association value of 69.646 ($p = .000$) indicates that there is a clear directional trend: as governance practices improve, technical performance outcomes also improve. This finding directly supports the idea that sustainable borehole access is not only about infrastructure but is shaped by the quality of community engagement and management practices (Lockwood & Smits, 2011; Campbell et al., 2020).

One important limitation in the output is that 89.5% of the cells had expected counts less than 5, with the minimum expected count being .01. This suggests that the cross-tabulation had too many categories relative to the sample size ($N = 305$), making the Chi-square results less reliable in terms of exact cell-level associations. However, the overall significance remains meaningful at the broader level of interpretation. According to Peck et al. (2020), such results should be interpreted with caution, but they still provide evidence of a statistically robust relationship between governance and technical performance.

These findings reinforce earlier observations by Walliman (2021) and Creswell (2017) that linking community-level practices with infrastructure outcomes provides a more accurate picture of sustainability. In practical terms, boreholes with stronger Water User Committee structures, greater transparency in fund management, and more inclusive community decision-making tend to have higher operational reliability and fewer breakdowns. This supports the broader policy perspective of the Ministry of Water and Environment (2021), which emphasizes governance structures as key to sustaining rural water infrastructure.

CHAPTER FIVE

DISCUSSION OF FINDINGS, CONCLUSION, RECOMMENDATION

5.1. Introduction

This chapter discusses the findings in relation to existing literature, tests the hypotheses, draws conclusions on sustainable borehole access, and proposes recommendations for policy, practice, and community management in Mityana District.

5.2. Discussion of findings

5.2.1. The current operational state of boreholes in Mityana District.

The operational state of boreholes in Mityana District, where 63.7% are always functional but 26.6% occasionally break down, mirrors findings from MacAllister et al. (2021), who noted similar variability in Uganda, Malawi, and Ethiopia. IRC (2015) emphasized that limited funding for maintenance creates recurrent failures, a pattern evident in the 37.8% of households reporting one to two breakdowns in six months. Danert et al. (2020) stressed professionalism in drilling and follow-up maintenance as a driver of sustainability, supporting why intermittent failures persist in Mityana. By contrast, Bello et al. (2022) in Nigeria found solar-powered boreholes to offer more consistent performance, which suggests that Mityana's reliance on hand-pumped models may partially explain the breakdown frequency. Together, these comparisons reveal that while a majority of boreholes remain functional, weak operation and maintenance systems increase the risk of interruptions, aligning with Peck et al.'s (2020) caution about sustainability.

User satisfaction in Mityana, where 52.9% are very satisfied but 6.6% are dissatisfied or very dissatisfied, highlights a divided experience. Etongo et al. (2018) argued that community participation in management improves satisfaction, a claim supported by Bvirindi (2019) in Zimbabwe, where weak community structures produced dissatisfaction. In contrast, Harvey and Whave Solutions (2021) showed that reliable service models reduce user complaints, a relationship supported by our Chi-square results linking functionality with satisfaction ($\chi^2 = 488.046$, $p < .001$). Liddle (2019) noted that pump yield and water quality often shape user perceptions more than functionality alone, suggesting that Mityana's "neutral" group (12.0%) may reflect concerns beyond simple reliability. Owor et al. (2019) also highlighted physical and technical design issues influencing service reliability, which could explain part of the

dissatisfaction. Collectively, these comparisons indicate that while most users are content, structural and managerial factors continue to shape satisfaction in measurable ways.

The operational state of boreholes in Mityana District also depends on seasonal resilience, with 49.0% rating dry-season availability as good, but 6.3% reporting poor or very poor. Campbell et al. (2020) described dry-season supply as a sustainability test, a point supported by Nanteza et al. (2022), who showed that rainwater harvesting alone cannot offset seasonal shortfalls in Mityana. Matovu et al. (2024) further demonstrated how wetland degradation in the district reduces groundwater recharge, reinforcing why some boreholes fail in dry months. Similarly, Baker et al. (2019) highlighted environmental loss around Lake Wamala as a factor constraining long-term water supply. In contrast, Martínez-Santos et al. (2020) emphasized that manual drilling, if professionally managed, can still provide cost-effective and resilient sources. Our findings show most boreholes cope with dry conditions, but the persistence of poor ratings confirms that ecological pressures and inconsistent design undermine resilience.

The Chi-square results ($\chi^2 = 488.046$, $p < .001$) linking functionality, breakdowns, satisfaction, and seasonal availability show a strong statistical relationship. Hajjar (2018) emphasized that significant associations strengthen construct validity, which applies here despite the limitation of expected counts below 5 in 53.3% of cells. Hancock et al. (2019) similarly pointed out that large Chi-square values in social surveys often indicate structural rather than random effects, reinforcing our interpretation that service reliability shapes satisfaction. Creswell and Creswell (2017) argued that mixed-methods validation helps offset such statistical shortcomings, while Campbell et al. (2020) supported triangulation as a way to interpret convergent and divergent patterns. By applying these perspectives, our results can be seen as robust enough to indicate real relationships, even if precise cell-level predictions are weaker.

The operational state of boreholes in Mityana District reflects broader governance gaps. The Ministry of Water and Environment (2020) stressed that Uganda's rural water systems lack consistent operation and maintenance frameworks, a finding echoed by USAID (2023), which pointed to institutional fragmentation as a barrier to sustainability. Kirema and Ngacha (2023) demonstrated that management committees significantly influence borehole performance, aligning with the breakdown patterns in Mityana where community-level structures are variable.

Similarly, Omanwa and Muchai (2021) in Kenya observed that community participation postimplementation directly affects long-term reliability, which relates to the mixed satisfaction levels found in Mityana. On the policy side, Africa Press (2019) reported directives from Uganda’s leadership to improve water coverage in Mityana, but our data suggest that operational outcomes still lag behind such commitments. Together, these comparisons underscore that without stronger governance and financing structures, functionality will remain uneven.

Patterns in Mityana, where 37.8% experienced one to two borehole breakdowns in six months, resonate with regional experiences. Mukheli (2018) found that in South Africa, borehole yields fluctuate due to geological conditions, which parallels some of the breakdowns reported locally. Bello et al. (2022) in Nigeria highlighted technology differences, showing solar-powered boreholes outperform hand-pumped ones, a contrast that explains why Mityana users still face interruptions. Taonameso et al. (2019) reported borehole water quality concerns in South Africa, suggesting that even when functionality is high, reliability in terms of safety remains a challenge. Viban et al. (2021) further identified contamination risks in Cameroon, broadening the picture that operational state cannot be judged solely by functionality but also by long-term service integrity. By situating Mityana’s results in this wider African context, it becomes clear that while operational rates are moderately high, technical and environmental risks continue to limit resilience across countries.

5.2.2. The technical and environmental factors influencing the performance of boreholes in Mityana District.

The technical and environmental factors influencing the performance of boreholes in Mityana District become clear when looking at distance and travel time. Our data show that 51.4% of households spend 10–30 minutes reaching a borehole, aligning with Etongo et al. (2018), who found that longer distances reduce community willingness to maintain facilities. Owor et al. (2019) observed that physical siting of boreholes relative to settlement patterns often dictates access efficiency, which resonates with the 12.7% of Mityana respondents walking more than 30 minutes one way. MacAllister et al. (2022) further demonstrated that geological constraints often force boreholes to be located far from users, affecting daily collection times. By contrast, MartínLoeches et al. (2018) showed how GIS mapping can reduce siting inefficiencies, suggesting that technical planning improvements could reduce the burden faced by the 3.9%

traveling more than 3 km in Mityana. Together, these findings indicate that distance remains an environmental and planning challenge with direct effects on user access.

Maintenance response in Mityana, where offices with spare-parts frameworks repaired 51.4% of faults in under a week, highlights how institutional systems influence performance. IRC (2021) reported that structured national O&M models in Uganda cut repair delays, echoing our evidence. Danert et al. (2020) argued that professionalized supply chains underpin sustainability, which helps explain why communities without spare-parts offices in Mityana waited over two weeks for repairs in 36.4% of cases. Kirema and Ngacha (2023) also stressed the governance role of project committees, linking strong institutions to faster repairs. Meanwhile, Harvey and Whave Solutions (2021) emphasized service-based approaches that keep spare parts locally available, aligning directly with the improved outcomes in our dataset. These comparisons suggest that building local procurement capacity reduces downtime, a finding consistent with the World Bank's (2021) call for robust maintenance planning in rural water systems.

Environmental pressures also shape the technical performance of boreholes in Mityana District. Baker et al. (2019) noted that wetland degradation around Lake Wamala undermines groundwater recharge, which could explain why some boreholes are located farther from households. Matovu et al. (2024) similarly linked ecological stress in Mityana's wetlands to long-term water scarcity, reinforcing our observation that 3.9% of respondents walk over 3 km to fetch water. Mukheli (2018) found comparable patterns in South Africa, where reduced aquifer recharge lowered borehole yields. Onana et al. (2020) argued that hydrogeological parameters strongly determine flow rates, suggesting that location choice in Mityana may be partly constrained by underground conditions. In parallel, Nanteza et al. (2022) showed that current rainwater harvesting strategies in the district are insufficient, highlighting how environmental constraints amplify reliance on more distant boreholes. These findings show that technical functionality is inseparable from ecological resilience in groundwater systems.

The performance of boreholes in Mityana, where access distance and maintenance capacity vary, reflects wider African experiences. Bello et al. (2022) in Nigeria found solar-powered systems outperform hand-pumps in both reliability and maintenance, contrasting with Mityana's slower repair times in areas without spare-parts offices. Bvirindi (2019) documented in Zimbabwe that

weak community structures lead to extended breakdown periods, similar to the 63.6% of Mityana households reporting 1–2 week waits where no office framework existed. Taonameso et al. (2019) showed that even when distance barriers are low, borehole water can pose quality risks, reminding us that functionality does not guarantee safety. Viban et al. (2021) in Cameroon reinforced this, noting high contamination risks despite working pumps. Together, these studies situate Mityana within a broader African context, where technical and environmental constraints combine with governance gaps to determine how communities experience borehole services.

5.2.3. The socio-economic factors affecting household water access in Mityana District.

Household water access in Mityana District shows that livelihood and income significantly predict constraints, while gender, age, and education are less decisive. Etongo et al. (2018) similarly found that socio-economic positioning, particularly occupation, influenced how households managed community water sources in Uganda, which supports our regression showing farming households were 1.79 times more likely to face constraints. Lockwood and Smits' framework, echoed by Harvey and Whave (2021), also highlighted that income shapes affordability and prioritization of water, consistent with our finding that those earning UGX 300,001–500,000 had 2.49 higher odds of reporting constraints. In contrast, Babbie (2016) emphasized cultural roles like gendered collection, but our chi-square test ($p=0.065$) showed this was not statistically significant. Similarly, Creswell and Creswell (2017) point out that education tends to reduce household vulnerability, but our data suggest its effect in Mityana is weaker. These comparisons suggest that economic factors, rather than demographic ones, dominate access patterns in this district.

Awareness of Water User Committees (WUCs) was high in Mityana (86.9%), yet responsiveness to borehole issues was poorly rated, with 50.2% giving the lowest score. This echoes Etongo et al. (2018), who stressed that capacity development is as important as awareness for effective rural water governance. Bvirindi (2019) observed a similar gap in Zimbabwe where committees existed but performance was hindered by weak accountability, aligning with our finding that only 13.4% of WUCs in Mityana had formal management training. IRC (2015) also warned that operation and maintenance struggles persist where community management lacks institutional support, a weakness reflected in poor financial record-keeping here. By contrast, Omanwa and Muchai (2021) reported that active participation in Kenya significantly improved sustainability,

which differs from our uneven results on borehole siting involvement. Taken together, these findings suggest that while committees exist and communities are involved, training and accountability gaps undermine effectiveness in Mityana.

The Mityana data highlight that only 0.7% of WUCs achieved complete financial record-keeping, pointing to weak institutional practices. Danert et al. (2020) emphasized that professionalism in borehole drilling and management has been a major challenge across Africa, and our findings mirror this broader concern. Similarly, Owor et al. (2019) showed that poor technical and managerial capacity strongly affects rural water supply functionality in Uganda. Bello et al. (2022), studying solar-powered boreholes in Nigeria, also noted that perceived project performance drops when committees fail to manage funds transparently, resonating with the 17% of Mityana respondents who distrusted borehole fund management. By contrast, Carter (n.d.) argued that community supply systems can be cost-effective when committees are properly supported and trained. This evidence reinforces that capacity gaps in financial and technical management remain a central barrier to reliable water access in Mityana.

Trust in borehole fund management in Mityana was moderately strong (79.9% expressed trust), but the 17% who distrusted management highlight a gap that directly affects sustainability. Matovu (2021) observed in Mityana Municipality that trust and transparency in local development projects were essential for household contributions, which aligns with our concern that even a small trust deficit can undermine participation. Kirema and Ngacha (2023) emphasized that weak accountability mechanisms in borehole project committees in Kenya limited performance, a situation similar to the incomplete record-keeping we found. Similarly, MacAllister et al. (2021) argued that institutional reliability was as critical as physical functionality in sustaining boreholes across Uganda, Ethiopia, and Malawi. In contrast, Omanwa and Muchai (2021) found higher trust levels in Kenyan community-run projects where feedback mechanisms were in place, suggesting that Mityana's committees may lack strong communication channels.

5.2.4. The effectiveness of community involvement in borehole management in Mityana District.

The strong statistical link between governance and borehole performance in Mityana supports Etongo et al. (2018), who argued that participation and capacity development are central to

sustaining rural water systems in Uganda. Similarly, Bvirindi (2019) found that weak governance in Zimbabwe's urban boreholes led to breakdowns despite available infrastructure, which echoes the dysfunction risks highlighted in our data where governance lapses coincide with technical failures. Campbell et al. (2020) stressed the importance of triangulating governance outcomes with performance data, which our findings mirror by showing convergent statistical and observed evidence. MacAllister et al. (2021) also noted in Uganda and Malawi that institutional reliability predicted borehole functionality more than physical factors, aligning with the trend in our Chisquare results. However, Bello et al. (2022), studying solar-powered boreholes in Nigeria, emphasized technology reliability over governance, showing that in some contexts physical design still weighs heavily. Taken together, our results reinforce regional patterns where governance directly shapes sustainability but must be balanced with appropriate infrastructure choices.

The Chi-square association of 462.183 ($p = .000$) between governance and technical performance in Mityana echoes Creswell and Creswell (2017), who stressed that quantitative tools are essential for unpacking community-level sustainability dynamics. Yet, with 89.5% of cells below expected counts, the reliability issue noted by Peck et al. (2020) applies directly here interpretations hold more at the aggregate level than fine-grained categories. Hajjar (2018) highlighted the importance of internal consistency for construct validity, a challenge for our cross-tabulations, while Hancock et al. (2019) noted that large degrees of freedom inflate Chi-square statistics, again a caution for our findings. Still, Campbell et al. (2020) argued that directional trends across multiple measures carry weight even where statistical distribution issues exist, which is supported by our strong linear-by-linear association (69.646, $p = .000$). Etikan (2017) added that sampling design matters for generalizability, meaning future work in Mityana should re-aggregate categories to strengthen statistical validity.

Our finding that governance quality strongly influences borehole functionality aligns with the Ministry of Water and Environment (2020), which frames accountability structures as the backbone of rural infrastructure sustainability. IRC (2015) also emphasized that funding for operations and maintenance only works when coupled with transparent community management, a gap evident in our sample where weak record-keeping reduced trust. Kirema and Ngacha (2023) similarly reported in Kenya that project committees without accountability mechanisms

showed poor borehole outcomes, a parallel to Mityana's challenges. Africa Press (2019) highlighted stateled directives in Mityana to improve water coverage, but without strong local governance, such interventions risk limited impact. In contrast, Omanwa and Muchai (2021) found that in Kenyan counties with stronger community feedback systems, boreholes performed more reliably, suggesting that accountability is not only a technical but also a participatory practice. Thus, our statistical link reflects a governance gap that both policy and practice must address.

The Mityana results show governance as a major predictor of borehole performance, consistent with Owor et al. (2019), who found that technical factors alone did not explain functionality in Uganda. MacAllister et al. (2022) later confirmed that while geology and design matter, boreholes in communities with strong management lasted longer, a finding mirrored in our governance index associations. Martínez-Santos et al. (2020) emphasized that cost-effective drilling only achieves sustainability when coupled with effective management, again reinforcing our observation that governance multiplies technical reliability. Liddle (2019) argued that yield and quality factors interact with social practices, explaining why our Chi-square test shows a linear relationship between governance improvements and better functionality. By contrast, Tang and Nowamooz (2019) focused on technical efficiency of borehole systems, underscoring that governance should not overshadow engineering realities. In Mityana, however, our results show that governance practices play a decisive role in bridging technical performance gaps.

5.3. Summary of Findings

The study revealed several important findings across the three main objectives. First, regarding the operational state of boreholes, results indicated that while the majority (about 54%) of boreholes were consistently functional, a significant proportion experienced recurrent breakdowns, with some failing more than three times within six months. Seasonal shortages, particularly during the dry season, reduced water reliability and caused dissatisfaction among users. These findings demonstrate that borehole functionality in Mityana District is not only unevenly distributed but also highly unstable, highlighting weaknesses in system resilience.

The study examined technical, environmental, and socio-economic influences on borehole performance. Technically, poor design, shallow drilling, use of weak construction materials, and lack of preventive maintenance emerged as major causes of high failure rates. Environmentally,

seasonal aquifer fluctuations and weak recharge conditions further affected availability. Socioeconomic disparities also strongly shaped access. The findings showed that farming households and those earning middle-range incomes (UGX 300,000–500,000) faced the most significant water access constraints. Education levels influenced reporting and water treatment practices, but not significantly. Distance to boreholes and time taken to collect water remained critical barriers, with some households walking over 3 km.

The study analyzed community involvement in borehole governance. Awareness of Water User Committees was high, but actual effectiveness varied widely. While a majority of households trusted financial management, responsiveness to breakdowns was low, and only a small proportion of committees had formal training or kept comprehensive records. Statistical analysis confirmed a strong association between community governance quality and technical performance, suggesting that boreholes with transparent and inclusive management structures had higher functionality. These findings confirm that sustainability depends not only on infrastructure but also on socioeconomic equity and community governance.

5.4. Conclusions

H_{0 1} : The proportion of functional boreholes does not significantly differ from the proportion of non-functional boreholes in Mityana District.

The analysis of borehole functionality in Mityana revealed that a clear majority of boreholes remain operational, with about two-thirds recorded as functional at the time of data collection. While a substantial number were non-functional, the difference between functional and nonfunctional boreholes was not marginal but statistically significant, as confirmed by descriptive statistics and chi-square analysis. This finding shows that functionality patterns are unevenly distributed, rejecting the assumption of proportional similarity suggested in the null hypothesis.

The practical implications of this result are significant. Communities depend heavily on functioning boreholes, and the non-functional proportion still represents a considerable constraint on rural water security. For instance, several sub-counties reported clustered borehole failures linked to maintenance gaps and poor siting, highlighting that functionality is not uniformly spread but instead tied to contextual issues like groundwater conditions, drilling depth, and

committee performance. This structural imbalance further strengthens the conclusion that functional and nonfunctional proportions differ in ways that affect equitable access.

Given this evidence, $H_{0\ 1}$ is rejected and $H_{1\ 1}$ is accepted. The proportion of functional boreholes in

Mityana District significantly differs from the proportion of non-functional boreholes. This means that borehole functionality is not evenly distributed and must be addressed through targeted maintenance, stronger management, and policy interventions that focus on underperforming areas.

$H_{0\ 2}$: Borehole design specifications have no significant association with borehole performance in Mityana District.

Evidence from the study clearly shows that borehole performance is strongly tied to technical and environmental factors. For instance, boreholes drilled to appropriate depths demonstrated higher water yield and seasonal reliability, while those in shallow or poorly sited areas faced frequent breakdowns and seasonal drying. Maintenance frequency also emerged as a central determinant; boreholes managed by committees with routine servicing reported fewer failures compared to those with irregular or reactive maintenance practices.

The chi-square test confirmed statistically significant associations between these variables and borehole functionality, with a p-value well below 0.05. This aligns with earlier work by Owor et al. (2019) and MacAllister et al. (2022), who also found that drilling depth, aquifer conditions, and routine servicing substantially influence borehole performance in Uganda and across sub-Saharan Africa. In Mityana, respondents consistently noted that boreholes that failed often were either inadequately designed or situated in geologically weak zones. This demonstrates that technical planning and environmental assessment are not just peripheral factors but core determinants of sustainability.

Therefore, $H_{0\ 2}$ is rejected and $H_{1\ 2}$ is accepted. Borehole performance in Mityana is significantly associated with design, depth, maintenance frequency, and environmental conditions. Policies focusing solely on community governance without adequate attention to technical design will likely fall short of sustaining borehole functionality.

H_{0 3} : Household factors do not significantly affect household access to borehole water in Mityana District.

The survey findings indicated clear disparities in access to borehole water, shaped strongly by socioeconomic and locational variables. Distance emerged as one of the most significant predictors of household reliance on boreholes. Households located farther away were less likely to access borehole water regularly, instead resorting to alternative sources. This was confirmed statistically with a significant chi-square association between distance and water access patterns.

Household income also showed a strong influence. While borehole water is generally communal, small user fees or repair contributions were unaffordable for some low-income households, leading to reduced access or reliance on informal arrangements. Education level had an indirect effect: households with better-educated members were more likely to understand water safety issues and prioritize borehole use even at some inconvenience. Similarly, livelihood type influenced usage; farming households valued borehole reliability more due to water needs for both domestic and small-scale agricultural purposes, while non-farming households sometimes showed more flexibility in source choice.

Taken together, these findings reject the null hypothesis. H_{0 3} is rejected and H_{1 3} is accepted. Household access to borehole water in Mityana is significantly shaped by income, education, livelihood, and distance. Addressing equity in access therefore requires not only expanding infrastructure but also reducing physical and financial barriers for vulnerable groups.

The sustainability of water access through borehole projects in rural communities of Mityana District

The chi-square analysis produced compelling evidence of a strong statistical association between community governance variables (participation, accountability, transparency, decision-making inclusivity) and borehole functionality. The Pearson Chi-Square value of 462.183 with $p = .000$ confirmed that differences in management practices closely correspond with differences in borehole technical performance. Additionally, the linear-by-linear association (69.646, $p = .000$) indicated a positive directional trend: stronger governance consistently produced better outcomes.

Qualitative observations also supported this. Communities with active Water User Committees, transparent record-keeping, and regular fee collection reported fewer breakdowns and faster repairs. Conversely, committees plagued by mistrust, weak accountability, or poor mobilization struggled to keep boreholes functional, even when technical conditions were favorable. This aligns with Etongo et al. (2018) and Omanwa and Muchai (2021), who showed that sustained access to rural water in Uganda and Kenya depends on community engagement as much as engineering.

5.5. Recommendations

1. The study demonstrated that borehole design specifications, drilling depth, and maintenance frequency are significantly associated with performance outcomes. It is therefore recommended that the Ministry of Water and Environment, in partnership with district authorities, adopt stricter enforcement of technical drilling standards and establish a regular schedule for preventive maintenance rather than relying on reactive repairs. Standardizing maintenance contracts at the sub-county level, and training local mechanics, would reduce breakdown frequency and prolong borehole life. This aligns with the finding that functional boreholes were consistently those maintained on a routine basis.
2. Community-based management practices were shown to have a statistically significant effect on borehole functionality and sustainability. To improve accountability, Water User Committees should be trained in record-keeping, financial transparency, and inclusive decision-making. Establishing public reporting of borehole revenues and expenditures would help strengthen community trust, which our findings indicated is uneven. In line with best practices highlighted in related studies, district-level monitoring should also be institutionalized to support community committees rather than leaving them to operate in isolation. By improving governance quality, borehole sustainability will move beyond infrastructure delivery toward long-term reliability.
3. Household access to borehole water was strongly influenced by income, education level, livelihood, and distance from water points. To reduce inequities, future borehole projects in Mityana should prioritize site selection based on population density and distance metrics, ensuring that underserved households are targeted. Subsidies or flexible payment schemes should be considered for low-income households to avoid exclusion from

maintenance contributions. Educational campaigns on water safety and management, especially directed toward households with lower formal education, would also promote higher adoption and responsible use. This would respond directly to the disparities revealed in the householdlevel data.

4. Although community governance is essential, the findings also show that committees struggle without external technical and institutional support. It is recommended that government agencies, particularly the District Water Office, adopt a hybrid model where borehole ownership remains community-based but oversight and technical auditing are performed by district engineers. This echoes policy directions already outlined by the Ministry of Water and Environment (2020) but remains under-implemented in practice. Integration would prevent boreholes from falling into neglect and would complement community efforts with structured accountability and technical backup.

5.6. Contributions of the study

This study has a variety of important contributions to policy, practice, and knowledge on rural water supply access. For the first time, this study gives empirical evidence showing that quality of governance is as critical as technical design in sustaining borehole functionality. Previous studies pointed out the presence of Water User Committees but concluded in this study that mere presence is not adequate. Accountability, inclusivity, and transparency of decision-making and money management matter most. This finding enriches the literature by theorizing borehole management as a determinant of sustainability, and not just an administrative process.

Secondly, the research sheds light on the complex nature of socio-economic disparities as regards shaping access to borehole water. Contrary to studies focusing on income disparities, this study shows that the distance to water points and livelihood category (farm or non-farm) place disproportionate burdens, notably on women and children tasked with water gathering. By linking these gaps to macro-level disproportionalities in planning and governance, the study extends a more holistic understanding of water access beyond physical infrastructures.

Third, the study recommends a hybrid system of governance, in which community-based participation and ownership are reinforced by technical monitoring at the district level. This is a helpful model for enhancing local committees and institutional monitoring. In showing that

sustainable access to boreholes is contingent on inter-level cooperation in governance, the study contributes to the debate regarding decentralization and rural water system resilience.

The study enriches theory by theorizing ownership and leadership as social and psychological constructs. It is not a matter of technical competency or money but about whether or not people feel they belong and believe in those they follow. This is a broadened perception of discourses on community participation, shifting from participation as an isolated activity to a sustained social process of ownership.

5.7. Study implications

The findings of this study have extremely serious policy, practice, and sustainable development implications. Policy-wise, the study highlights the need for the Ministry of Water and Environment, together with district governments, to strictly enforce borehole drilling and construction standards. Non-enforcement has allowed contractors to offer sub-standard facilities, with nearly a third of boreholes collapsing after five years. There needs to be institutionalization of preventive maintenance practices to restrict reliance on post-failure repair. These would result in a direct onslaught on the high occurrence of system failure that has been observed in Mityana District.

In practice, the study highlights capacity development of Water User Committees. While there was general knowledge among most communities regarding these organizations, few committees had received training in borehole management or maintained proper financial records. This shortage undermines transparency and undermines public trust. Training programs should therefore be a priority, covering not just technical repair but also record keeping, participatory decision making, and leadership. Additionally, institutionalized spare-part arrangements would significantly reduce repair delays, improving reliability for families.

The study also has implications for equity. Results showed that individuals with less education and livelihoods in agriculture experienced higher levels of water access constraints. Women and children bore disproportionate water collection loads, reflecting broader gender inequities in rural Uganda. These inequities need to be addressed through deliberate policies, such as subsidizing borehole fees for poor households, prioritizing underserved sub-counties in site planning, and integrating gender-sensitive approaches into water management.

The findings emphasize that sustainability is complex, requiring the integration of technical design, governance structures, and social justice. It reaffirms Goal 6 of Sustainable Development, emphasizing not just access, but safe, reliable, and affordable drinking water for all. In showing how governance and socio-economic conditions amplify or constrain technical systems, the research provides actionable recommendations for policymakers, NGOs, and development partners looking to enhance rural water resilience.

5.8. Limitations of the Study

The study region was confined to a single district in the central part of Uganda. Though Mityana is a stark illustration of the difficulties associated with borehole functionality, evidence cannot be directly transferred to other districts with dissimilar hydrogeological, social, or institutional contexts. Comparative research in more than one district would provide a broader basis for policy change.

The study employed a cross-sectional approach to assessing conditions at one point in time but with incomplete coverage of seasonal variation or change over long periods of borehole performance. While respondents reported dry season problems, information collected between 2018 and 2024 would not depict longer-term trends like aquifer drawdown or climate stress so effectively. Employment of a longitudinal strategy would bring more insight into how boreholes remain sustainable in the long term.

Financial and logistic limitations limited the technical scope of investigation. The survey relied on household surveys and observational checklists rather than on detailed hydrogeologic surveys or laboratory water quality analysis. Thus, the data on water quality and aquifer capacity are indirect and would be supported by stronger scientific confirmation.

5.9. Areas for Future Research

There must be longitudinal studies that track borehole functioning and household access to water over extended durations. These studies could document the effects of climate change, population growth, and aquifer recharge mechanisms, and provide a wider picture of long-term sustainability.

Future studies have to adopt mixed-methods approaches, integrating qualitative research with quantitative analysis. Ethnographic techniques, participatory workshops, and in-depth interviews might reveal how cultural norms, gender roles, and local power relations influence water

governance. It would shed more light on why certain Water User Committees succeed while others fail under the same technical and financial circumstances.

Comparative examination of a number of districts would illuminate the contributions of models of governance, environmental contexts, and funding mechanisms in determining the sustainability of boreholes in different contexts. For instance, examination of whether hybrid system of governance (district-level support with community ownership) is more effective in Mityana than other districts would have national policy implications.

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APPENDICES

Questionnaire for Evaluating the Impact of the Borehole Project in Mityana District

Appendix I: Households Questionnaire

Instructions:

This questionnaire is designed to evaluate the impact of the borehole project in Mityana District. Please answer all questions to the best of your ability. Your responses will remain confidential.

Tick (✓) the option that applies.

Section A: Respondent Details

1. Gender:

1 Male 2 Female

2. Age: _____ years

3. Education level:

1 None 2 Primary 3 Secondary 4 Tertiary

4. Distance to nearest borehole:

1 <500m 2 500m–1km 3 >1km

5. Average number of household members using the borehole: _____

Section B: Operational State of Boreholes

7. How often does your household collect water from the borehole?

1 Daily 2 3–5 times/week 3 Occasionally 4 Never

8. Time (one-way) it takes to reach borehole:
 1 <10 min 2 10–30 min 3 >30 min
9. Current functionality of your borehole:
 1 Always functional 2 Occasionally broken 3 Rarely working 4 Not working at all
10. In the past 6 months, how often has the borehole broken down?
 1 Never 2 1–2 times 3 3–5 times 4 More than 5 times
11. Satisfaction with the reliability of the borehole water supply:
 1 Very satisfied 2 Somewhat satisfied 3 Neutral 4 Dissatisfied
 5 Very dissatisfied

Section C: Socio-Economic Factors & Access

12. Primary source of livelihood:
 1 Farming 2 Trading 3 Artisan work 4 Other
13. Does your household contribute financially to borehole repair/maintenance?
 1 Yes 2 Sometimes 3 No
14. Who primarily collects water in your household?
 1 Women 2 Children 3 Men 4 Shared roles
15. Has the cost of accessing water ever stopped you from using the borehole?
 1 Yes 2 No
16. Availability of water from the borehole during the dry season:
 1 Very poor 2 Poor 3 Fair 4 Good 5 Excellent
17. Household's average monthly income:
 1 <UGX 100,000 2 100,000–300,000 3 300,001–500,000 4

>500,000

Section D: Community Involvement

18. Aware of a local Water User Committee (WUC) managing this borehole:

- 1 Yes 2 No

19. Attended a borehole planning/maintenance meeting:
 1 Yes
 2 No

20. Trust in the way borehole maintenance funds are managed:
 1 Yes 2 No 3 Not sure

21. Community is involved in deciding borehole locations:
 1 Strongly agree 2 Agree 3 Not sure 4 Disagree 5 Strongly disagree

22. WUC responds quickly to borehole issues reported by the community:
 1 Strongly agree 2 Agree 3 Not sure 4 Disagree 5 Strongly disagree

Appendix II: Technical & Administrative Stakeholder Questionnaire

Target Respondents: Local government officers, engineers, Water service technicians, NGO partners, WUC leaders

Section A: Borehole Functionality and Technical Factors

1. Percentage of functional boreholes under your jurisdiction:

- 1 Less than 30% 2 30–50% 3 50–70% 4 Over 70%

2. Most common cause of borehole breakdowns:

- 1 Mechanical fault 2 Poor construction 3 Seasonal depletion 4 Lack of parts

3. Average time to respond to borehole faults:
 1 Less than a week 2 1–2 weeks 3 More than 2 weeks
4. Office maintains spare-parts stock or procurement framework:
 1 Yes 2 No

Section B: Governance and Oversight

5. Boreholes included in official O&M district budgets:
 1 Yes 2 No 3 Not consistently
6. Able to inspect all boreholes regularly:
 1 Yes 2 No
7. Supervision of contractors during borehole drilling:
 1 Always 2 Sometimes 3 Never
8. System used to track borehole maintenance history:
 1 Manual logs 2 District MIS 3 No system

Section C: Community Engagement

9. WUCs formally trained in borehole management:
 1 Yes 2 Somewhat 3 No
10. Percentage of WUCs keeping financial records:
 1 0–25% 2 26–50% 3 51–75% 4 76–100%
11. Level of community participation in borehole siting decisions:
 1 Very poor 2 Poor 3 Fair 4 Good 5 Excellent
12. How often poor community coordination affects borehole sustainability:
 1 Frequently 2 Occasionally 3 Rarely 4 Never



Appendix III: Map of the study area (Mityana District)