

**EXPLORING THE IMPLICATIONS OF COMMUNITY ENGAGEMENTS IN
ENSURING ACCESS TO SAFE BOREHOLE WATER IN RURAL SETTING
IN UGANDA**

BY

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DECLARATION

With the exception of instances where proper citation has been made in the text and reference list, I, David Edhaya, hereby declare that this submission is my original work and that, to the best of my knowledge and belief, it is free of any previously published or written works by others as well as any content that has been approved for the award of any degree by the university or other higher education institutions.

Signature: -----

Date: -----

APPROVAL

The signatories certify that they have read the dissertation titled "Exploring the implication of community engagement in ensuring access to safe borehole water in rural settings in Uganda" and urge Kyambogo University to accept it as partial fulfillment of the requirements for the award of a Master of Science degree in Water and Sanitation Engineering.

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TABLE OF CONTENTS

DECLARATION.....	I
APPROVAL	II
ACKNOWLEDGEMENTS.....	III
DEDICATION.....	IV
LIST OF ACRONYMS AND ABBREVIATIONS	XI
ABSTRACT	XII
CHAPTER ONE: INTRODUCTION	1
1.1. Background of the study	1
1.2. Statement of the problem	2
1.3. Research objectives.....	4
1.3.1. Main objective.....	4
1.3.2. Specific objectives of the study.....	4
1.4. Research questions	4
1.5. Conceptual framework.....	5
1.6. Significance of the study	6
1.7. Scope of study.....	7
1.7.1.Geographical scope	7
1.7.2. Content scope	7
1.7.3. Time scope	8
1.8. Chapter One Summary	8
CHAPTER TWO: LITERATURE REVIEW.....	9
2.1. Introduction.....	9
2.2. Theoretical Review of Community Participation	9

2.1.1. Rural water access challenges	10
2.1.2. Case Studies of Community Participation	12
2.1.3. Challenges and Research Gaps	16
2.1.4. Lessons Learned and Best Practices	19
2.2. Chapter Summary.....	19
CHAPTER THREE: METHODOLOGY	21
3.1. Introduction.....	21
3.2. Research design and approach	21
3.2.1. Research design.....	21
3.2.2. Research approach	22
3.3. Description of the study area.....	22
3.4. Population and sample	23
3.4.1. Population	24
3.4.2. Sample and sampling strategy.....	24
3.5. Data collection	28
3.5.1. Procedure for Data collection.....	28
3.5.2. Community Participation in Borehole Administration	29
3.7. Data analysis	33
3.7.1. Survey data.....	33
3.7.2 Water quality data analysis	34
3.7.3. Analyzing Community Engagement and Water Quality	34
3.8. Findings on the Validity and reliability	35
3.9. Chapter Three Summary	35
CHAPTER FOUR: RESULTS AND DISCUSSION	36

3.10. Demographic characteristics of respondents.....	36
4.3.1. Community engagement in borehole administration	39
4.4 Water Quality	45
4.4.1 Water quality examinations for all the districts	45
4.5. Analyzing Community Engagement and Water Quality	56
CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS	69
5.1 SUMMARY	69
5.2 KEY FINDINGS.....	69
5.3 CONCLUSION	70
5.4 RECOMMENDATIONS	71
5.4.1 GENERAL RECOMMENDATIONS	71
5.4.2 POLICY RECOMMENDATIONS.....	71
5.4.3 RECOMMENDATIONS FOR FUTURE RESEARCH.....	71
REFERENCES.....	72
ANNEX	76
Annex 1: Sample size selection table.....	76
Annex 2: Distribution of Borehole Sample Size per District.....	76
Annex 3: Sample size determination table.....	77
Annex 4: Data collection questionnaire (Households).....	78
Annex 6: Data collection questionnaire (officials)	93
Annex 7: Location of Buyanga and Namalemba subcountyies	98
Annex 8: Location of Ajia and Vurra subcounties.....	99
Annex 9: Location of Kasagama and Kinuuka subcounties	100
Annex 10: Location of Nakaseke & Kinoni subcounties.....	101

Annex 11: Summary of literature reviewed.	102
Annex 12: Water Quality Results	106
Annex 13: Location of boreholes considered in the study	114

LIST OF TABLES

Table 3.4.2: Distribution of sample size per district	25
Table 3.4.3: Distribution of sample size per sub-county	26
Table 3.10.1: Demographics of the respondents	37
Table 4.3.1.1: Results from household questionnaires per Districts.....	40

LIST OF FIGURES

Figure 1.5.1: Conceptual framework for the study	5
Figure 3.4.1: Study area map	23
Figure 3.5.1: Questionnaire administration.....	28
Figure 4.3.1: location of boreholes in study District.....	30
Figure 3.5.2: Collection of water samples	32
Figure 3.5.3: Water quality testing.....	32
Figure 4.4.1: Comparison of pH values for all the districts.	47
Figure 4.4.2: Comparison of turbidity levels across all the four districts	49
Figure 4.4.3: Comparison of e.coli levels across all the four districts.	51
Figure 4.4.4: Comparison of total coliform levels across all the four districts.....	54
Figure 4.5.1: E.Coli and water source location.....	57
Figure 4.5.2: E.Coli & construction supervision.....	60
Figure 4.5.3: Total Coliform and faecal material seen around the water source	63
Figure 4.5.4: E-Coli and observable cases of water related diseases.....	66

LIST OF ACRONYMS AND ABBREVIATIONS

CC	Community Contribution
CDA	Community Development Assistant
CWO	County Water Officer
DWD	Directorate of Water Development
DWO	District Water Officer
FY	Financial Year
GFS	Gravity Flow Scheme
GoU	Government of Uganda
HA	Health Assistants
LC1	Local Council One
MWE	Ministry of Water & Environment
NWSC	National Water and Sewerage Corporation
OP5	Operation Plan 5
PAF	Poverty Action Fund
RGC	Rural Growth Centre
RUWASA	Rural Water and Sanitation East Uganda Project
RWH	Rainwater Harvesting
STD	Standard Measurement
SWC	Safe Water Coverage
TSU	Technical Support Unit
WHO	World Health Organization
WUC	Water User Committee

ABSTRACT

Groundwater is essential for human consumption, agriculture and industry, traditionally deemed safe due to natural filtration. However, increasing pollution and limited community participation in borehole development have raised contamination concerns in Uganda's rural districts like Arua, Nakaseke, Lyantonde and Bugweri, where this study was conducted. This research examined the relationship between community engagement and borehole water quality using a mixed-methods approach, including surveys, water quality testing and geographical mapping. It assesses how community involvement in borehole site selection, construction, monitoring and maintenance influences water source protection and quality. A total of 530 structured questionnaires were analyzed to gauge engagement levels, while direct water quality analysis was conducted in Bugweri, with secondary data from Nakaseke, Lyantonde and Arua. Results show a significant link between community engagement and water quality, with better quality maintained in districts with higher community involvement. Factors like inadequate drainage and cracks around boreholes contributed to water contamination. For instance, Arua district showed a reduction in *E. coli* contamination with higher community adherence to borehole maintenance instructions. This study highlights the importance of active community participation in borehole development and maintenance for ensuring safe water access and improving public health, particularly during the wet season.

CHAPTER ONE: INTRODUCTION

1.1. Background of the study

Water is vital for survival, agriculture and industry, underpinning social and economic development. However, groundwater, once considered clean, is increasingly threatened by contaminants such as improper waste disposal, agricultural runoff with nitrates and pesticides and industrial pollutants (Joshua, et al., 2022).

Groundwater globally faces growing risks from microbiological contamination, notably *E. coli*, alongside pH variations and increased turbidity, all of which threaten water safety. Despite these dangers, monitoring and management of groundwater quality, especially concerning microbiological and chemical factors, remain inadequate, highlighting the need for more focused studies (Banach & Van Der Fels-Klerx, 2021)

In Africa, recent studies in countries like Nigeria, Kenya and South Africa reveal growing concerns over groundwater contamination from agricultural runoff and waste mismanagement. Persistent pollutants, including *E. coli* and other microbial contaminants, impact groundwater safety, highlighting the need for improved monitoring and water management strategies (Mugisha Bruce & Limin Ma, 2021)

In response to water quality concerns, the World Health Organization (WHO) and the Uganda National Bureau of Standards have established national drinking water guidelines. These standards mandate that no Thermo Tolerant Coliforms (TTC) or *Escherichia coli* (*E. coli*) should be present in any 100 mL sample of drinking water. Despite these regulations, WHO and UNICEF frequently report faecal contamination

in Ugandan water sources such as springs and boreholes, particularly in low-income areas. Consequently, waterborne diseases remain a leading cause of death among children under five (WHO & UNICEF, 2020).

Previous studies highlight that community involvement is crucial for improving water source protection and quality. Active participation in borehole site selection, construction and maintenance has led to better water quality and sustainability. This study examines the impact of community engagement on safe water access in rural Uganda, aiming to enhance borehole management and groundwater protection to reduce waterborne disease transmission.

1.2. Statement of the problem

Despite Uganda's commitment to achieving universal access to safe water and sanitation services by 2030 (SDG 6), significant challenges remain, particularly in rural areas where groundwater is the predominant source of drinking water (Ministry of Water & Environment, 2019) reports that over 75% of Uganda's population lives in rural regions, where water supply projects often fail to provide continuous access to safe and clean water.

Evidence indicates high levels of faecal contamination in water sources across several districts in Uganda, including Bugweri (85%), Lyantonde (75%), Arua (50%) and Nakaseke (75%) (2022-2023 water quality reports). These contamination rates are primarily due to low community participation in the planning, implementation and maintenance of boreholes (DeGabriele, 2022).

Globally, evidence from countries like Kenya and India shows that community participation in water management projects has significantly improved water quality and sustainability. In Kenya, community-led initiatives in borehole management led to a 40% reduction in contamination levels, while in India, participatory water projects reported a 35% increase in borehole longevity. Beyond water, community involvement has also proven effective in other engineering fields, such as irrigation and sanitation projects, where it enhances system functionality, ownership and long-term success (Amani , et al., 2022).

While large-scale initiatives have been implemented to improve water access, these projects frequently struggle to maintain water quality due to human activities and inadequate community involvement. For example, preserving borehole catchment areas to reduce pollution is mandated but often neglected (WHO & UNICEF, 2020) The resulting poor water quality has significant health impacts, including increased cases of waterborne diseases.

This study focuses on the relationship between community involvement and access to safe drinking water in specific districts, highlighting how enhancing community participation can improve water quality and sustainability in local water supply projects.

1.3. Research objectives

1.3.1. Main objective

The main objective of this study was to assess the impact of community involvement across all stages of a project on the accessibility of clean borehole water in a rural Ugandan context.

1.3.2. Specific objectives of the study

The specific objectives of the research were:

1. To investigate whether community members were involved during the planning, implementation and utilization stages of boreholes in selected districts in Uganda;
2. To assess the quality of water for the physiochemical and microbiological parameters that are caused by human activity; and
3. To examine how community involvement (in planning, implementing and using boreholes) relates to water quality (physiochemical and microbiological factors) in selected Ugandan districts.

1.4. Research questions

1. Does community participation in boreholes administration affect the quality of water?
2. What are the levels of microbiological contamination (for example, total coliforms, E. coli and others) in the borehole water in the selected rural districts?

3. Are there notable differences in physiochemical and microbiological water quality parameters between boreholes with high community engagement and those with low engagement?

1.5. Conceptual framework

The independent variable will be community participation/involvement in planning, implementation and utilization of boreholes. The dependent variable will be the quality of water as shown in Figure 1.1

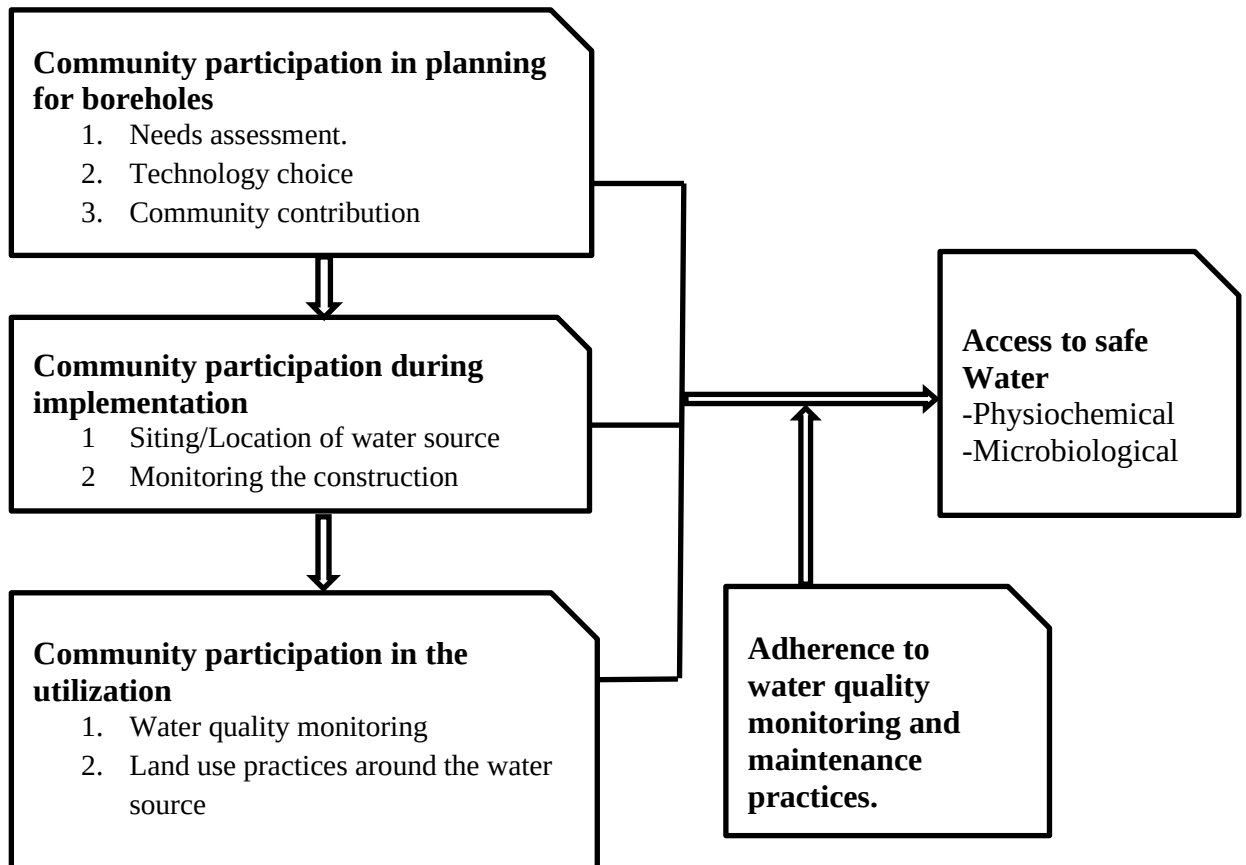


Figure 1.5.1: Conceptual framework for the study

1.6. Significance of the study

1.6.1. Socio-Economic Significance of the Study

This study will contribute to:

- **Improved Water Access and Health:** By highlighting the role of community participation in water management, the findings will help improve access to clean borehole water, reducing waterborne diseases such as diarrhea in vulnerable districts.
- **Sustainable Development:** The study aligns with Uganda's National Development Plan (NDP III), the African Union's Agenda 2063 and the UN Sustainable Development Goal (SDG 6), focusing on ensuring access to clean water and sanitation. It emphasizes the importance of community involvement for sustainable water resource management.
- **Capacity Building and Skill Development:** The study will guide local governments and communities in building capacity for better water management practices, strengthening skills in water monitoring and borehole maintenance. This contributes to long-term water sustainability.

1.6.2. Academic Significance of the Study

- **Knowledge Advancement:** The research will expand the body of knowledge on the relationship between community participation and water quality, especially in the context of borehole water management in Uganda.
- **Empirical Evidence:** The study provides data-driven insights and empirical evidence on the effectiveness of community engagement in managing and

maintaining clean water sources, supporting future research and policy decisions in water resource management.

1.7 Justification of the Study

- Water-related challenges in Bugweri, Arua, Nakaseke and Lyantonde districts—such as diarrhea due to poor sanitation and water access—have had significant public health impacts. This study assesses how community engagement can improve access to safe borehole water, providing a solution to these challenges. By addressing local water management issues, the findings will contribute to Uganda's National Water Policy and support the achievement of international targets, including SDG 6 on clean water and sanitation. The research also aligns with Uganda's Vision 2040 by promoting community-driven approaches to improve water access and public health.

1.7. Scope of study

1.7.1. Geographical scope

The study was carried out in Arua, Bugweri, Nakaseke and Lyantonde districts.

1.7.2. Content scope

Water sources in Arua, Bugweri, Nakaseke and Lyantonde districts include surface water sources, protected springs, rain-water harvesting tanks and boreholes. This study, however, will concentrate only on boreholes. Community participation in all phases of provision of borehole water to communities including planning phase, implementation phase and utilization phase is necessary. This study explored the implication of community engagement at all stages of provision of borehole on the quality of water.

1.7.3. Time scope

This research was carried out from November 2022 to July 2023.

1.8. Chapter One Summary

The chapter introduces the study's background, summarizes key elements, including the research problem, goals and topics. It emphasizes the study's significance. The next chapter reviews community participation literature, covering theory, history, indicators and studies on water management effects. It identifies research gaps the study aims to address.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

The purpose of this chapter is to provide the theoretical and practical foundations of the concept of continuous process improvement of Community Participation in the management of Community Water Sources.

2.2. Theoretical Review of Community Participation

Community participation in water management has roots in democratic governance and has evolved significantly. Historically, community engagement in development planning has been documented since ancient times, including pre-colonial Uganda, where local leaders mobilized communities for self-help projects (Tseklevs & Braga, 2022). Modern theories and practices of community participation have developed over time, emphasizing local involvement in decision-making and project management (Syamsu Rijal, 2023).

Post-colonial principles of community participation gained traction in the 1970s and 1980s, with international organizations like the UN and USAID emphasizing the need for local engagement to counteract centralized control (UN, 2023). The Sustainable Development Goals (SDGs), particularly target 6b, highlight the importance of community engagement in water and sanitation (UN, 2023). Despite these advances, challenges remain, especially in Sub-Saharan Africa (SSA), where access to clean water and sanitation is still limited (Tseklevs & Braga, 2022). Recent data underscores the persistent water access issues and the need for effective community involvement to address these challenges (Abid Rasool, et al., 2024)

2.1.1. Rural water access challenges

Safe water access in rural areas faces several challenges:

- **Limited Infrastructure:** Many rural areas lack essential water infrastructure, such as piped distribution systems, making access to safe water difficult (Abid Rasool, et al., 2024)
- **Distance and Accessibility:** Long distances to water sources, particularly in rugged terrains, burden rural communities, especially women and children (Sarah, et al., 2021)
- **Water Quantity and Availability:** Water scarcity, exacerbated by seasonal changes and droughts, affects the availability of adequate water for drinking and hygiene (Abid Rasool, et al., 2024)
- **Water Quality Concerns:** Contamination from agricultural runoff and poor sanitation poses significant health risks (Lifewater International, 2019)
- **Health Impact:** Limited water access leads to waterborne diseases, affecting vulnerable populations and increasing morbidity and mortality rates (Sarah, et al., 2021)

2.1.2 Significance of Borehole Water Sources

Boreholes significantly enhance water access by offering a reliable, high-quality water source that mitigates seasonal and drought impacts. They improve convenience by reducing travel distances for water collection and support community empowerment through local management, fostering sustainability and ownership. Additionally, the cleaner water from boreholes promotes better health and hygiene, addressing both immediate needs and long-term well-being (Sarah, et al., 2021)

2.2 Community Participation in Borehole Management

Community participation is crucial for effective water management. It involves local communities in decision-making, planning and management, recognizing their role as key stakeholders. Effective community initiatives require thoughtful planning and communication, often facilitated by community development workers (Amani , et al., 2022)

2.2.1 Significance of Engaging Local Communities

Engaging local communities in water management leverages their valuable insights, fosters ownership and sustainability and builds trust within the community. It empowers individuals, enhances skill development and improves the effectiveness and efficiency of water management strategies. This holistic involvement ensures more informed decision-making and better resource allocation, leading to more effective and lasting water solutions (Mugema & Walekhwa, 2022).

2.2.2 Theories and Frameworks for Community Engagement

Effective water management is guided by several key frameworks: Integrated Water Resources Management (IWRM) promotes stakeholder participation, including local communities; Participatory Rural Appraisal (PRA) engages communities in assessing and solving their own water challenges; Social Learning Theory emphasizes collaborative knowledge exchange; and Adaptive Management supports flexibility and continuous learning by involving communities in monitoring and adjusting strategies. Together, these approaches ensure a comprehensive, inclusive and adaptive strategy for sustainable water resource management (Buytaert; Wouter; Zulkafli; Zed; Grainger; Sam, 2023).

2.2.3 Factors Affecting Rural Community Participation

Effective community participation in water initiatives hinges on several key factors: cultural and social norms shape engagement levels, while strong governance and leadership enhance involvement. Transparent communication and awareness campaigns boost participation and addressing socio-economic challenges through income-generating activities supports engagement. Trust and collaboration are vital, as are learning from past experiences with water projects. Adequate infrastructure also plays a crucial role by showcasing tangible benefits (Walekhwa & Kawungezi, 2022). Addressing these factors in Bugweri, Lyantonde, Nakaseke and Arua districts is essential for fostering meaningful and sustainable community involvement in water management efforts.

2.1.2. Case Studies of Community Participation

Case studies and examples of community participation in water-related initiatives highlight the diverse ways in which communities have actively engaged in decision-making, planning, implementation and management of water projects. Here are a few notable examples:

- **Community Led Water Management, Ethiopia:** In rural Ethiopia, community-led planning improved water access and reduced waterborne diseases. However, challenges included inadequate financial resources and conflicts over water usage (Nebiyu Gashawbeza, 2022)
- **Nepal's Drinking Water and Sanitation Program** Community participation in Nepal empowered marginalized groups and improved water access. A key

challenge was the lack of technical expertise, leading to delays in system maintenance (UNICEF , 2018)

- **Water User Associations in Kenya:** Communities in rural Kenya participated in managing water systems, improving distribution. Despite these successes, conflicts arose over water allocation and some associations struggled with financial mismanagement (Mwanga, 2017)
- **Community Monitoring in Bangladesh:** In arsenic-affected regions, communities monitored water quality. Challenges included limited access to testing equipment and insufficient governmental support (WASH Alliance International, 2023)
- **Northern Uganda Water and Sanitation Program:** In post-conflict northern Uganda, the program aimed to improve water access through community managed water points. However, challenges arose from the low literacy levels of water management committees, which led to poor record-keeping and mismanagement of funds. Limited community involvement in long-term maintenance planning further undermined the project's effectiveness (African Development Fund – Uganda, 2022)
- **Karamoja Water Governance Project, Uganda:** In Karamoja, a participatory approach to water governance sought to involve local pastoralist communities in water resource management. The project faced significant challenges due to existing inter-community conflicts over grazing land and water access, which hindered cooperation and led to water scarcity issues in some areas (Nebiyu Gashawbeza, 2022).

- Bugesera Rural Water Supply Project, Rwanda: Community participation in the Bugesera District helped install water infrastructure, but the project encountered difficulties when community members lacked technical expertise to maintain the systems. Additionally, disputes over labor contributions and water tariffs led to delays and disagreements, affecting the sustainability of the project (Mininfra, et al., 2019)
- Kibera Integrated Water, Sanitation and Waste Management Project, Kenya: In Nairobi's Kibera slum, community members were involved in managing water kiosks and sanitation facilities. However, the project faced challenges related to lack of trust in leadership, conflicts over water pricing and vandalism of infrastructure. These issues reduced the overall effectiveness of the initiative (Janet Muriuki & Nkirina Severina, 2021)

2.1.4 Impact of Community Participation on Access to Safe Water

Community involvement significantly enhances access to safe borehole water in several ways:

- **Behavior Change:** Engagement leads to better hygiene practices and water management behaviors, reducing waterborne disease risks (Sarah, et al., 2021)
- **Sustainability:** Active participation fosters ownership, leading to improved maintenance and long-term sustainability of water sources (Sarah, et al., 2021)

2.2 Assessment of Borehole Water Quality

Recent research on borehole water quality emphasizes the importance of monitoring physical, chemical and bacteriological parameters:

- **Physical Parameters:** Temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, color and taste affect water quality. Elevated TDS, high turbidity and abnormal color or taste indicate potential contamination or pollution (Etongo, et al., 2018)
- **Chemical Parameters:** The chemical composition of borehole water includes essential ions and trace elements. Recent studies highlight the significance of monitoring calcium, magnesium, sodium and contaminants like iron, manganese and trace elements (Etongo, et al., 2018)
- **Bacteriological Parameters:** Monitoring bacterial indicators such as total coliforms, faecal coliforms, E. coli and enterococci is crucial for assessing microbiological safety. High levels of these indicators point to potential contamination risks (Barrell, et al., 2020)

2.3 Community Engagement Levels and Borehole Water Quality

Community engagement impacts borehole water quality significantly:

- **Monitoring and Reporting:** Engaged communities can detect and report contamination promptly, leading to timely interventions (Andres, et al., 2018).

- **Ownership and Responsibility:** Participation fosters a sense of responsibility, enhancing borehole maintenance and water quality (Walekhwa & Kawungezi, 2022)
- **Education and Awareness:** Educated communities are more likely to adopt practices that protect water quality (Andres, et al., 2018)
- **Advocacy for Improved Infrastructure:** Communities may advocate for better infrastructure to prevent contamination (Etongo, et al., 2018)
- **Data Collection and Analysis:** Engaged communities contribute valuable data on water quality trends, aiding in effective decision-making (Barrell, et al., 2020)

2.1.3. Challenges and Research Gaps

This section presents research gaps that emerged from the literature review, reflecting areas requiring further investigation. The following gaps are based on available evidence and where literature is lacking, it is explicitly mentioned.

2.1.3.1. Community Participation and Water Management

- **Mechanisms for Effective Participation:** Limited research exists on specific strategies and frameworks that enhance community involvement in borehole water management. There is a need to investigate actionable mechanisms to strengthen participation, which has only been partly explored (Ateya, 2023)
- **Utilization and Maintenance:** While community-managed borehole projects are common, research is lacking on the specific ways communities improve long-term maintenance and operation. Further studies are required to

document best practices and the challenges communities face in sustaining boreholes (Tseklevesa & Braga, 2022)

- **Innovative Solutions for Rural Water Access:** Despite known challenges in rural water access, there is a gap in research exploring innovative, community-driven solutions to overcome these hurdles (Amani Joseline, Magunda Hilary, Mutekanga David R, 2022)
- **Applicability of Engagement Frameworks:** Frameworks for community engagement exist, but little evidence assesses their effectiveness in the context of borehole administration, particularly in Uganda and East Africa. Research is needed to assess how applicable these models are in specific settings (Mugisha Bruce & Limin Ma, 2021)

2.1.3.2. Water Quality and Safety

- **Sustainability of Engagement Efforts:** There is a need to examine the long-term sustainability of community involvement in borehole water quality monitoring. Evidence on sustained community roles and their impact on water safety is limited (Subodh & Sudan, 2021)
- **Contextual Variability:** The effectiveness of community participation can differ across social, cultural and economic contexts and research should focus on understanding these variations to tailor engagement strategies (Walekhwa & Kawungezi, 2022)
- **Measuring Participation Impact:** Standardized methods to measure community participation's influence on water quality are lacking.

Developing metrics would help evaluate the effectiveness of these efforts (Subodh & Sudan, 2021)

- **Inclusivity and Equity:** Although community engagement is promoted, research on reaching marginalized groups and ensuring inclusivity remains limited. Strategies that specifically address the inclusion of vulnerable populations are needed (Braunstein & Joy, 2020)

2.1.3.3. Borehole Water Quality Assessment

- **Scaling Successful Models:** There is limited research on replicating successful community engagement models that enhance borehole water quality. Understanding what drives these successes will inform broader implementation (Walekhwa & Kawungezi, 2022)
- **Emerging Contaminants and Pathogens:** While microbial indicators are studied, emerging pathogens and chemical contaminants like pharmaceuticals need more research attention to ensure comprehensive water safety assessments (Donald, et al., 2022)
- **Impact of Climate Change:** The effects of climate change on borehole water quality remain under-researched. Investigating how shifting weather patterns influence contamination is critical for future-proofing water access (Subodh & Sudan, 2021)

2.1.4. Lessons Learned and Best Practices

1. **Participatory Approach:** Engaging the community throughout the borehole project lifecycle is essential to ensuring ownership and long-term commitment (Ateya, 2023)
2. **Capacity Building:** Providing community training in water management, maintenance and financial accountability enhances borehole functionality and sustainability (Tseklevesa & Braga, 2022)
3. **Inclusive and Gender-Sensitive Participation:** Prioritizing women and marginalized voices strengthens decision-making and improves equity in water access (Amani , et al., 2022)
4. **Effective Governance:** Establishing user committees with clear roles and responsibilities fosters local oversight and accountability (Mugema & Walekhwa, 2022)
5. **Monitoring and Evaluation:** Regular assessment of community satisfaction, water quality and operational progress ensures project success and adaptability (Mwanga, 2017)

2.2. Chapter Summary

The literature on community participation and borehole water access reveals both success stories and challenges, but there are clear gaps in understanding the long-term impacts and sustainability of these efforts. Future research should focus on scaling successful community-led models, addressing emerging contaminants and ensuring that vulnerable populations benefit equitably from these initiatives. A targeted

approach to addressing the gaps will improve water resource management and public health outcomes (Walekhwa & Kawungezi, 2022)

CHAPTER THREE: METHODOLOGY

3.1. Introduction

This chapter presents the methodology of the study. It is divided into: the research design, study population, sample size and selection, sampling techniques and procedures, data collection methods, procedure and data collection and data analysis.

3.2. Research design and approach

The study explores how community involvement affects access to safe borehole water. Employing both descriptive and experimental research methods, I utilized both qualitative and quantitative approaches. This research design and approach are the cornerstones of the study, guiding data collection, analysis and interpretation, ensuring the trustworthiness and credibility of the findings.

3.2.1. Research design

This study employed a mixed-methods design, combining descriptive and experimental approaches to examine the relationship between community engagement and access to safe borehole water in rural Uganda.

Descriptive Research: Quantitative data were collected on community participation levels, household demographics and involvement in borehole management (decision-making, water practices, monitoring). This provided a broad overview of community engagement in water access, using statistics like frequencies, means and percentages, without implying causality.

Experimental Research: Water quality tests (e.g., *E. coli*, pH, turbidity) were conducted to assess the impact of community engagement on borehole water safety.

Boreholes with different levels of community involvement were compared to determine a causal link between participation and water quality.

This combined approach enabled a detailed understanding of the role of community involvement in water access and its measurable impact on water safety.

3.2.2. Research approach

In the quest to unravel the multifaceted implications of community involvement in accessing safe borehole water, this research adopts a qualitative research approach. In this journey of exploration, the study delves into the rich tapestry of human experiences, narratives and perceptions, unearthing the nuances that quantitative methods alone may not fully capture, this is followed by quantitative and analytical research methods for assessing the physical, chemical, biological and microbiological characteristics of water samples.

3.3. Description of the study area

The study area is expansive, encompassing multiple sub-counties across distinct districts within Uganda. Including Nakaseke and Kinoni in Nakaseke district, Kasagama and Kinuuka in Lyantonde district, Ajia and Vurra in Arua district and Namalembe and Buyanga in Bugweri District. These districts represent specific geographical regions, each marked by its individual topographical features, demographic composition and socio-economic dynamics.

Bugweri District stands as a representative of the Eastern region in Uganda, Nakaseke as a representative of the Central region, Lyantonde representing the Western region and Arua representing the Northern Region. This geographical representation is visually depicted in Figure 3.4.1 of the study area map.

The selection of these districts was informed by a crucial factor: their underperformance in their respective regions as highlighted in the 2019 National Assessment report conducted by the Office of the Prime Minister of Uganda in the water and sanitation sector. This deliberate selection ensures that this research addresses critical areas facing diverse communities, making it possible to delve into the implications of community involvement in borehole water access within contexts that demand comprehensive attention.

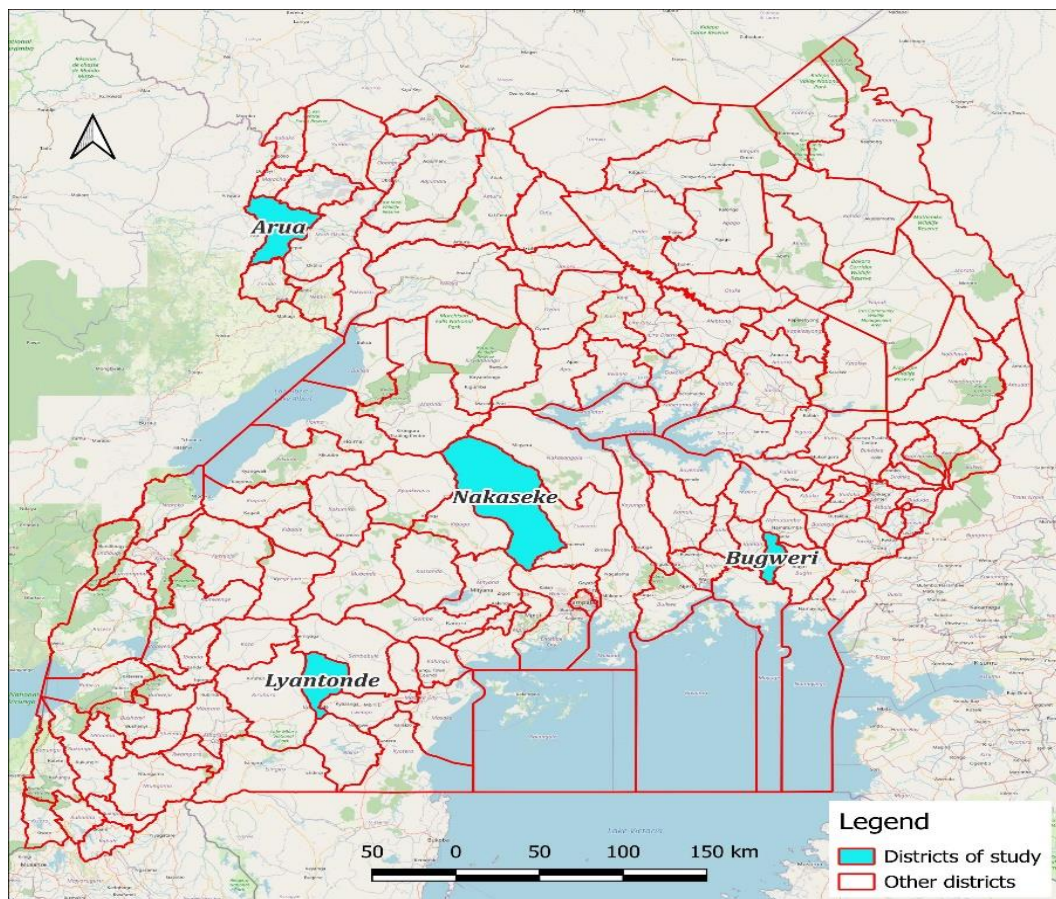


Figure 3.3.1: Study area map

3.4. Population and sample

The "population" in this research represents the entire group of interest, encompassing all the communities, households, or individuals potentially affected by the issues

surrounding borehole water access and community involvement. However, the sheer magnitude and diversity of this population often make it impractical to collect data from every member. This is where the concept of a "sample" comes into play

3.4.1. Population

In this study, the study population comprises the diverse communities residing in the sub-counties of Nakaseke and Kinoni in Nakaseke district, Kasagama and Kinuuka sub counties in Lyantonde district, Ajia and Vurra sub-counties in Arua district, Namalembe and Buyanga sub counties in Bugweri District who are directly impacted by issues related to borehole water access and community involvement.

3.4.2. Sample and sampling strategy

The sample size for this study was determined using Krejcie and Morgan's (Krejcie, *et al.*, 1970), sample size determination tables, ensuring adequate representation across different categories involved in water access, governance and quality assessment. The sampling techniques applied were both probabilistic and non-probabilistic to ensure the collection of a representative sample from the population as shown in Annex 1.

The borehole sampling was designed to select one borehole per village, aiming for a sample size of 155 boreholes. This method ensured that the water quality was representative of the entire village. Villages were selected using simple random sampling from a total of 259 villages across four districts: Bugweri, Arua, Nakaseke and Lyantonde. Each sub-county's village names were randomly drawn to guarantee an unbiased sample. This sampling technique reflects the varying environmental conditions of each district's water supply.

The planned distribution was: 29 boreholes from Bugweri, 69 from Arua, 22 from Nakaseke and 26 from Lyantonde. However, during data collection, limitations in data

from the Ministry of Water and Environment (MWE) led to variations. A total of 124 borehole samples were analyzed 29 from Bugweri, 36 from Arua, 22 from Nakaseke and 12 from Lyantonde. The borehole data from Arua, Nakaseke and Lyantonde was secondary data from MWE, while Bugweri samples were primarily collected by the researcher. These adjustments are scientifically justified by the constraints of available secondary data.:

Household Sampling Strategy and Rationale

A total of 380 household members were selected for this study. Simple random sampling was used to select households in each village. This technique ensures that every household had an equal chance of being included, making the sample more representative of the village population. The household sample distribution across the four districts is detailed in the table below.

Table 3.4.1: Distribution of sample size per district

S/N	District	District population	Total number of LCs per District	LCIs Sample size per district	Household Sample size per district	Politicians sample size per district
1	Bugweri	205,600	48	29	104	25
2	Arua	168,400	116	69	85	21
3	Nakaseke	254,900	53	32	129	31
4	Lyantonde	119,600	42	25	61	15
	Total	748,500	259	155	380	92

Table 3.4.3 below shows the number of returned questionnaires from different districts. A total of 370 household questionnaires were returned, with the highest from Nakaseke (126) and the lowest from Lyantonde (60). For LC1 leaders, 93 questionnaires were returned, with Arua contributing the most (38). Four

questionnaires were returned each from Water Officers and Health Officials across all districts. Politicians returned 59

Table 3.4.3: Returned questionnaires per district.

SN	Bugweri	Returned Household questionnaires	LCI's returned	Water Officers returned	Health Officials returned	Politicians returned
1	Bugweri	101	18	1	1	16
2	Arua	83	38	1	1	14
3	Nakaseke	126	20	1	1	18
4	Lyantonde	60	17	1	1	11
	Total	370	93	4	4	59

The distribution of the sample size amongst the sub counties in each district was done using proportional methods and the table below shows the sample size per sub-county.

Table 3.4.2: Distribution of sample size per sub-county

S/N	District	Sub-county	Total popn per s/c	S/c popn	Total number of LCs per S/C	Total LCs per district	LCs for the study per S/C	H/H per district for study	H/H Sample size per S/C
1	Bugweri	Namalemba	91,700	28,700	21	48	13	104	33
2	Bugweri	Buyanga		63,000	27		16		71
3	Arua	Vurra	90,500	56,100	84	116	50	85	53
4	Arua	Ajia		34,400	32		19		32
5	Nakaseke	Nakaseke	31,400	8,700	41	53	25	129	36
6	Nakaseke	Kinoni		22,700	12		7		93
7	Lyantonde	Kasagama	25,300	14,200	21	42	13	62	35
8	Lyantonde	Kinuuka		11,100	21		13		27
	Total		238,900	238,900	259	259	155	380	380

Table 3.4.4 details the distribution of the sample size across sub-counties. It shows the total population, number of Local Councils (LCs), and household (H/H) sample sizes for each sub-county within the districts of Bugweri, Arua, Nakaseke, and Lyantonde. The table summarizes the total number of returned questionnaires per sub-county, with a total of 370 households surveyed.

Table 3.4.4: Distribution of sample size per sub-county

S/N	District	Sub-county	Total popn per s/c	S/c popn	Total number of LCs per S/C	Total LCs per district	LCs for the study per S/C	H/H per district for study	H/H Sample size per S/C
1	Bugweri	Namalemba	91,700	28,700	21	48	13	101	30
2	Bugweri	Buyanga		63,000	27		16		71
3	Arua	Vurra	90,500	56,100	84	116	50	83	52
4	Arua	Ajia		34,400	32		19		31
5	Nakaseke	Nakaseke	31,400	8,700	41	53	25	126	36
6	Nakaseke	Kinoni		22,700	12		7		90
7	Lyantonde	Kasagama	25,300	14,200	21	42	13	60	33
8	Lyantonde	Kinuuka		11,100	21		13		27
	Total		238,900	238,900	259	259	155	370	370

The Sampling techniques included both probabilistic and non-probabilistic sampling techniques. Under the probabilistic technique, stratified random sampling was used (Etikan & Bala, 2017)

LCI and Other Key Informants Sampling Strategy and Rationale

Local Council I (LCI) members, District Water Office staff, District Health Office staff and area politicians were selected purposively. The rationale for purposive sampling was to ensure the inclusion of key decision-makers and individuals directly

involved in water governance, health and administration. These respondents provided valuable insights into the management and maintenance of boreholes, water quality and related health issues.

3.5. Data collection

In the quest to explore the implications of community involvement in accessing safe borehole water, the process of data collection emerges as a pivotal phase of this research journey. It is through this systematic gathering of information that led to unearth valuable insights, narratives and perspectives from the communities under study.

3.5.1. Procedure for Data collection

Introductory Letters and Permissions: An introductory letter from the Directorate of Research and Graduate Training at Kyambogo University and another from the Head of the Department of Civil and Environmental Engineering were obtained. These letters were used to seek permission from relevant authorities in Bugweri, Nakaseke, Arua and Lyantonde districts for administering questionnaires, collecting water samples and accessing necessary data



Figure 3.5.1: Questionnaire administration

Figure 3.5.1 above shows the researcher and the research assistants carrying out a survey in a quest to administer the questionnaires

3.5.2. Community Participation in Borehole Administration

Community participation was assessed through questionnaires administered to a diverse group of participants, including district technical staff, household members, LC 1 members and area politicians. Focus group discussions, interviews and observation checklists were also used to gather qualitative data-.

A total of 635 questionnaires were distributed and 530 were completed and returned. This results in a response rate of approximately 83%. This high response rate indicates strong engagement from participants and supports the robustness of the collected data. The near-complete return rate helps ensure that the sample accurately represents the target population, thereby enhancing the validity of the survey results.

Figure 4.3.1 below Provides a map displaying the locations of boreholes in all the districts. This map, using grid references, offers an overview of the physical condition of boreholes, highlighting factors such as cleanliness, the presence of protective fencing, platform condition and nearby flooding. It is also useful for assessing the level of community involvement in maintaining water quality and ensuring access to safe borehole water (Andres, et al., 2018)

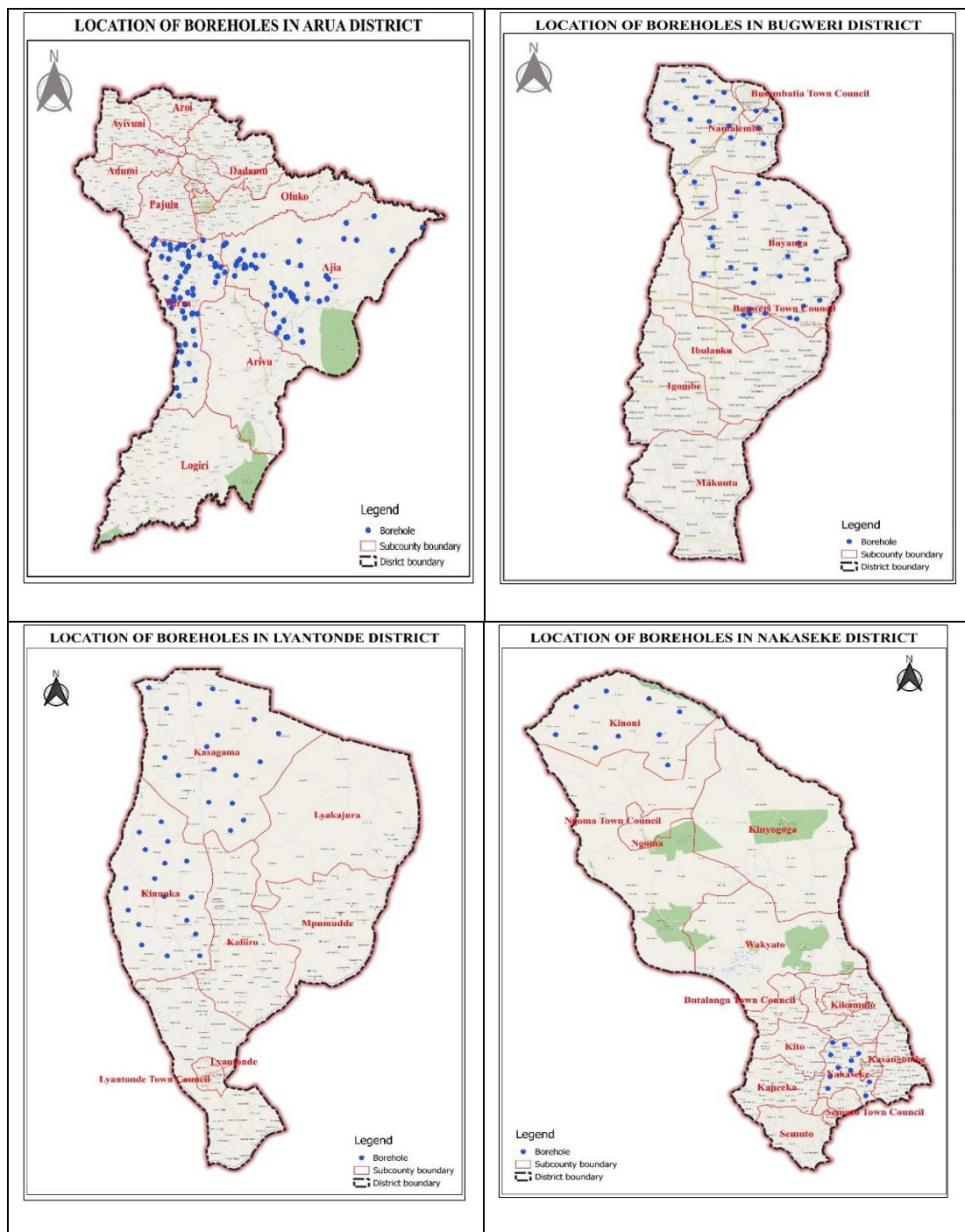


Figure 3.5.2: location of boreholes in study District

3.5.3 Sample collection and analysis

Water samples were collected from boreholes for microbiological and physiochemical analysis using sterile 500 ml bottles. Samples were labeled, stored in cool boxes at 4°C and transported to the laboratory within 6 hours of collection.

- **Microbiological Analysis:**
 - **Parameters:** E. coli and Total Coliforms
 - **Method:** Membrane Filtration Technique
- **Physiochemical Analysis:**
 - **Parameters:** pH and Turbidity
 - **Methods:**
 - pH: Measured with a calibrated pH meter
 - Turbidity: Measured using a turbidity meter

Samples were collected during both dry and wet seasons to assess variations in water quality, focusing on parameters affected by human activity due to insufficient community participation.

3.5.4 Sample Collection and Analysis Instruments

- **Microbiological Parameters:** Portable testing kits, membrane filtration systems, autoclaves, microscopes, incubators and sterile containers.
- **Physiochemical Parameters:** pH meters, buffer solutions, turbidity meters, turbidity standards and data loggers.

3.5.5 Data Organization and Validation

Data was cleaned for errors, duplicates and missing values, validated for consistency and organized by key parameters. Excel tools were used to create summary tables and check for inconsistencies.

3.5.6 Sources of Data

- **Primary Data:** Structured questionnaires and water sampling.
- **Secondary Data:** Obtained from the Ministry of Water and Environment after validation.



Figure 3.5.3: Collection of water samples



Figure 3.5.4: Water quality testing

Figure 3.5.3 above is an illustration of my self being guided by water quality testing experts at the Ministry of water and Environment Entebbe National reference laboratory before going to the field collect data and carry out the tests using the water quality testing kit in Kaliro district water office that was given to the district by the ministry of water and environment under the guidance by experts from the Ministry of water and Environment.

3.7. Data analysis

3.7.1. Survey data

The survey data were first collected and then systematically organized to facilitate analysis. The primary data collection involved gathering both qualitative and quantitative data, as described in the previous section. Upon collection, the raw data were coded according to predefined themes to ensure consistency and relevance.

For the analysis, the data were initially sorted and entered into Microsoft Excel. In Excel, the following steps were performed:

1. **Data Coding and Cleaning:** The raw survey responses were coded to categorize and organize the data effectively. This involved assigning numerical or categorical codes to qualitative responses and ensuring the accuracy of quantitative data.
2. **Data Processing:** The coded data were processed to generate summary statistics for quantitative data and thematic summaries for qualitative data. This included calculating measures of central tendency (mean, median, mode) and dispersion (standard deviation, range) for quantitative variables.

3. **Data Analysis:** The processed data were analyzed using various statistical techniques to identify patterns, correlations and trends. For qualitative data, thematic analysis was conducted to extract meaningful insights and patterns from the responses.
4. **Interpretation and Implications:** The analyzed data were interpreted to draw conclusions and implications relevant to the research objectives. This involved comparing findings with existing literature and assessing their significance in the context of the study.

3.7.2 Water quality data analysis

In order to determine whether there were any mistakes made during the collection, analysis, or data entry of the water quality sample, it was necessary to study and evaluate the data. A number of data checks were carried out to find any data problems. It involved data checking in the first step, i.e., data entering, to determine whether the data is within the parameters as compared to the East African drinking water standards (East African Community, 2014) to see that the data is within the detection limits. Data on water quality were analyzed graphically using Microsoft Excel. Trends in the data were discovered.

3.7.3. Analyzing Community Engagement and Water Quality

Data on community engagement levels and water quality for the specific boreholes was gathered. By use of Microsoft excel graphs showing the relationship between community engagement levels and the quality of water from particular boreholes were developed

3.8. Findings on the Validity and reliability

3.8.3. Validity

The content validity test was used to determine the reliability of the questionnaires.

The content validity indices were calculated using the ratings.

$$\begin{aligned} \text{CVI} &= \frac{\text{Number of items declared valid}}{\text{Number of items in the questionnaire}} \\ &= 66/90 \qquad \qquad \qquad = 0.73 \end{aligned}$$

Since the coefficients are over 0. 7, the lowest Content Validity Index (CVI) that is advised for survey investigations, the questionnaire was deemed legitimate using the Content Validity Index (Almohanna, et al., 2022)

3.9. Chapter Three Summary

The chapter contains the methodology of the study. Questionnaire were used to achieve objective one. Water tests were used to achieve objective two and a relationship between community engagement levels and the quality of water from particular boreholes were developed.

CHAPTER FOUR: RESULTS AND DISCUSSION

This study aimed to investigate how community engagement impacts access to safe borehole water in Ugandan rural areas. This chapter presents research outcomes aligned with study goals, covering questionnaire response rates, respondent demographics, interpretations, discussions, water sample analysis results, the link between Community Engagement, Water Quality, recommendations and conclusions regarding community participation's impact on access to safe borehole water.

3.10. Demographic characteristics of respondents

The study was conducted in four districts of Arua, Nakaseke, Lyantonde and Bugweri and in eight sub counties of Buyanga, Namalembe, Nakaseke, Kinoni, Kasagama, Kinuuka, Ajia and Vurra and in 155 villages. The respondents' demographic characteristics provide essential insights into community dynamics, which are crucial for understanding their involvement in water quality management (Arieko, et al., 2020) Table 4.1.1: below summarizes the demographics of the respondents, including gender, age, education level, occupation and their roles within the household.

Table 3.10.1: Demographics of the respondents

Demographic Details		Bugweri	Arua	Nakaseke	Lyantonde
Gender	Male	59%	76%	75%	61%
	Female	41%	24%	37%	42%
Designation	Household head	63%	76%	73%	60%
	Member of a household	37%	24%	39%	43%
Age	18-35	17%	10%	4%	37%
	36-45	45%	65%	42%	38%
	46-60	33%	25%	49%	19%
	Over 60	5%	0%	17%	9%
Level of Education	None	12%	22%	25%	15%
	P1-P7	61%	28%	73%	17%
	S1-S4	23%	27%	13%	36%
	S5-S6	1%	12%	1%	16%
	Tertiary	3%	12%	1%	19%
Occupation	Formal Jobs	15%	21%	5%	25%
	Informal Jobs	1%	12%	9%	21%
	Business	76%	23%	83%	12%
	Farmer	7%	44%	3%	42%
	Student	1%	1%	0%	1%
Total respondents per district		147	112	122	149

The demographic data reveal significant insights into the relationship between community characteristics and water quality management:

- **Gender Distribution:** With a higher proportion of male respondents, particularly in Arua and Nakaseke, there may be implications for community decision-making and participation in water management practices. Men often take on leadership roles, which could influence the prioritization of water quality initiatives and sanitation practices in these areas.

- **Age Groups:** The dominant age group (36-45 years) is typically more involved in community activities, which could positively affect water quality management practices. However, the lower participation of younger age groups (18-35 years) might indicate a gap in engaging the youth in sustainable water practices, which could impact the long-term sustainability of water quality initiatives.
- **Education Levels:** The varying levels of education across the districts suggest differences in understanding and implementing water quality measures. For example, districts like Lyantonde and Arua, with a higher proportion of tertiary-educated respondents, might have a better grasp of the technical aspects of water quality management, leading to improved practices and outcomes.
- **Occupational Engagement:** The prevalence of certain occupations, such as farming in Lyantonde and Arua, could influence water usage patterns and contamination risks. Farmers might have a more direct impact on borehole water quality due to their activities, making their engagement in hygiene and sanitation practices crucial for maintaining water standards.

By understanding these demographic characteristics, the study highlights the need for tailored community engagement strategies that consider the specific socio-economic contexts of each district. This approach will ensure more effective water quality management and enhanced community participation.

4.3.1. Community engagement in borehole administration

This analysis explores the role of community participation in the implementation and management of boreholes in rural Uganda. It assesses how community involvement influences the effectiveness and sustainability of water supply projects.

Results and discussions for Community engagement

This section discusses the findings on community engagement in borehole management across four districts. Data was gathered through questionnaires administered to stakeholders, supplemented by geographic data from maps showing borehole locations and conditions in the districts. The analysis highlights the impact of community involvement on ensuring sustainable access to safe water.

Table 4.3.1 below presents the results from the questionnaires administered to household members in the four districts. A total of 380 questionnaires were distributed and 370 were filled and returned with varying numbers per district.

The collected data from the questionnaires provide insights into how community involvement at various stages including planning, implementation and utilization affects the sustainability and quality of water sources. Studies have shown that active community participation is crucial for the success of water projects, as it promotes ownership, ensures that local needs are met and improves long-term maintenance and quality (Raphael, et al., 2017). The results in **Table 4.3.1** reflect these dynamics across the four districts and offer a basis for discussing the impact of community engagement on water quality.

Table 4.3.1.1: Results from household questionnaires per Districts

Stage of borehole construction	Number of respondents = 370	Arua			Bugweri			Nakaseke			Lyantonde		
	Questions/Responses	A	NS	D	A	NS	D	A	NS		A	NS	D
Planning Stage	Were the community members were given a chance to choose where the borehole should be sited	96%	4%	0%	88%	10%	2%	88%	5%	7%	82%	4%	14%
Implementation	Were community members allowed to monitor and supervise the construction during the drilling of the borehole	79%	8%	13%	88%	11%	1%	93%	7%	0%	81%	9%	10%
Utilization	Community Members adherence to Borehole Contamination Prevention Instructions	100%	0%	0%	72%	6%	22%	92%	2%	6%	97%	2%	1%
	Are there cases of family Members Affected by Water-Related Diseases	31%	0%	69%	7%	7%	86%	22%	1%	77%	7%	3%	90%
Respondents per District		83			101			126			61		

Legend: A = Agreed, NS = Not Sure, D = Disagreed

The planning stage data indicate high levels of community involvement in borehole location decisions, particularly in Arua, which could be influenced by higher education levels and active involvement by governmental and non-governmental organizations. Community members' participation is critical as it leverages local knowledge, potentially enhancing the sustainability and quality of water sources (Raphael, et al., 2017)

At the implementation stage, community supervision during borehole drilling was highest in Nakaseke and Bugweri, likely due to a greater availability of community members with informal employment or lower educational commitments. Active participation at this stage ensures that local needs and preferences are considered, contributing to the project's success and fostering a sense of ownership among residents (Barrell, et al., 2020)

In the utilization stage, adherence to contamination prevention measures was strongest in Arua and Lyantonde. This adherence is attributed to higher awareness and education levels, highlighting the importance of knowledge in maintaining water quality. The lower adherence in Nakaseke and Bugweri suggests a need for targeted education and awareness campaigns to improve community practices and water safety.

The presence of physical factors such as faecal material and cracked platforms around boreholes was noted, particularly in Bugweri, indicating inadequate protective measures and potential contamination risks. Addressing these issues is crucial for maintaining the quality of water and preventing water-related diseases, which were reported more frequently in districts with lower community engagement and adherence to maintenance practices (Barrell, et al., 2020)

Overall, this analysis underscores the importance of community engagement at all stages of borehole administration in ensuring sustainable and safe water access. Improved community involvement can enhance water quality and reduce health risks, reinforcing the need for education and continuous community participation in water management

Table 4.3.3: Showing results from officials' questionnaires for all the four Districts

Stage of borehole construction	Number of officials = 160	Arua			Bugweri			Nakaseke			Lyantonde		
	Questions/Responses	A	NS	D	A	NS	D	A	NS	D	A	NS	D
Planning Stage	Were people involved in planning & implementation, and utilization stages.	82%	6%	12%	57%	23%	20%	69%	5%	29%	73%	10%	17%
Implementation	Were there efforts to supervise and monitor construction process by the locals?	76%	4%	20%	44%	15%	41%	58%	12%	30%	66%	12%	22%
Utilization	Is there any observation of water related diseases?	10%	20%	70%	65%	5%	30%	42%	27%	31%	32%	25%	43%
	Do communities adhere to borehole contamination prevention rules?	86%	4%	10%	54%	23%	23%	67%	13%	20%	78%	9%	13%
Officials per District		54			36			40			30		

Legend: A = Agreed, NS = Not Sure, D = Disagreed

Local Council I (LCI) leaders, District Water Officers (DWO), politicians, and District Health Officers (DHO) offer a critical view on community involvement in borehole construction, contrasting with household feedback.

Planning Stage:

Officials' responses show variation in community involvement. In Arua, 82% of officials agreed communities were engaged in planning and utilization, compared to only 57% in Bugweri. Lower involvement in Bugweri, reflected in weak borehole management and higher water-related diseases, suggests poor early planning participation. Nakaseke and Lyantonde reported moderate community involvement (69% and 73%), aligning with household reports of active participation. Stronger official involvement in planning, as seen in Arua and Lyantonde, correlates with better project outcomes.

Implementation Stage:

Officials reported gaps in community supervision during implementation, with only 44% in Bugweri agreeing there was oversight, while 41% disagreed. This matches the household data on low participation and higher contamination. In Nakaseke and Arua, 58% and 76% of officials noted community monitoring, though these figures are lower than household reports, indicating a perceived gap in formal supervision.

Utilization Stage:

Officials in Bugweri observed 65% of water-related diseases, contrasting with household reports where 86% disagreed. This may reflect underreporting or a lack of

illness recognition among households. In Arua, only 10% of officials noted waterborne diseases, aligning with high community adherence to contamination prevention. However, the gap in formal supervision, especially in Bugweri, underscores the need for better collaboration between officials and communities for successful borehole management.

Higher official involvement, as seen in Arua, led to better outcomes, while lack of structured engagement in Bugweri contributed to project inefficiencies. This highlights the importance of aligning community efforts with formal project supervision.

4.4 Water Quality

This section presents the results, analysis and subsequent discussions derived from the comprehensive analysis of water quality from all the four districts. Primary data collection focused exclusively on Bugweri District, while secondary data from the Ministry of Water and Environment encompassed additional districts. Through a meticulous examination, the following pages delve into the outcomes and interpretations of this pivotal aspect, shedding light on the fundamental characteristics that define the integrity and suitability of the water supply.

4.4.1 Water quality examinations for all the districts

This section presents a comprehensive analysis of water quality assessments in Bugweri, Arua, Nakaseke and Lyantonde districts, focusing on key parameters: pH, E. coli, turbidity and total coliforms. These parameters were chosen due to their direct relevance to public health, as they provide crucial insights into microbial contamination and water safety, which are priority concerns in rural Uganda. Testing was limited to these indicators due to time, cost considerations and the higher

prevalence of microbial issues over mineral content in these areas. Elevated E. coli and total coliform levels were found to be linked to inadequate community engagement in borehole planning, construction and maintenance, leading to potential health risks.

4.4.1.1 Water Quality Results, Analysis and Interpretation for All Districts

Summarized water quality results for the four districts are provided in Table A.3 in the appendix. The analysis compares contamination levels across districts, focusing on pH, turbidity, E. coli and total coliforms during both wet and dry seasons. The results highlight variations in contamination, guiding district-specific interventions to improve water quality and safeguard community health.

1 pH in all the four Districts

pH levels in water sources within the four districts were measured using a pH meter. A water sample was collected using a clean container for the measurement. The results are shown in table A.3 in the annexes. Analysis was done using Microsoft excel and figure 4.4.1 below is a graph showing the variation in PH values for different water sources during dry season and wet season in all the four studied districts.

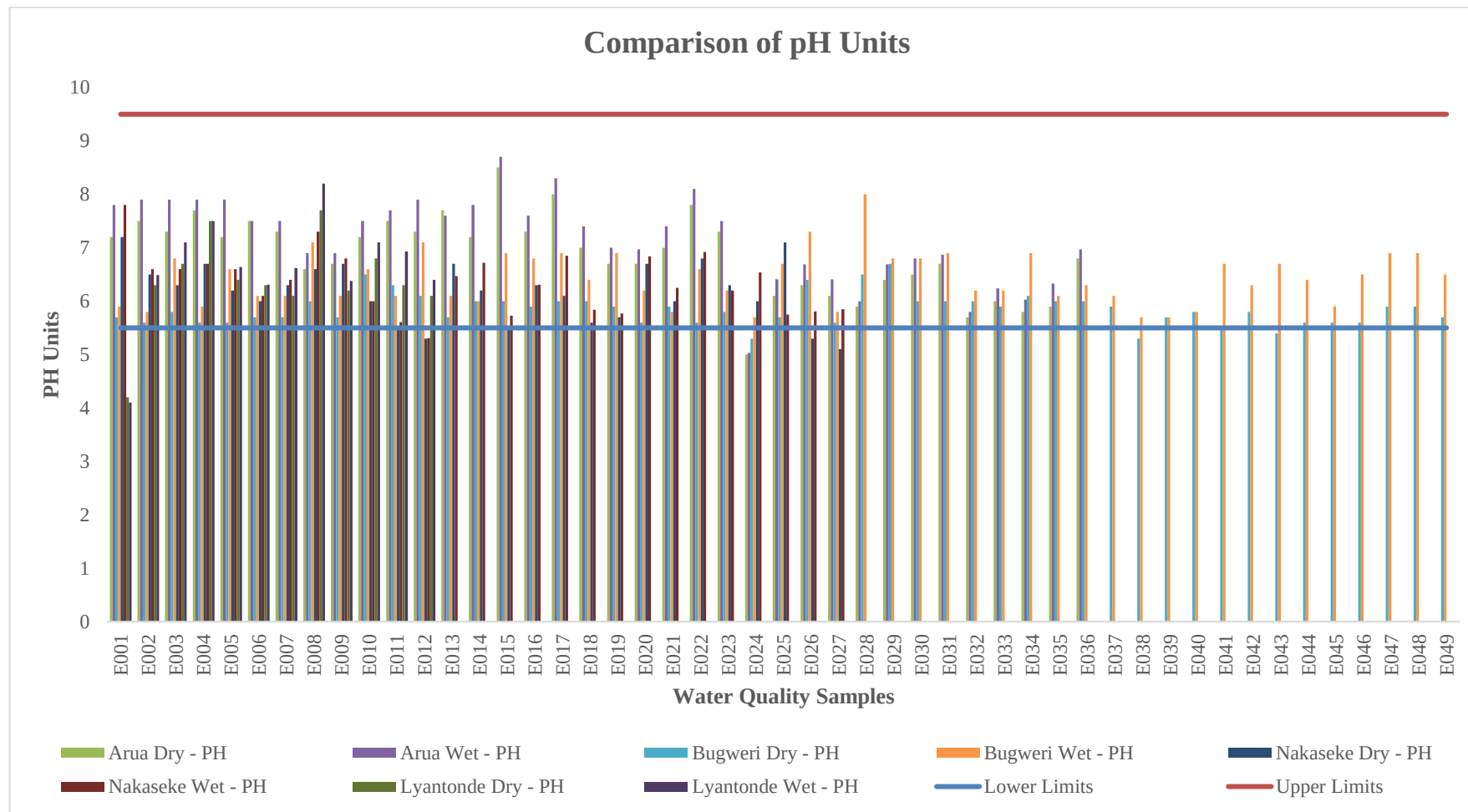


Figure 4.4.1: Comparison of pH values for all the districts.

All districts maintain pH within WHO's safe drinking range, ensuring balanced pH and good water quality. Consistent pH levels across districts indicate low risk to health and infrastructure. This study validates effective water quality management. Ongoing monitoring of broader parameters is crucial for sustained community safety.

Even in the wet season, all districts have pH levels within WHO's safe drinking water range, implying balanced pH and good water quality (Sarah, et al., 2021) apart from sample E001 in Lyantonde district which has pH less than the acceptable range. This may be as a result of agricultural activities carried around the water source as observed by (Ismanto; Hadibarata; Widada; Indrayanti; Ismunarti, 2022), in their studies, they found out that pollution from nearby industrial or agricultural activities can introduce acidic or alkaline substances into the groundwater, altering its pH

1 Turbidity in all the four Districts

Turbidity levels in water sources within the districts of Bugweri, Arua, Nakaseke and Lyantonde were measured using a turbidity meter. A water sample was collected using a clean container for the measurement. The results are shown in table A.3 in the annexes. Analysis was done using Microsoft excel and figure 4.4.2 below is a graph illustrating variations in turbidity levels across the four studied districts for different water sources during dry season and wet season.

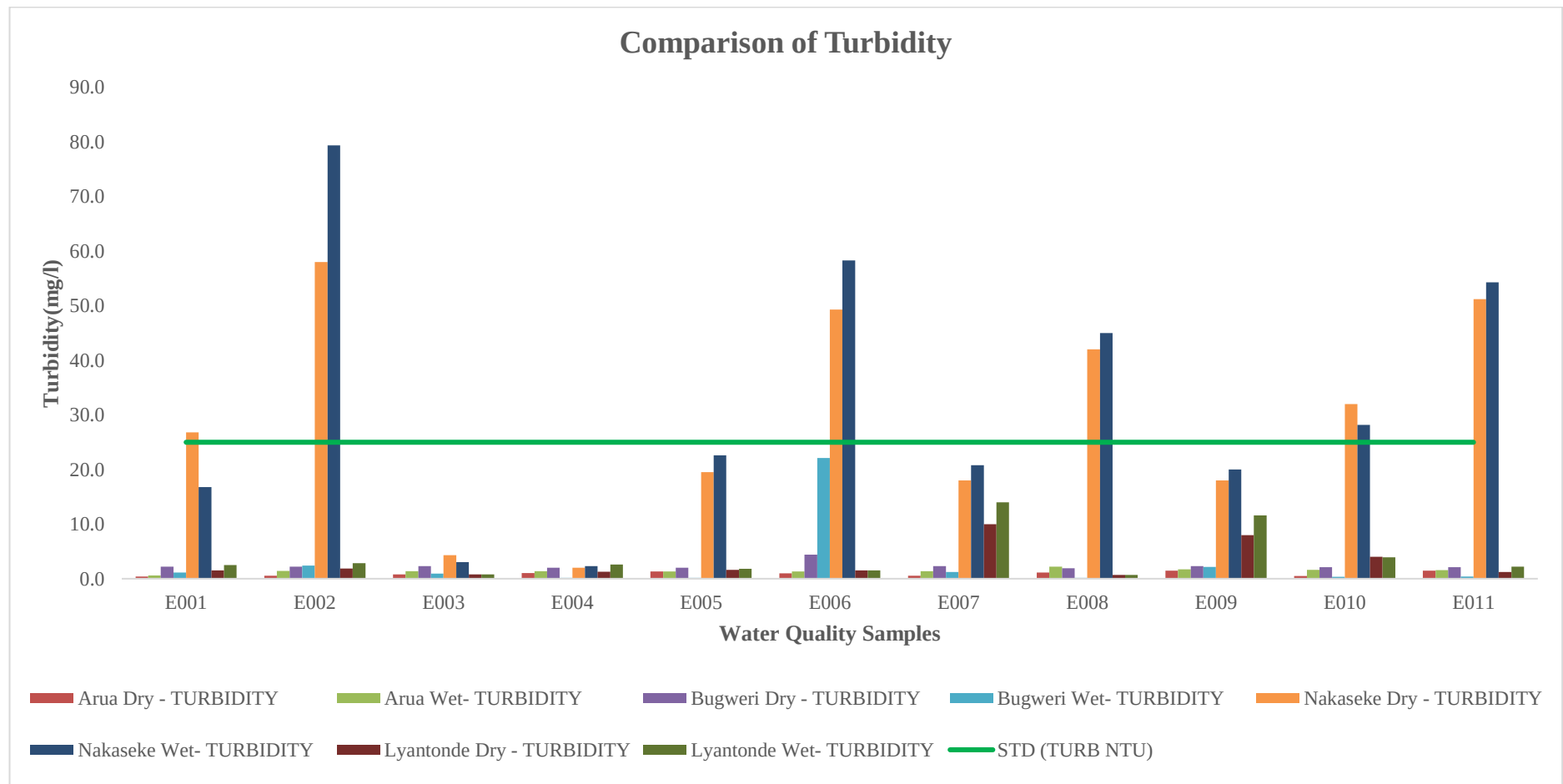


Figure 4.4.2: Comparison of turbidity levels across all the four districts

In the dry season, Nakaseke exhibits the highest turbidity, followed by Lyantonde, while Bugweri and Arua display significantly lower levels. This variation may be attributed to local or geological factors. High turbidity in Nakaseke and Lyantonde can impact water aesthetics, taste and health, highlighting the need for improved treatment. Bugweri and Arua's lower turbidity suggests clearer water sources, possibly due to geological factors.

During the wet season, turbidity levels rise across all districts, including Nakaseke, Lyantonde, Bugweri and Arua but remain within the acceptable drinking water standards of WHO apart from Sample E002 in Nakaseke district that shows turbidity levels higher than the acceptable levels and this may be due rain runoff and sediment. The data underscores the importance of addressing water quality concerns, particularly in Nakaseke and Lyantonde during the rainy season and highlights the need for continuous monitoring and improved strategies to ensure clear and safe water in all districts (Sarah, et al., 2021).

2 **E.Coli** in all the four Districts

E.Coli levels in water sources within the districts of Bugweri, Arua, Nakaseke and Lyantonde were measured using a mobile water quality testing kit. A water sample was collected using a clean container for the measurement. The results are shown in table A.3 in the annexes. Analysis was done using Microsoft excel and figure 4.4.3 below is a graph illustrating variations in e-coli levels across the four studied districts for different water sources during dry season and wet season.

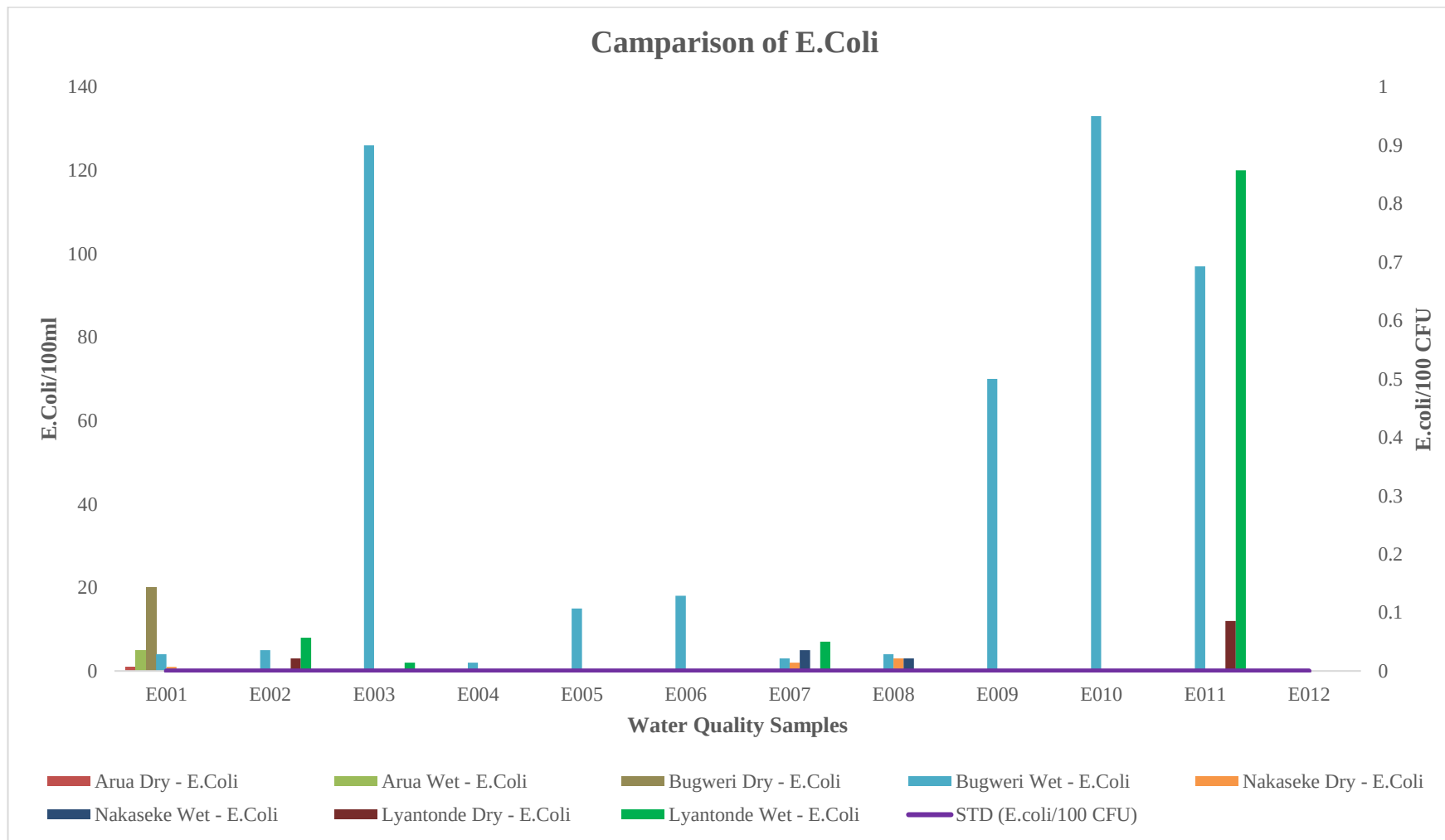


Figure 4.4.3: Comparison of e.coli levels across all the four districts.

In the dry season, Lyantonde and Bugweri exhibit the highest *E. coli* counts, Nakaseke follows with slightly lower counts and Arua shows minimal contamination levels. This discrepancy points to concerning contamination issues in Lyantonde and Bugweri, necessitating immediate action in terms of identifying contamination sources and enhancing water treatment. Arua's minimal counts indicate effective water safety measures.

During the wet season, *E. coli* counts rise in Bugweri and Lyantonde, followed by Nakaseke, while Arua maintains consistently low levels. The consistent pattern of higher *E. coli* counts in Bugweri and Lyantonde during both wet and dry seasons suggests elevated faecal contamination, likely exacerbated by rainfall. Nakaseke shows a moderate increase, while Arua continues to demonstrate strong water quality management with minimal *E. coli* counts (Sarah, et al., 2021)

Addressing the higher wet season *E. coli* counts in Bugweri and Lyantonde requires tailored interventions, focusing on sanitation, treatment and source protection to ensure safe drinking water and community health. Continuous vigilance is crucial to maintaining safe drinking water quality across all districts, particularly during periods of elevated contamination.

3 Total Coliform in all the four Districts

Total Coliform levels in water sources within the districts of Bugweri, Arua, Nakaseke and Lyantonde were measured using a mobile water quality testing kit. A water sample was collected using a clean container for the measurement. The results are shown in table A.3 in the annexes. Analysis was done using Microsoft excel and figure 4.4.4

below is a graph illustrating variations in total coliform levels across the four studied districts for different water sources during dry season and wet season.

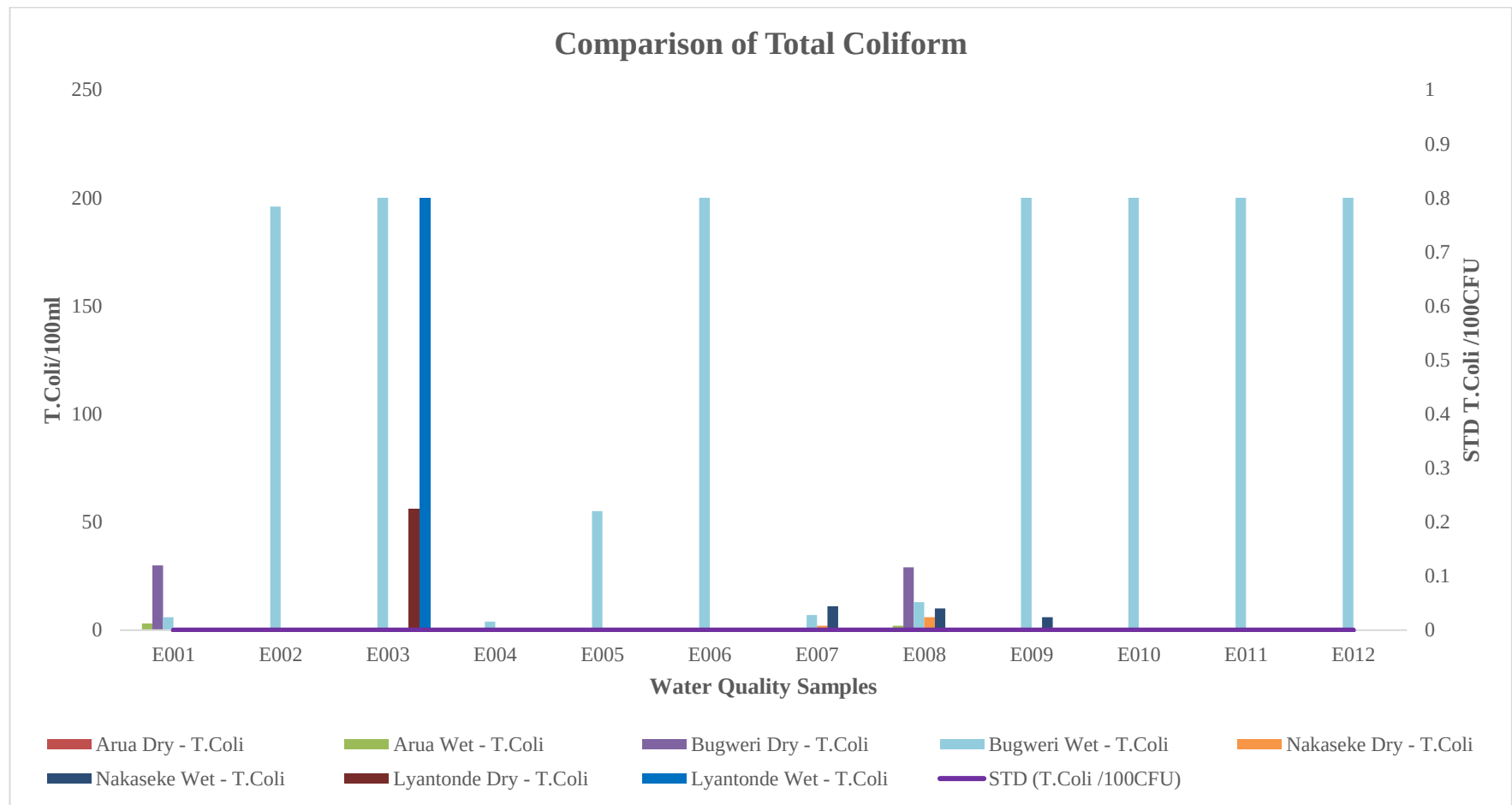


Figure 4.4.4: Comparison of total coliform levels across all the four districts

Lyantonde registers the highest coliform counts in the dry season followed by Bugweri and Nakaseke, while Arua maintains minimal levels. This disparity suggests potential microbial contamination in Lyantonde's water sources, emphasizing the importance of addressing factors such as sanitation, proximity to contamination sources and water treatment to ensure safe drinking water. Bugweri and Nakaseke exhibit comparatively lower counts, indicating better water quality management. Arua's almost non-existent coliform counts affirm its well-maintained water quality. Resolving the elevated counts in Lyantonde is vital for overall water safety in the district.

In the wet season, the graph presents Total Coliform Counts for the same districts, notably, coliform counts increase during the wet season, particularly in Lyantonde and Bugweri. Nakaseke follows with a slight increase, while Arua continues to maintain minimal coliform counts. The elevated wet season counts across all districts, especially in Lyantonde and Bugweri, could be attributed to factors like runoff, contamination, or rainy conditions. This underscores the need for enhanced water management practices, sanitation measures and effective water treatment in these areas. Conversely, Arua's consistently low counts reflect its efficient water quality management. Addressing the challenges in Lyantonde and Bugweri is crucial to ensure water safety, while continuous quality management, sanitation and treatment remain essential for safe drinking water across all districts (Sarah, et al., 2021)

4.5. Analyzing Community Engagement and Water Quality

This section delves into how community engagement levels relate to borehole water quality, emphasizing community's role in water quality outcomes. It uncovers the influence of communities on water preservation, enhancement and management. Through district-based data analysis, this section explores the direct connection between community engagement and borehole water quality. The graphs visually present this relationship, illuminating the dynamics that impact water quality outcomes across the districts as follows:

- 1 Community engagement at planning stage and its relationship with
 water quality

Figure 4.5.1 below shows the relationship between community participation in borehole location selection and water quality outcomes in particular e-coli levels for borehole water.

Relationship between E.Coli & whether communities were given chance to choose where the water source should be located

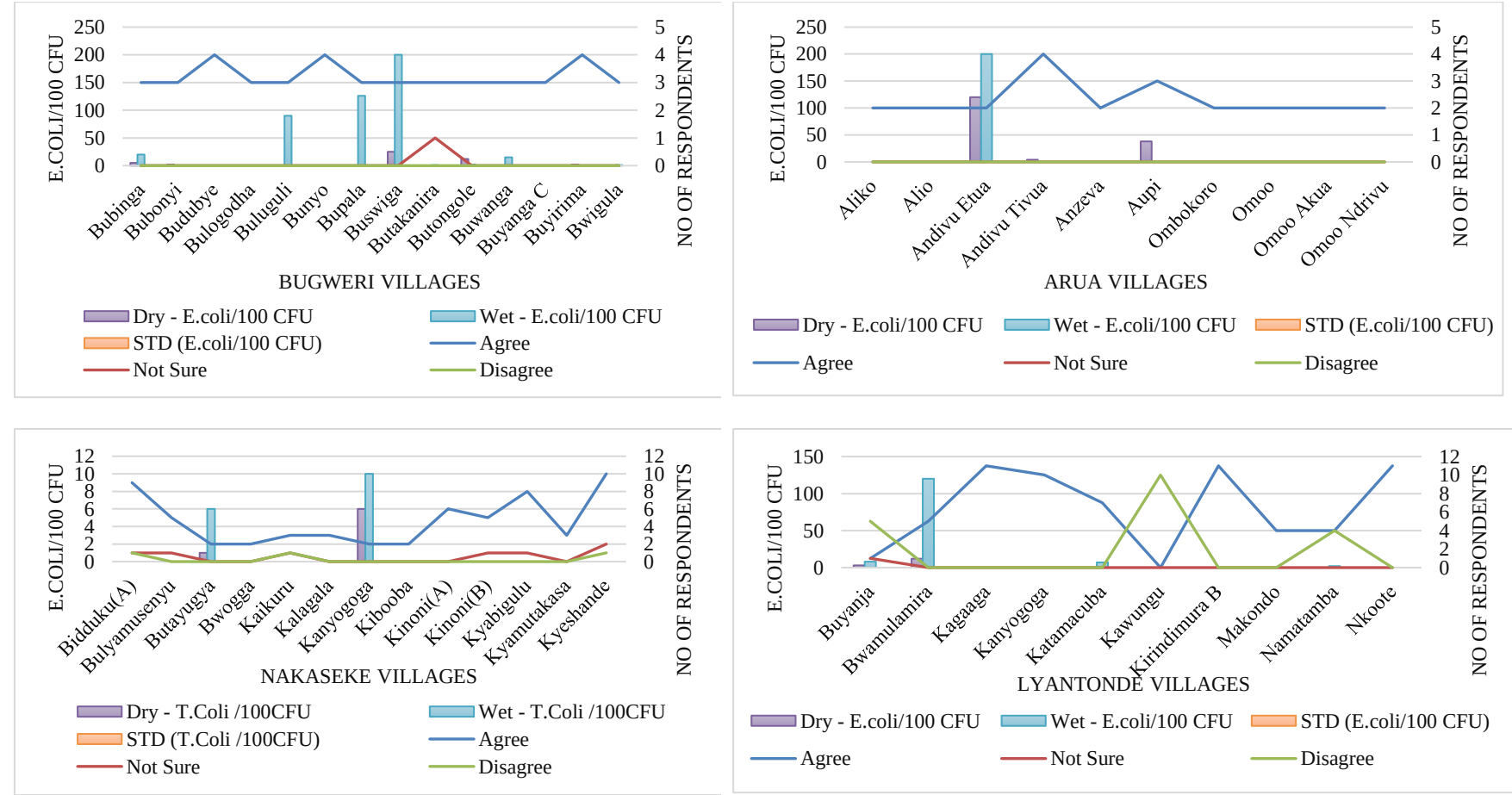


Figure 4.5.1: E.Coli and water source location

In the analysis of the relationship between *E. coli* presence in borehole water and community involvement in borehole location selection provides valuable insights, but it also highlights complexities that warrant further exploration.

The data indicates that higher community involvement generally correlates with lower *E. coli* counts, as seen in Arua and Lyantonde districts, where nearly all respondents participated in site selection, resulting in minimal contamination. However, exceptions exist, particularly in Bugweri and Nakaseke districts, where lower involvement coincides with higher *E. coli* counts, especially during the wet season. These observations suggest a connection between community participation and water safety, but the relationship is not straightforward.

Despite high levels of community involvement reported across all districts, with the lowest being 88% in Bugweri and Nakaseke and the highest 96% in Arua, *E. coli* contamination still occurs. This indicates that while community engagement at this stage is crucial, it is not the sole determinant of water quality. Other factors, such as construction quality, drainage systems, cracks around the borehole pedestal and proximity to contamination sources, also play significant roles. The presence of *E. coli* in some boreholes where communities were involved in site selection suggests that these additional factors need closer examination. The analysis aligns with the findings of (Sarah, et al., 2021), which emphasize the importance of avoiding contamination sources like septic tanks, proximity to latrines and waste disposal sites, flood-prone areas, existing contaminated sites, areas with poor drainage and surface water bodies during borehole placement. However, the data also suggests that even with careful site selection, other variables can contribute to water contamination. This complexity

underscores the need for further research to identify and address these additional factors.

Therefore, while community involvement in borehole site selection is important and generally beneficial for reducing E. coli contamination, it is not sufficient on its own. A comprehensive approach that includes careful engineering practices, continuous monitoring, robust community education and a focus on other potential contamination sources is essential to ensuring the safety of borehole water in rural Uganda. Further studies are needed to explore the multifaceted factors that contribute to E coli presence and to develop more effective strategies for water source protection.

2 Community engagement at implementation stage and its relationship with water quality

Figure 4.5.2 below shows the relationship between community participation in monitoring and supervision of borehole implementation activities and water quality outcomes in particular e-coli levels for borehole water.

Relationship between E.Coli & whether community members were allowed to monitor and supervise construction

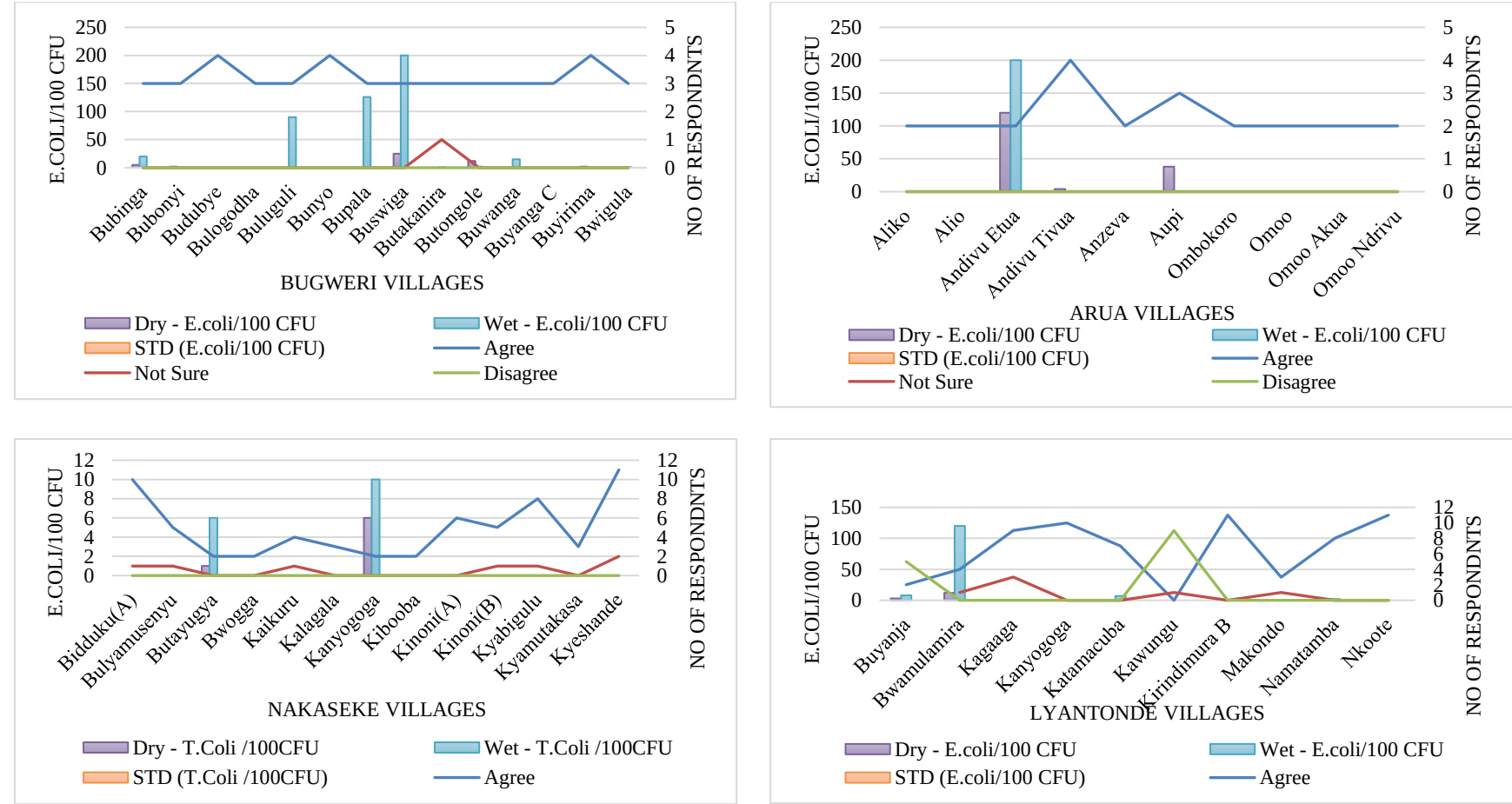


Figure 4.5.2: E.Coli & construction supervision

The analysis of the relationship between *E. coli* presence in borehole water and community involvement in the supervision and monitoring of borehole construction reveals a nuanced and complex scenario. The graphical data, which illustrates *E. coli* levels against the number of respondents involved in borehole construction supervision, does not show a straightforward correlation between these variables.

In Bugweri and Nakaseke districts, despite high levels of community involvement in supervision, the boreholes still exhibit significant *E. coli* contamination. Conversely, in Arua and Lyantonde districts, where community involvement was lower, water quality is notably better, with minimal *E. coli* presence. This suggests that while community involvement is important at this stage, it is not the sole factor influencing borehole water quality.

The study by (Abid Rasool, et al., 2024) emphasize the role of community supervision in ensuring adherence to construction standards and reducing contamination risks. However, the current findings suggest that other factors may be contributing to *E. coli* contamination, overriding the benefits of community involvement at this stage. These factors include:

Poor Drainage Systems: Inadequate drainage around boreholes can lead to water stagnation, creating conditions conducive to bacterial growth.

Poor Source Protection Practices: Insufficient protection of the borehole from environmental contaminants increases the risk of contamination.

Cracked Platforms: Structural issues, such as cracks in the borehole pedestal, can allow contaminants to enter the water supply.

Presence of faecal Material: The proximity of faecal material to the water source significantly heightens the risk of E. coli contamination.

Nearby Latrines: Latrines located too close to boreholes, particularly in the wet season, can leach contaminants into the water source.

Community Education and Engagement: Ongoing education to raise awareness of hygiene and sanitation practices around water sources.

3 Community engagement at utilization stage and its relationship with water quality

Figure 4.5.3 illustrates the relationship between community participation in maintaining hygiene and sanitation around boreholes and water quality outcomes, specifically in terms of total coliform levels in borehole water.

Relationship between Total Coliform and faecal material seen around the water source surrounding

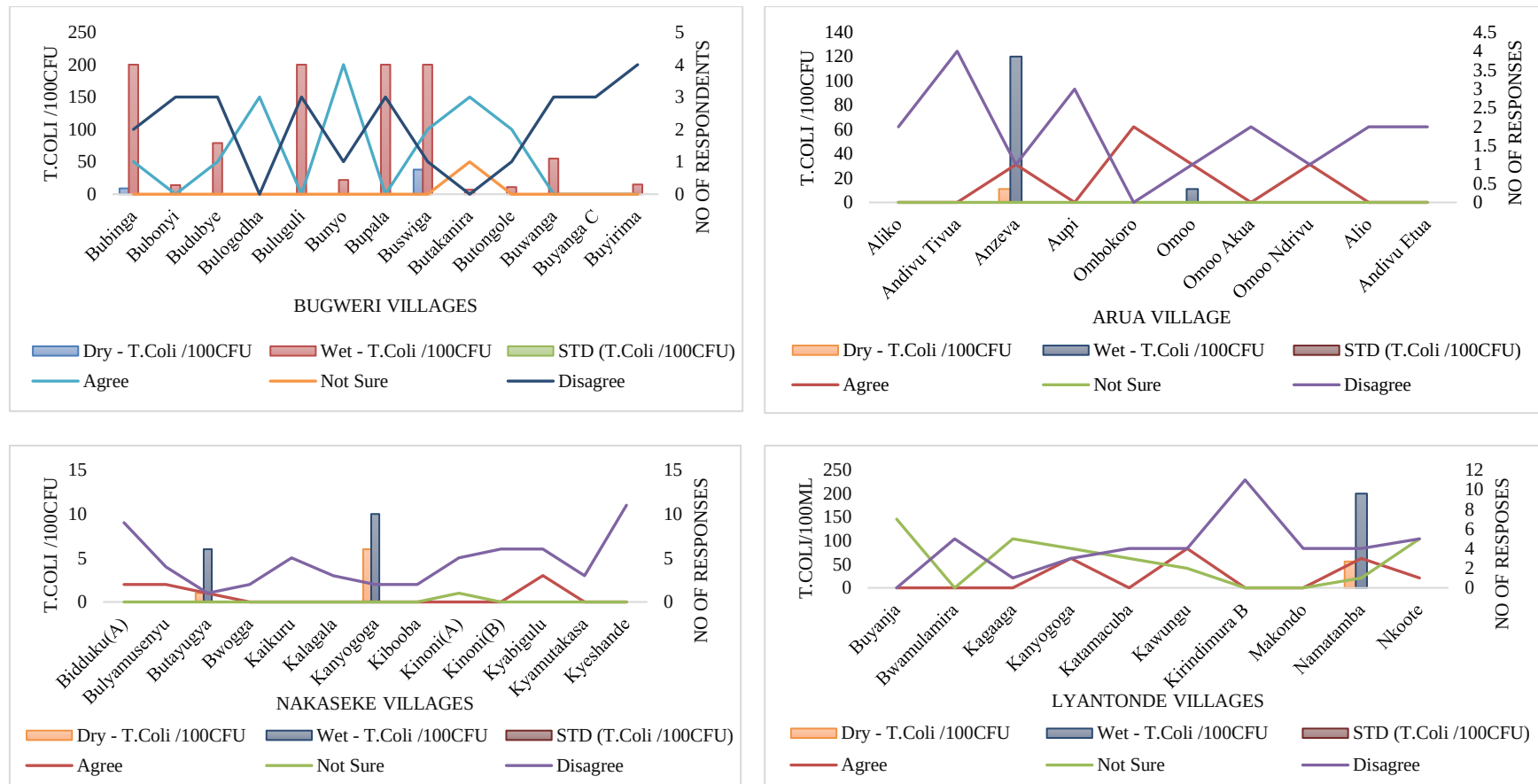


Figure 4.5.3: Total Coliform and faecal material seen around the water source

The analysis of the relationship between total coliforms and the presence of faecal material around boreholes, as depicted in the graphs, reveals a complex interaction between community observations and actual water contamination. The x-axis represents different boreholes sampled, while the left vertical axis indicates total coliform levels and the right vertical axis represents the number of respondents reporting the presence of faecal material near the boreholes.

In districts like Bugweri, where a high number of respondents reported seeing faecal material around the boreholes, there is a corresponding high level of total coliforms in the water. This aligns with the findings of (Sarah, et al., 2021), which suggest that visible faecal material often correlates with higher coliform counts. However, in Lyantonde, despite reports of faecal material, the coliform levels remain low, indicating that other factors are at play in determining water contamination.

Several scientific explanations can account for the observed discrepancies:

Construction Quality: Poorly constructed boreholes, with cracks in the platform or inadequate drainage, can allow contaminants to enter the water, even if faecal material is not visible. Conversely, well-constructed boreholes may resist contamination despite the presence of faecal material nearby.

Hygiene and Sanitation Practices: The presence of faecal material does not always lead to water contamination if proper hygiene practices, such as regular cleaning and waste management, are followed. Conversely, poor hygiene practices can result in contamination even if faecal material is not immediately visible.

Environmental Factors: Seasonal variations, such as heavy rains, can wash faecal material away from the borehole site, making it less visible but still leading to water

contamination. In contrast, dry seasons may reduce the spread of contaminants, resulting in lower coliform levels despite the presence of faecal material.

Natural Filtration: In some cases, the soil surrounding the borehole may act as a natural filter, reducing the levels of coliforms in the water even when faecal material is present nearby. Conversely, the absence of visible faecal material does not guarantee the absence of coliforms if contamination occurs upstream or underground.

These findings emphasize the importance of considering multiple factors in water source protection. The presence or absence of visible faecal material is not a definitive indicator of water safety. Effective borehole management requires:

Enhanced Community Education: Communities need ongoing education to understand the importance of hygiene, proper waste disposal and the implications of visible contaminants.

Improved Construction and Maintenance: Ensuring that boreholes are built and maintained to high standards can mitigate the risk of contamination, regardless of community observations.

Regular Monitoring and Testing: Water quality should be regularly monitored, with communities actively involved in detecting potential contamination risks beyond visible signs.

1- E. coli Levels, Water-Related Diseases and Community Participation

Figure 4.5.4 shows the relationship between E. coli levels in borehole water and observable cases of water-related diseases, using these disease cases as indicators of the effectiveness of community participation in maintaining water quality.

Relationship between E-Coli and observable cases of water related diseases

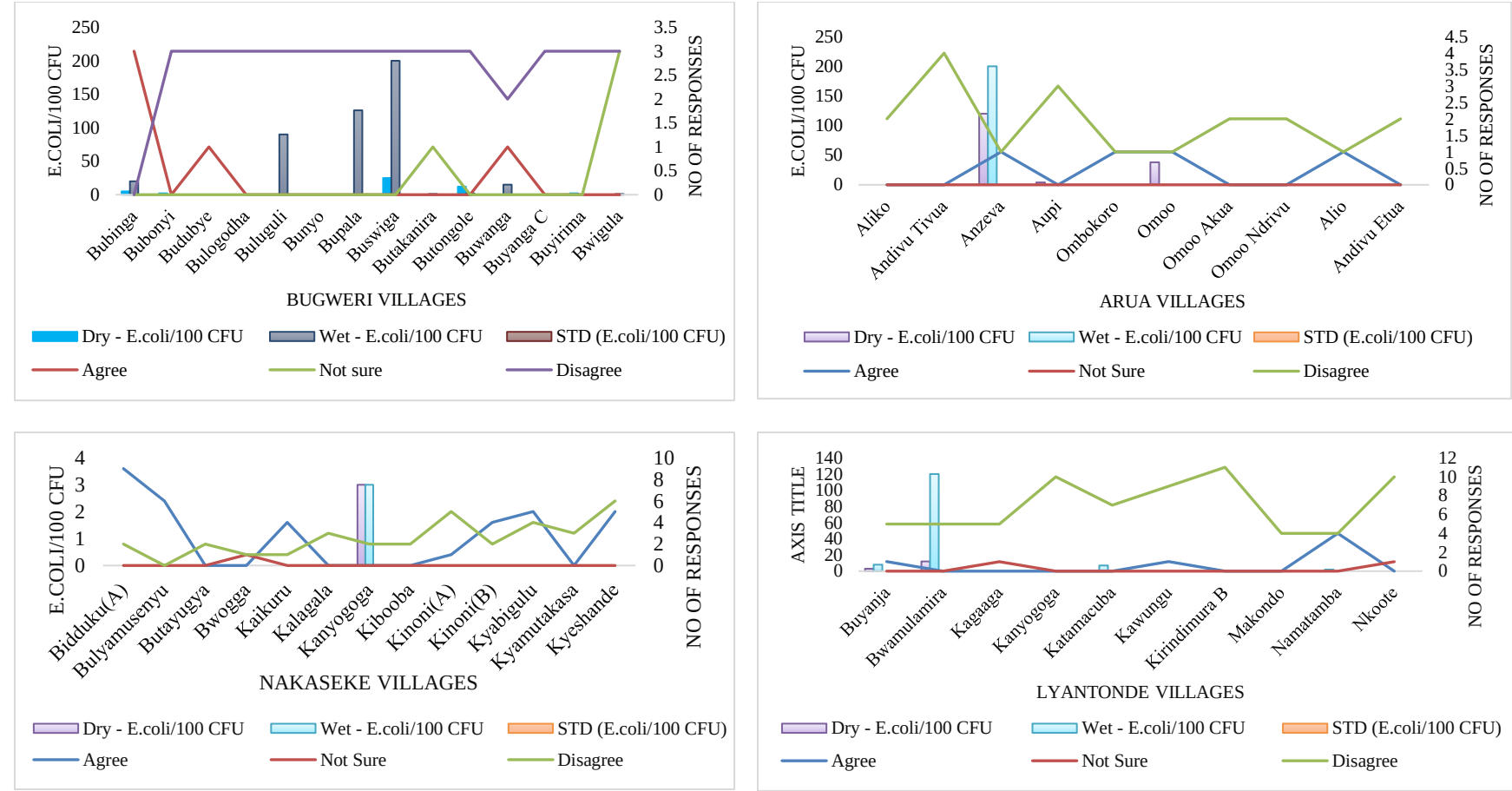


Figure 4.5.4: E-Coli and observable cases of water related diseases

The analysis of the relationship between *E. coli* presence in borehole water and observable cases of water-related diseases across Bugweri, Nakaseke, Arua and Lyantonde districts reveals a clear correlation. The graphs indicate that in areas where water-related diseases are reported, there is a corresponding presence of *E. coli* in the water samples. This correlation underscores the direct impact of water contamination on public health.

E. coli, a key indicator of faecal contamination, is closely associated with gastrointestinal illnesses and other waterborne diseases. The presence of *E. coli* in borehole water, as observed in districts with higher disease incidence, suggests that contamination is likely contributing to these health issues. This aligns with established research, which shows that *E. coli* contamination in drinking water is a significant risk factor for outbreaks of water-related diseases (Braunstein & Joy, 2020)

The correlation between *E. coli* and disease cases further supports the importance of effective water source protection, community involvement and proper borehole management (Sarah, et al., 2021) The findings highlight the need for:

Enhanced Water Source Protection: Preventing contamination at the source is critical. This includes proper site selection, construction and maintenance of boreholes.

Regular Water Quality Monitoring: Continuous testing for *E. coli* and other contaminants is essential to detect and address issues before they lead to health problems.

Community Education and Engagement: Educating communities about the link between water quality and health can lead to better practices in water source protection and hygiene.

Integrated Health and Water Management Strategies: Collaboration between health and water management authorities can ensure that waterborne disease prevention is a key focus in rural water supply programs.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

With a focus on the districts of Bugweri in the east, Nakaseke in the central, Arua in the north and Lyantonde in the west, the research investigated the effect of community engagement on the accessibility of clean borehole water in Uganda. The study's objectives guided the chapter's organization. It provides a summary, conclusions and recommendations based on the study's findings in line with the goals.

5.1 Summary

This research investigated the impact of community engagement on access to clean borehole water in the four districts. It utilized a mixed-methods approach, combining quantitative data collection (e.g., water quality analysis) and qualitative interviews with community members and officials. The findings demonstrated a strong correlation between community participation and improved perceptions and actual quality of borehole water. Regions with higher community engagement showed better water quality management, fewer contamination instances and greater resilience to seasonal changes. Additionally, the study identified key factors influencing community participation, including education programs and supportive local governance.

5.2 Key Findings

- **Community Awareness:** High levels of community engagement correlated with increased awareness of water source protection and enhanced water quality perception.

- **Impact on Water Quality:** Active community involvement resulted in better water quality, with fewer instances of contamination, particularly in areas with sensitization programs.
- **Seasonal Variation:** Water quality varied with seasons, but regions with proactive community participation demonstrated greater resilience against contamination during wet seasons.
- **Educational Programs:** Effective community education and sensitization programs significantly improved community behavior towards protecting water sources, reducing contamination.
- **Local Governance:** Supportive local governance structures were crucial in fostering community participation and improving water quality outcomes.
- **Complex Relationship:** While higher community engagement often correlates with better water quality, the relationship is complex, dynamic and context-dependent.

5.3 Conclusion

The study confirms that community engagement is crucial for effective water source protection and management. Findings indicate that areas with strong community involvement and supportive governance exhibit better water quality. The direct link between community engagement and water quality underscores the importance of ongoing education and active participation to ensure safe water access. Districts like Bugweri, with higher contamination levels, contrast with those like Arua, where strong community involvement and governance contribute to improved outcomes.

5.4 Recommendations

5.4.1 General Recommendations

- **Strengthen Community Education and Sensitization Programs:** Expand educational initiatives focused on water source protection and contamination risks. Tailor programs to address local needs and engage all community members effectively.
- **Enhance Local Governance Support:** Advocate for local governments to implement policies that support community involvement in water management. Provide resources and training to local leaders to facilitate community-led water safety initiatives.

5.4.2 Policy Recommendations

- **Develop Inclusive Borehole Management Policies:** Formulate policies that mandate community participation at all stages of borehole projects. Ensure that planning, implementation and maintenance phases incorporate community input to improve water quality and sustainability.

5.4.3 Recommendations for Future Research

- **Investigate Long-Term Impacts:** Conduct longitudinal studies to evaluate the long-term effects of community engagement models on water quality across different contexts.
- **Evaluate Educational Strategies:** Research the effectiveness of various educational approaches in sustaining community involvement and improving water source protection.

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ANNEX

Annex 1: Sample size selection table

Category	Population	Sample	Technique
Household members	34,130	380	Simple random
LCI	256	155	Purposive
District water Office staff	4	4	Purposive
Area politicians	120	92	Purposive
District Health Office staff	4	4	Purposive
Water quality analysis	256	155	Experimental

Annex 2: Distribution of Borehole Sample Size per District

District	Population	Borehole Sample Size Planned	Actual Samples Collected
Bugweri	205,600	29	29
Arua	168,400	69	36
Nakaseke	254,900	22	22
Lyantonde	119,600	26	12
Total	748,500	155	124

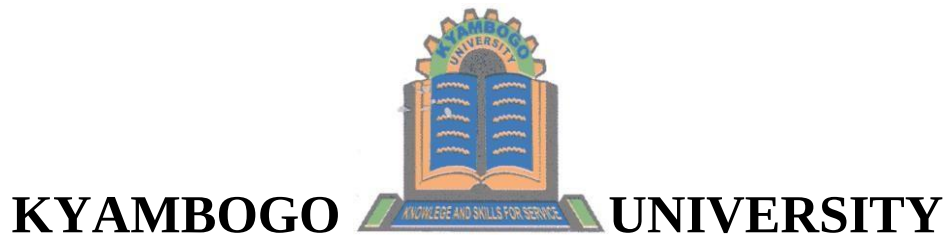
Annex 3: Sample size determination table

<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>	<i>N</i>	<i>S</i>
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—*N* is population size. *S* is sample size.

Source: Krejcie & Morgan, 1970

Annex 4: Data collection questionnaire (Households)



DIRECTORATE OF RESEARCH AND GRADUATE TRAINING

**QUESTIONNAIRE TO BE USED IN INVESTIGATING WHETHER
COMMUNITY MEMBERS WERE INVOLVED IN PLANNING,
IMPLEMENTATION AND UTILISATION STAGES OF PROVISION OF
SAFE BOREHOLE WATER IN UGANDA**

RESPONDENT CONSENT FORM

ARE YOU WILLING TO PARTICIPATE IN THIS STUDY

a) YES ☐

b) NO ☐

If "yes" continue with the questions from part "a", if "no" continue with another
respondent

DATE:.....

a) HOUSEHOLD HEADS/MEMBERS

Part (1): General Information: Please add (✓) as appropriate:

1.1 Location Details:

1.1.1 District.....

1.1.2 Subcounty.....

1.1.3 Parish.....

1.1.4 Village.....

1.2 Gender:

a) Male ☐

b) Female ☐

1.3 Designation:

a) Household head ☐

b) Member of a household ☐

1.4 Your age bracket?

a) 18-35 ☐

b) 36 – 45years ☐

c) 46 – 60 years ☐

d) Over 60 years ☐

1.5 Highest Level of Education?

a) Primary One - Primary Seven ☐

b) Senior One – Senior Four ☐

c) Senior Five – Senior Six ☐

d) Tertiary ☐

e) None ☐

1.6 Occupation

.....
.....

Part (2): Effectiveness of participation of community members throughout the entire project life cycle

Section 'A': Needs assessment.

A-1 I was present when the borehole was being constructed.

- a) **Strongly agree** ☐
- b) **Agree** ☐
- c) **Not sure** ☐
- d) **Strongly Disagree** ☐
- e) **Disagree** ☒

A-2 Before the construction of the borehole, the number of people in my/our family was.

- a) **1** ☐
- b) **2** ☐
- c) **3** ☐
- d) **4** ☐
- e) **5** ☐
- f) **6** ☐
- g) **More than 6** ☐
- h)

A-3 In my/our home, we could use on average the following number of jerricans of water per day

- a) 1 ☐
- b) 2 ☐
- c) 3 ☐
- d) 4 ☐
- e) 5 ☐
- f) More than 5 ☐

A – 4 For each of the following statements tick were applicable the extent to which you agree using the Likert scale; SA = Strongly agree (5), A = agree (4), NS = not sure (3), SD = Strongly disagree (2), D = Disagree (1)

s/n	Statement	Response					Comments
		SA	A	NS	SD	D	
1	We had a meeting to determine the quantity of water required to meet our demand.						
2	We agreed on the average quantity of water that we need as a community						

3	We agreed that a borehole installed with a hand pump could meet the demand						
4	We were asked about the available sources of water.						
5	We said there is an existing source of water.	.					
5	We said there is no existing source of water.						
6	The existing source of water could meet the calculated demand.						
7	The existing source of water could not meet the water demand.						
8	The existing source of water could yield water of good quality.						
9	There was need for a new water source in this area.						
10	We were asked to define alternative sources of contaminant-free water.						

11	We agreed that a groundwater source would be the most appropriate for us.						
12	We were asked to define three sites of our proposed areas of contaminated free water within our area.						
13	The borehole construction was funded by Government						
14	The borehole construction was funded by a humanitarian organisation						
15	Before the construction, it was required that the critical requirements be met that includes: Land agreement, Memorandum of Understanding with the sub-county, Operation and maintenance plan, Sanitation improvement by 30% from the time of needs assessment and implementation stage						

	Community contribution of 1% to the capital cost of the borehole.						
If you agree with 15 above then proceed and answer numbers 16-29 otherwise proceed to Section B.							
16	The land on which the borehole was constructed was provided by the community members freely.						
17	The land was bought by the funding organization.						
18	The land was provided by an individual.						
19	An operation and maintenance plan is in place						
20	There was a Sanitation improvement campaign in this area to ensure an increment by 30% from the time of needs assessment and implementation stage						
21	We were asked whether it we were willing to make community						

	contribution of 1% of the total project cost						
22	We agreed to contribute						
23	We paid community contribution of 1% in cash						
24	We contributed as a community to the 1% cash contribution						
25	One person paid the 1% contribution						
26	Community contribution was paid in form of materials not cash						
27	The community applied for the borehole						
28	The community was involved through community meetings during the planning stage in allocating a new water source						
29	The community was told how to keep the water source free from any contamination						

Section 'B': Implementation stage

For each of the following statements tick were applicable the extent to which you agree using the Likert scale; SA = Strongly agree (5), A = agree (4), NS = not sure (3), SD = Strongly disagree (2), D = Disagree (1)

s/n	Statement	Response					Comment
		SA	A	NS	SD	D	
1	The community members were given a chance to choose where the borehole should be sited before the hydrogeological surveys were carried out						
2	The borehole was located in the preferred location by the community						
3	Community members were allowed to monitor and supervise the construction during the drilling of the borehole						

4	The community members were allowed to fully participate in drilling operations						
5	The Water User committee was selected by the community members themselves						
6	The water user committee was trained in how to maintain the borehole free from contamination						
7	Community members were trained in hygiene and sanitation improvement						

Section 'C': Utilisation stage

For each of the following statements tick were applicable the extent to which you agree using the Likert scale; SA = Strongly agree (5), A = agree (4), NS = not sure (3), SD = Strongly disagree (2), D = Disagree (1)

s/n	Statement	Response					Comment
		SA	A	NS	SD	D	

1	The community members are satisfied with where the borehole was located						
2	The community members were given all the relevant information regarding the proper utilization of the borehole						
3	In order to maintain the borehole free of contaminants, community members do what they were instructed.						
4	There are established rules governing this borehole						
5	The community members report to the district changes in the quality of water						
6	There are noticeable changes in the colour of the water during rainy seasons						

7	There are sprayable agricultural activities within a radius of 50m from the borehole						
8	There are pit latrines within a radius of 30m from the borehole						
9	There are pit latrines uphill of the borehole 50m from the borehole						
10	There are efforts by the community to maintain the water source						
11	The water source is fenced						
12	Faecal material has ever been seen within a radius of 10m from the borehole						
13	The drainage is faulty allowing ponding within a radius of 2m from the borehole						
14	The drainage channel is cracked and broken and needs cleaning						

15	Spoilt water collects around the borehole area						
16	There are other contaminants within a distance of 10m from the borehole						

Section 'D': Intervening variables

For each of the following statements tick were applicable the extent to which you agree using the Likert scale; SA = Strongly agree (5), A = agree (4), NS = not sure (3), SD = Strongly disagree (2), D = Disagree (1)

s/n	Statement	Response					Comments
		SA	A	NS	SD	D	
1	Animals drink water from the borehole						
2	The borehole platform is cracked						
3	There are cases of water related diseases among your family members						

4	There have been some road construction activities within a radius of 50m from the borehole						
---	--	--	--	--	--	--	--

Part (3) the physiochemical and microbiological characteristics of water source

3.1 What was the Source of water before you were given a borehole in this Village?

.....

3.2 Why did you propose the borehole to be located in your proposed location?

.....

3.3 How would you rate the quality of your drinking water from the main source?

a) Very Good ☐

b) Good ☐

c) Neutral ☐

d) Bad

e) Very bad ☐

3.4 Do you treat your water in any way to make it safer to drink?

(a) Yes ☐

(b) No ☐

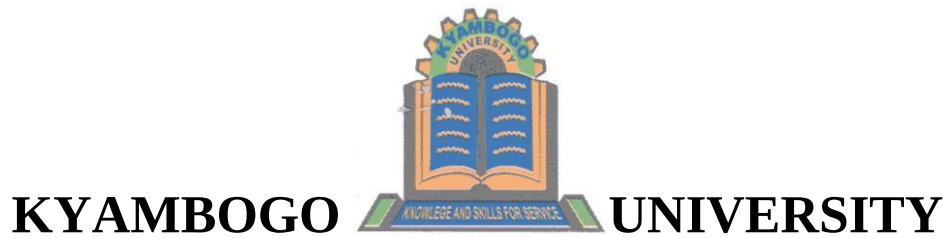
3.5 If yes in 3.5 above, how do you treat the water?

.....

E) Researcher's Observations / Engineering Assessments

- 1 The borehole construction technology used
- 2 Observable latrines within a radius of 30m from the borehole
- 3 Borehole platform cracked
- 4 Other observable contaminants within a radius of 10m from the borehole
- 5 Borehole fenced
- 6 Cracks around the borehole pedestal
- 7 Cleanliness of the surrounding

Annex 6: Data collection questionnaire (officials)



DIRECTORATE OF RESEARCH AND GRADUATE TRAINING

**QUESTIONNAIRE TO BE USED IN INVESTIGATING WHETHER
COMMUNITY MEMBERS WERE INVOLVED IN PLANNING,
IMPLEMENTATION AND UTILISATION STAGES OF PROVISION OF
SAFE BOREHOLE WATER IN UGANDA**

RESPONDENT CONSENT FORM

ARE YOU WILLING TO PARTICIPATE IN THIS STUDY

c) YES ☐

d) NO ☐

If "yes" continue with the questions from part "a", if "no" continue with another
respondent

DATE:.....

b) OFFICIALS

SECTION A: General Information

Name/Designation: _____

District/Area of Jurisdiction: _____

Role in the Community:

a) Local Council Leader ☐

b) Water Officer ☐

c) Politician ☐

d) Health Official ☐

Years in this role:

a) 1-3 years ☐

b) 4-6 years ☐

c) 7-10 years ☐

d) More than 10 years ☐

SECTION B: Planning Stage

Were you involved in the planning of the borehole construction in your area?

a) Yes ☐

b) No ☐

If yes, what was your role in the planning process?

a) Decision-making ☐

b) Mobilizing the community ☐

c) Identifying suitable sites ☐

d) Monitoring and reporting ☐

e) Other (specify) _____

Was a needs assessment carried out before the project?

a) Yes ☐

b) No ☐

c) Not sure ☐

How would you rate the level of community involvement during the planning stage?

a) Very good ☐

b) Good ☐

c) Fair ☐

d) Poor ☐

e) Not involved ☐

SECTION C: Implementation Stage

Were local leaders consulted during the borehole drilling and construction?

a) Yes ☐

b) No ☐

Were there efforts to supervise and monitor the construction process?

a) Yes ☐

b) No ☐

Were there any challenges faced during the implementation stage?

a) Yes ☐

b) No ☐

If yes, what were the key challenges?

- a) Lack of community participation ☐
- b) Financial constraints ☐
- c) Technical difficulties ☐
- d) Other (specify) _____

SECTION D: Utilization Stage

How satisfied are you with the community's use and maintenance of the borehole?

- a) Very satisfied ☐
- b) Satisfied ☐
- c) Neutral ☐
- d) Dissatisfied ☐

Are there established rules for maintaining the borehole?

- a) Yes ☐
- b) No ☐

How often do you receive reports of water contamination or borehole-related issues?

- a) Frequently ☐
- b) Occasionally ☐
- c) Rarely ☐

d) Never ☐

In your view, what is the biggest threat to the long-term functionality of the borehole?

a) Poor maintenance ☐

b) Vandalism ☐

c) Lack of funds ☐

d) Other (specify) _____

SECTION E: Water Quality and Health

Have there been any reports of water-related diseases in the area since the borehole was constructed?

a) Yes ☐

b) No ☐

If yes, what actions have been taken to address these concerns?

a) Health campaigns ☐

b) Water treatment ☐

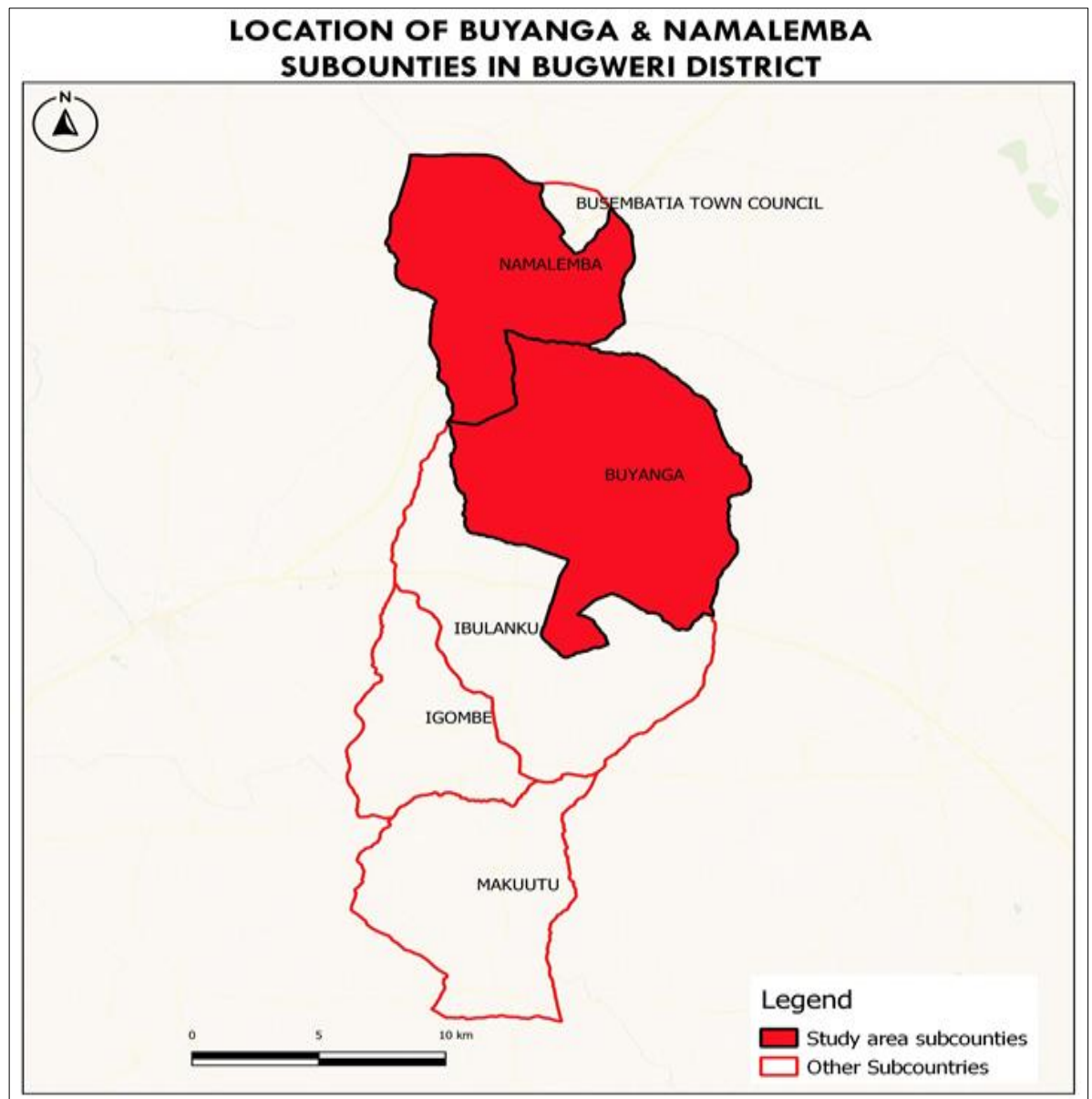
c) Community meetings ☐

d) Other (specify) _____

SECTION F: Final Thoughts

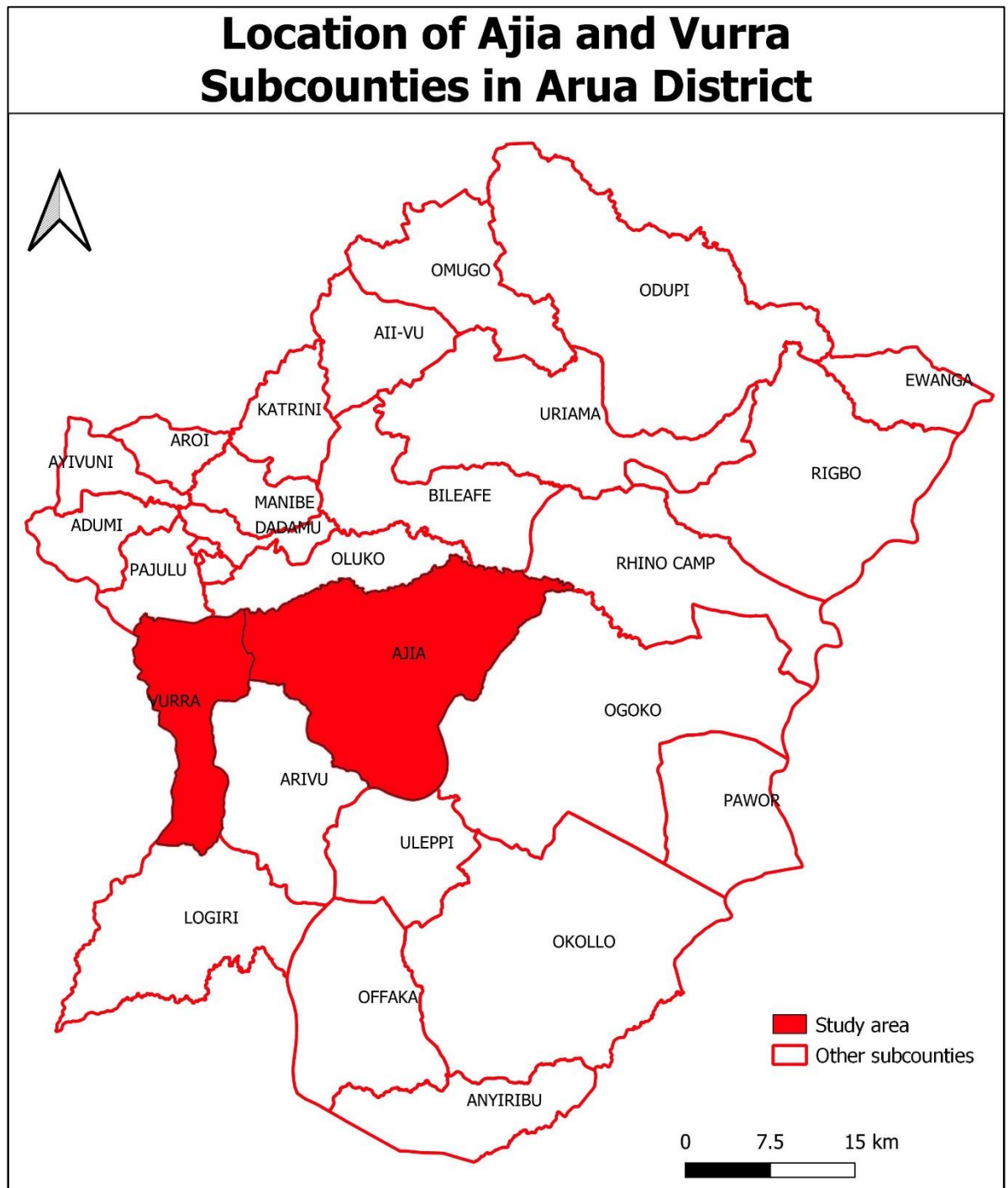
What additional support do you think the community needs to maintain the borehole and ensure water quality?

Annex 7: Location of Buyanga and Namalemba subcountyies



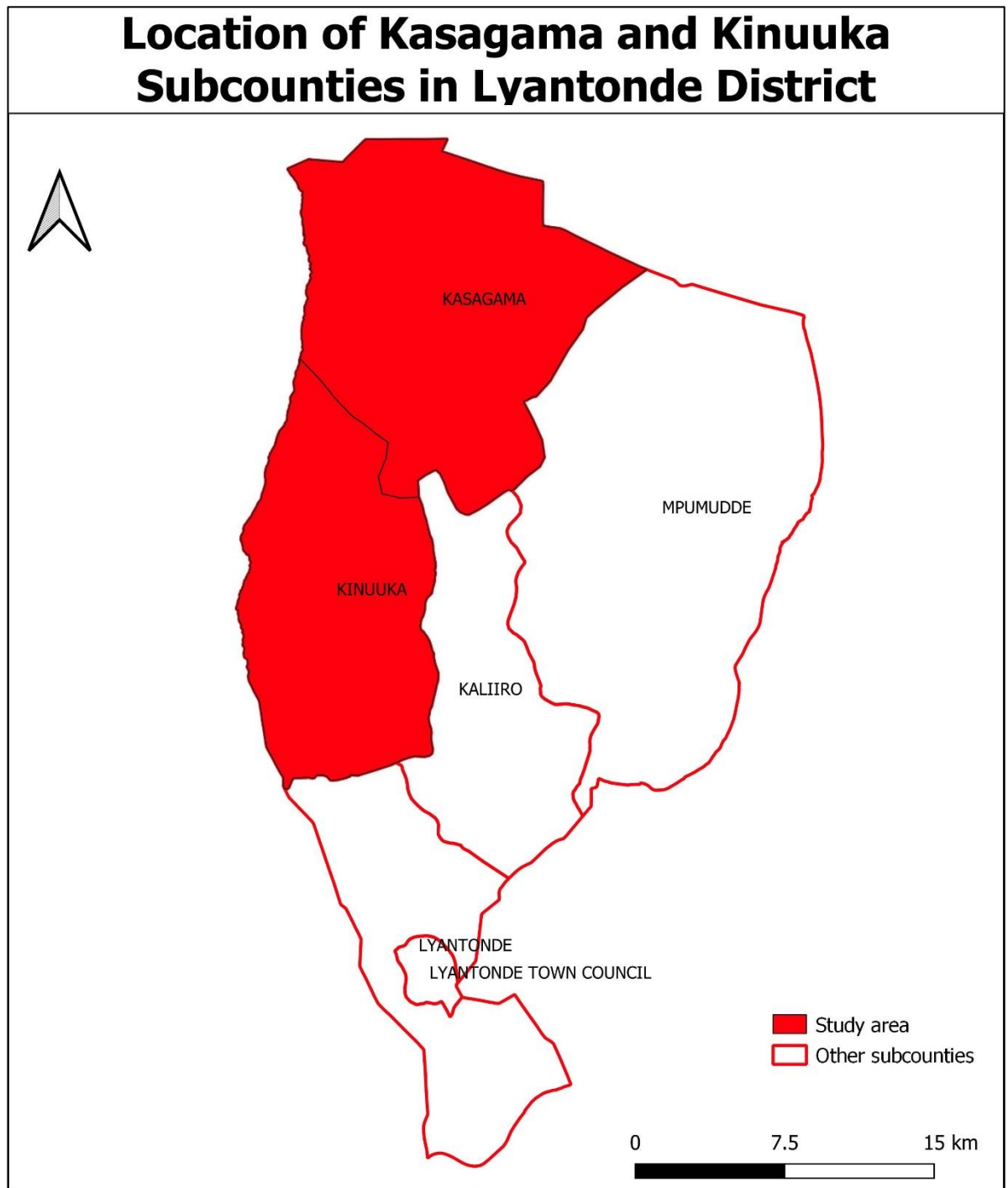
Namalemba and Buyanga subcounties in Bugweri District comprise of 11 parishes and 48 villages Figure 3 above

Annex 8: Location of Ajia and Vurra subcounties



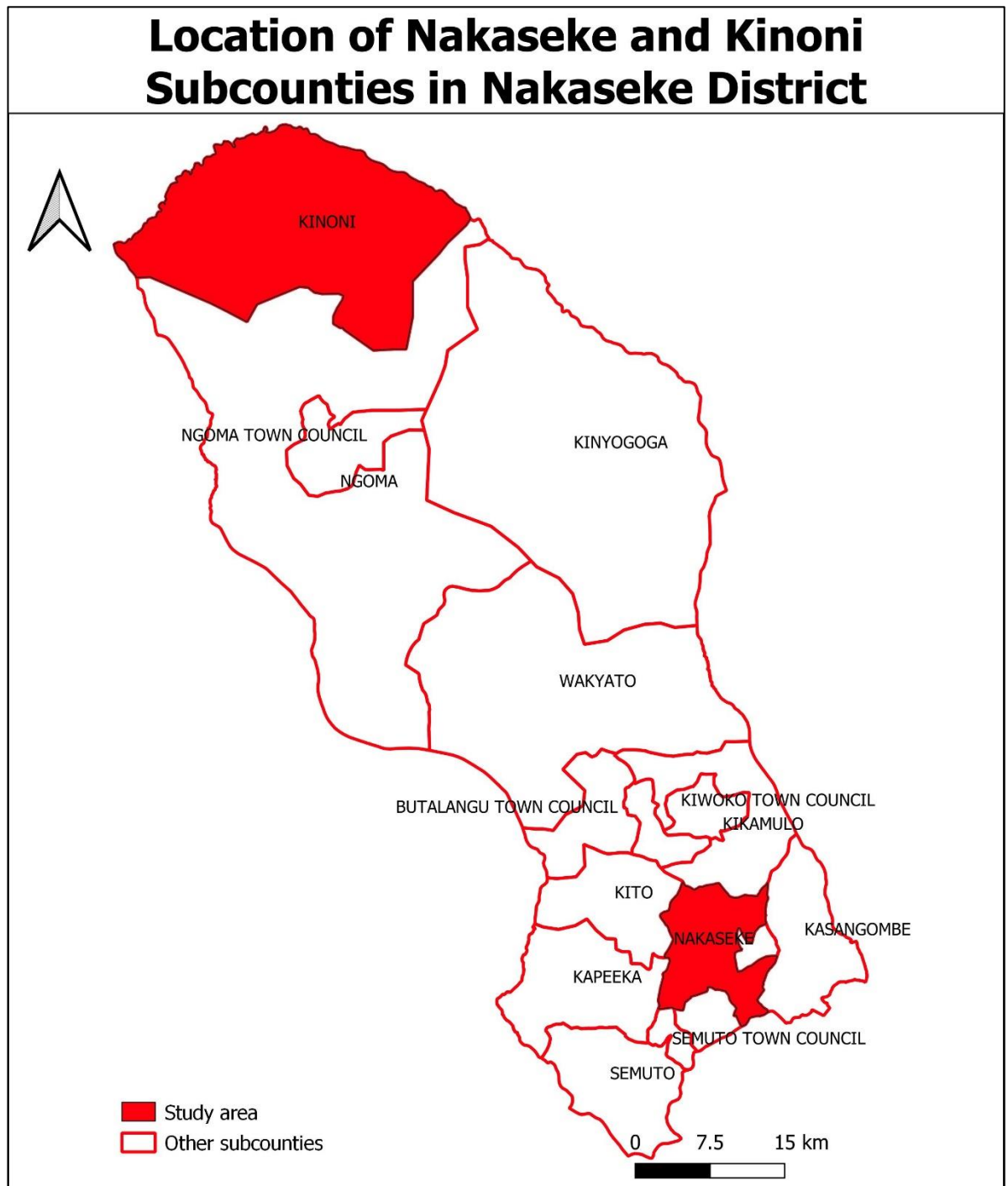
Ajia and Vurra sub-counties in Arua district comprise of 21 parishes and 116 Villages

Annex 9: Location of Kasagama and Kinuuka subcounties



Kasagama and Kinuuka sub counties in Lyantonde district comprise of 14 parishes and 119 Villages

Annex 10: Location of Nakaseke & Kinoni subcounties



Annex 11: Summary of literature reviewed.

S/N	Topic/Area	Source	Key Findings
1	Introduction	(UNICEF, 2022)	• Citizen participation is as old as the idea of democratic governance • The Sustainable Development Goals (SDGs) of the UN acknowledge the significance of local communities' involvement. • Diverse parties are involved in efforts to increase access to safe water in these regions.
2	Community Participation in implementation and Management of boreholes	(Abid Rasool, et al., 2024)	• Benefits and importance of involving local communities. • Theories and frameworks that exist to guide community participation in the water sector.

			Barriers to Community Participation
3	Assessment of Borehole Water Quality	(Buytaert; Wouter; Zulkafli; Zed; Grainger; Sam, 2023)	- A man's socioeconomic growth and well health depend on having access to potable water. - Physical, chemical, biological, or socioeconomic measurements that accurately depict the essential components of a complex ecosystem are referred to as environmental indicators. - In Lagos, wells ground water quality constituent exceeded the WHO standards for drinking water irrespective of the sources of pollution

4	Community engagement levels and water quality in Ugandan Boreholes	(Murphy, 2017).	The problem is worse in rural places, where people are prohibited from treating drinking water and preventing water sources from pollution by other sanitation-related activities and strong cultural beliefs.
5	Lessons Learned and Best Practices	By applying these best practices, borehole water projects can foster meaningful community participation, ensure sustainable management and improve access to safe water in rural settings.	

6	Conclusion	• Successful experiences of community participation have positively influenced access to borehole-safe water. Case studies and examples have demonstrated the importance of community involvement in decision-making, capacity-building and sustainable water management practices. • However, there are several research gaps and areas that require further investigation: • More research is needed to explore the long-term sustainability of borehole safe water sources and the factors that contribute to their continued safety.
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Annex 12: Water Quality Results

Dist rict	Sam ple No	Dry - PH	Wet - PH	STD (PH Units)	Dry - TURBIDI TY(mg/l)	Wet - Turbidit y(mg/l)	STD (TURB NTU)	Dry - E.Coli/1 00ml	Wet - E.Coli/1 00ml	STD (E.coli/10 0 CFU)	Dry - T.Coli/1 00ml	Wet - T.Coli/1 00ml	STD (T.Coli /100CFU)
Aru a	E00 1	7.2	7.8	6.5 - 8.5	0.4	0.6	25.0	1	5	0	0	3	0
Aru a	E00 2	7.5	7.9	6.5 - 8.5	0.5	1.4	25.0	0	0	0	0	0	0
Aru a	E00 3	7.3	7.9	6.5 - 8.5	0.8	1.4	25.0	0	0	0	0	0	0
Aru a	E00 4	7.7	7.9	6.5 - 8.5	1.0	1.4	25.0	0	0	0	0	0	0
Aru a	E00 5	7.2	7.9	6.5 - 8.5	1.3	1.3	25.0	0	0	0	0	0	0
Aru a	E00 6	7.5	7.5	6.5 - 8.5	1.0	1.3	25.0	0	0	0	0	0	0
Aru a	E00 7	7.3	7.5	6.5 - 8.5	0.6	1.4	25.0	0	0	0	0	0	0
Aru a	E00 8	6.6	6.9	6.5 - 8.5	1.1	2.2	25.0	0	0	0	0	2	0
Aru a	E00 9	6.7	6.9	6.5 - 8.5	1.5	1.7	25.0	0	0	0	0	0	0
Aru a	E01 0	7.2	7.5	6.5 - 8.5	0.5	1.6	25.0	0	0	0	0	0	0
Aru a	E01 1	7.5	7.7	6.5 - 8.5	1.5	1.6	25.0	0	0	0	0	0	0
Aru a	E01 2	7.3	7.9	6.5 - 8.5	0.6	6.9	25.0	0	0	0	0	0	0

Aru a	E01 3	7.7	7.6	6.5 - 8.5	0.7	1.6	25.0	0	0	0	0	0	0
Aru a	E01 4	7.2	7.8	6.5 - 8.5	4.6	4.7	25.0	0	0	0	0	0	0
Aru a	E01 5	8.5	8.7	6.5 - 8.5	0.4	3.1	25.0	0	0	0	0	0	0
Aru a	E01 6	7.3	7.6	6.5 - 8.5	0.5	20.7	25.0	0	0	0	0	0	0
Aru a	E01 7	8	8.3	6.5 - 8.5	0.8	1.0	25.0	0	0	0	0	0	0
Aru a	E01 8	7	7.4	6.5 - 8.5	1.0	1.4	25.0	0	0	0	0	0	0
Aru a	E01 9	6.7	7.0	6.5 - 8.5	1.3	1.4	25.0	0	0	0	0	0	0
Aru a	E02 0	6.7	7.0	6.5 - 8.5	1.0	3.1	25.0	120	200	0	11	120	0
Aru a	E02 1	7	7.4	6.5 - 8.5	0.6	1.4	25.0	0	0	0	0	0	0
Aru a	E02 2	7.8	8.1	6.5 - 8.5	1.1	1.7	25.0	0	0	0	0	0	0
Aru a	E02 3	7.3	7.5	6.5 - 8.5	1.5	1.4	25.0	0	0	0	0	0	0
Aru a	E02 4	5	5.0	6.5 - 8.5	1.2	1.0	25.0	0	0	0	0	0	0
Aru a	E02 5	6.1	6.4	6.5 - 8.5	1.5	1.4	25.0	0	0	0	0	0	0
Aru a	E02 6	6.3	6.7	6.5 - 8.5	0.6	0.5	25.0	0	0	0	0	0	0
Aru a	E02 7	6.1	6.4	6.5 - 8.5	0.7	5.7	25.0	0	0	0	0	0	0

Aru a	E02 8	5.9	6.0	6.5 - 8.5	6.6	7.5	25.0	0	0	0	0	0	0
Aru a	E02 9	6.4	6.7	6.5 - 8.5	0.4	5.3	25.0	12	82	0	5	98	0
Aru a	E03 0	6.5	6.8	6.5 - 8.5	0.5	1.5	25.0	0	2	0	0	0	0
Aru a	E03 1	6.7	6.9	6.5 - 8.5	0.8	4.8	25.0	0	4	0	0	0	0
Aru a	E03 2	5.7	5.8	6.5 - 8.5	5.0	4.4	25.0	0	3	0	0	0	0
Aru a	E03 3	6	6.2	6.5 - 8.5	1.3	3.7	25.0	0	0	0	0	0	0
Aru a	E03 4	5.8	6.0	6.5 - 8.5	1.0	3.0	25.0	0	0	0	0	0	0
Aru a	E03 5	5.9	6.3	6.5 - 8.5	0.6	6.9	25.0	25	38	0	0	11	0
Aru a	E03 6	6.8	7.0	6.5 - 8.5	2.1	3.1	25.0	26	200	0	8	145	0
Bug weri	E00 1	5.7	5.9	6.5 - 8.5	2.2	1.12	25	20	4	0	30	6	0
Bug weri	E00 2	5.6	5.8	6.5 - 8.5	2.2	2.42	25	0	5	0	0	196	0
Bug weri	E00 3	5.8	6.8	6.5 - 8.5	2.3	0.95	25	0	126	0	0	200	0
Bug weri	E00 4	5.6	5.9	6.5 - 8.5	2	0.17	25	0	2	0	0	4	0
Bug weri	E00 5	5.6	6.6	6.5 - 8.5	2	0.14	25	0	15	0	0	55	0
Bug weri	E00 6	5.7	6.1	6.5 - 8.5	4.4	22.1	25	0	18	0	0	200	0

Bug weri	E00 7	5.7	6.1	6.5 - 8.5	2.3	1.22	25	0	3	0	0	7	0
Bug weri	E00 8	6	7.1	6.5 - 8.5	1.9	0.16	25	0	4	0	29	13	0
Bug weri	E00 9	5.7	6.1	6.5 - 8.5	2.3	2.16	25	0	70	0	0	200	0
Bug weri	E01 0	6.5	6.6	6.5 - 8.5	2.1	0.35	25	0	133	0	0	200	0
Bug weri	E01 1	6.3	6.1	6.5 - 8.5	2.1	0.42	25	0	97	0	0	200	0
Bug weri	E01 2	6.1	7.1	6.5 - 8.5	2	0.12	25	0	0	0	0	200	0
Bug weri	E01 3	5.7	6.1	6.5 - 8.5	2.1	0.12	25	0	90	0	0	200	0
Bug weri	E01 4	6	6	6.5 - 8.5	1.9	0.13	25	0	0	0	0	20	0
Bug weri	E01 5	6	6.9	6.5 - 8.5	2	0.1	25	2	0	0	0	15	0
Bug weri	E01 6	5.9	6.8	6.5 - 8.5	2.1	0.12	25	0	0	0	0	0	0
Bug weri	E01 7	6	6.9	6.5 - 8.5	2	0.13	25	0	0	0	0	79	0
Bug weri	E01 8	6	6.4	6.5 - 8.5	2.3	1.26	25	2	0	0	0	14	0
Bug weri	E01 9	5.9	6.9	6.5 - 8.5	2.6	0.65	25	0	3	0	0	17	0
Bug weri	E02 0	5.6	6.2	6.5 - 8.5	2.1	0.29	25	5	20	0	9	200	0
Bug weri	E02 1	5.9	5.8	6.5 - 8.5	2	0.38	25	0	11	0	0	113	0

Bugweri	E02 2	5.6	6.6	6.5 - 8.5	1.9	0.31	25	0	1	0	0	68	0
Bugweri	E02 3	5.8	6.2	6.5 - 8.5	2	0.11	25	5	5	0	0	200	0
Bugweri	E02 4	5.3	5.7	6.5 - 8.5	2.4	1.64	25	7	7	0	0	51	0
Bugweri	E02 5	5.7	6.7	6.5 - 8.5	2.7	0.18	25	0	0	0	0	2	0
Bugweri	E02 6	6.4	7.3	6.5 - 8.5	13.3	4.03	25	0	0	0	0	2	0
Bugweri	E02 7	5.6	5.8	6.5 - 8.5	2.1	1.3	25	0	0	0	0	0	0
Bugweri	E02 8	6.5	8	6.5 - 8.5	1.9	0.11	25	0	1	0	0	7	0
Bugweri	E02 9	6.7	6.8	6.5 - 8.5	1.8	0.42	25	0	0	0	1	200	0
Nakaseke	E00 1	7.2	7.8	6.5 - 8.5	26.8	16.8	25.0	1	0	0	0	0	0
Nakaseke	E00 2	6.5	6.6	6.5 - 8.5	58.0	79.4	25.0	0	0	0	0	0	0
Nakaseke	E00 3	6.3	6.6	6.5 - 8.5	4.3	3.0	25.0	0	0	0	0	0	0
Nakaseke	E00 4	6.7	6.7	6.5 - 8.5	2.0	2.3	25.0	0	0	0	0	0	0

Nakaseke	E005	6.2	6.6	6.5 - 8.5	19.5	22.6	25.0	0	0	0	0	0	0
Nakaseke	E006	6	6.1	6.5 - 8.5	49.3	58.3	25.0	0	0	0	0	0	0
Nakaseke	E007	6.3	6.4	6.5 - 8.5	18.0	20.8	25.0	2	5	0	2	11	0
Nakaseke	E008	6.6	7.3	6.5 - 8.5	42.0	45.0	25.0	3	3	0	6	10	0
Nakaseke	E009	6.7	6.8	6.5 - 8.5	18.0	20.0	25.0	0	0	0	1	6	0
Nakaseke	E010	6	6	6.5 - 8.5	32.0	28.2	25.0	0	0	0	0	0	0
Nakaseke	E011	5.5	5.61	6.5 - 8.5	51.2	54.3	25.0	0	0	0	0	0	0
Nakaseke	E012	5.3	5.31	6.5 - 8.5	20.0	18.0	25.0	0	0	0	0	0	0
Nakaseke	E013	6.7	6.47	6.5 - 8.5	15.4	16.8	25.0	0	0	0	0	0	0
Nakaseke	E014	6.2	6.72	6.5 - 8.5	32.8	64.3	25.0	0	0	0	0	0	0

Nakaseke	E015	5.5	5.73	6.5 - 8.5	3.0	3.0	25.0	0	0	0	0	0	0
Nakaseke	E016	6.3	6.31	6.5 - 8.5	12.2	11.2	25.0	0	0	0	0	0	0
Nakaseke	E017	6.1	6.85	6.5 - 8.5	21.1	20.6	25.0	0	0	0	0	0	0
Nakaseke	E018	5.6	5.84	6.5 - 8.5	60.0	58.3	25.0	0	0	0	0	0	0
Nakaseke	E019	5.7	5.77	6.5 - 8.5	19.4	18.8	25.0	0	0	0	0	0	0
Nakaseke	E020	6.7	6.84	6.5 - 8.5	48.2	58.1	25.0	0	0	0	0	0	0
Nakaseke	E021	6	6.25	6.5 - 8.5	30.0	25.0	25.0	0	0	0	0	0	0
Nakaseke	E022	6.8	6.92	6.5 - 8.5	6.2	5.3	25.0	0	0	0	0	0	0
Lyahtonde	E001	4.2	4.1	6.5 - 8.5	1.5	2.5	25.0	0	0	0	0	0	0
Lyahtonde	E002	6.3	6.5	6.5 - 8.5	1.9	2.9	25.0	3	8	0	0	0	0

Lya nton de	E00 3	6.7	7.1	6.5 - 8.5	0.8	0.8	25.0	0	2	0	56	200	0
Lya nton de	E00 4	7.5	7.5	6.5 - 8.5	1.3	2.6	25.0	0	0	0	0	0	0
Lya nton de	E00 5	6.4	6.6	6.5 - 8.5	1.6	1.8	25.0	0	0	0	0	0	0
Lya nton de	E00 6	6.3	6.3	6.5 - 8.5	1.5	1.5	25.0	0	0	0	0	0	0
Lya nton de	E00 7	6.1	6.6	6.5 - 8.5	10.0	14.0	25.0	0	7	0	0	0	0
Lya nton de	E00 8	7.7	8.2	6.5 - 8.5	0.7	0.7	25.0	0	0	0	0	0	0
Lya nton de	E00 9	6.2	6.4	6.5 - 8.5	8.0	11.6	25.0	0	0	0	0	0	0
Lya nton de	E01 0	6.8	7.1	6.5 - 8.5	4.0	3.9	25.0	0	0	0	0	0	0
Lya nton de	E01 1	6.3	6.9	6.5 - 8.5	1.2	2.2	25.0	12	120	0	0	0	0
Lya nton de	E01 2	6.1	6.4	6.5 - 8.5	0.5	0.8	25.0	0	0	0	0	0	0

Annex 13: Location of boreholes considered in the study

Bugweri				Arua				Nakaseke				Lyantonde			
Subcounty	Parish	Village	Sample no.	Subcounty	Parish	Village	Sample no.	Subcounty	Parish	Village	Sample no.	Subcounty	Parish	Village	Sample no.
Buyanga	Buwoya	Buyanga B	E001	VURA	Eruba	Okuvu	E001	Nakaseke	Nakaseke	Lukyamu	E001	Kasaga	buyanja	Kagaaga	E001
Buyanga	Bumozi	Nkombe	E002	VURA	Eruba	Ayele mbe	E002	Nakaseke	Kigege	Kigege	E002	Kasaga	Buyanja	Buyanja	E002
Buyanga	Bumozi	Bupala	E003	VURA	Eruba	Ayele mbe	E003	Nakaseke	Kasambya	Wandegya	E003	Kasaga	Buyanja	Namatamba	E003
Buyanga	Buwoya	Bubala	E004	VURA	Eruba	Odiaryadri	E004	Nakaseke	Kyamutakasa	Kyamutakasa	E004	Kasaga	Kisawuloko	Kirindimur a B	E004
Buyanga	Bumozi	Buwanga	E005	VURA	Vurra	Opevu	E005	Nakaseke	Kigege	Kibooba	E005	Kinukula	Wabu saana	Kawungu	E005
Buyanga	Bumozi	Nsozibiri	E006	VURA	Ajono	Opevu	E006	Nakaseke	Kigege	Bwogga	E006	Kinukula	Wabu saana	Nkoote	E006
Buyanga	Lubira	Butyabule	E007	VURA	Ajono	Micu	E007	Nakaseke	Kasambya	Kyapisi	E007	Kasaga	Katebe	Katamucub a	E007

Buyanga	Lubira	Lubira	E008	VURA	Ajono	Micu	E008	Nakaseke	Kigege	Kanyogoga	E008	Kinukaa	Wabu saana	Nkoote A	E008
Buyanga	Kalalu	Kalalu B	E009	VURA	Ajono	Andivu Tivua	E009	Nakaseke	Mifunya	Butayugya	E009	Kinukaa	Wabu saana	Kanyogoga	E009
Buyanga	Kalalu	Kalalu A	E010	VURA	Ajono	Andivu Tivua	E010	Nakaseke	Kigege	Mulungu omu	E010	Kinukaa	Nakas ozi	Makondo	E010
Buyanga	Bulunguli	Kiwanyi A	E011	VURA	Ajono	Omoo Ndrivu	E011	Nakaseke	Kiggege	Kiwembe	E011	kinukaa	nakas ozi	bwamulam ira	E011
Buyanga	Bulunguli	Kiwanyi B	E012	VURA	Ajono	Omoo arava	E012	Nakaseke	Nakaseke	Lukyamu	E012	kinukaa	nakas ozi	bwamulam ira	E012
Buyanga	Bulunguli	Bulunguli	E013	VURA	Ajono	Omoo arava	E013	Nakaseke	Kyamura kosa	Kalagala	E013				
Buyanga	Buwoya	Bugumpole	E014	VURA	Ajono	Etorib ali	E014	Nakaseke	Mitunga	Kyambogo	E014				
Buyanga	Buwaya	Buyirima	E015	VURA	Ajono	Etori Bali	E015	Kinoni	Bidduku	Kinoni(B)	E015				
Buyanga	Buwoya	Buyanga C	E016	VURA	Ajono	Andivu Etua	E016	Kinoni	Kyes hande	Kyeshande	E016				
Buyanga	Buwoya	Budhubye	E017	VURA	Ajono	Andivu Etua	E017	Kinoni	Kyes hande	Kyensha ma	E017				
Buyanga	Bumozzi	Bubonyi	E018	VURA	Ajono	Omoo akua	E018	Kinoni	Kyes hande	Kaikuru	E018				
Buyanga	Bwigula	Nakawoiza	E019	AJIA	Ockoko	Odapa	E019	Kinoni	Kaikuru	Kyeshande	E019				

Buyanga	Bwigula	Bubinga p/s	E020	AJIA	Ockoko	Anzev a	E020	Kinoni	Bidd uku	Kinoni(A)	E020
Buyanga	Bwigula	Bubinga/Bwi gula	E021	AJIA	Ockoko	Anzev a	E021	Kinoni	Bulya muse nyu	Kyabigulu	E021
Buyanga	Bwigula	Bwigula	E022	AJIA	Ochoko	Embar i/Luyi	E022	Kinoni	Bulya muse nyu	Kyabigulu	E022
Namalemba	Namale mba	Butakanira	E023	AJIA	Ochoko	Aliko	E023				
Namalemba	Namale mba	Butongole	E024	AJIA	Ochoko	Aliko	E024				
Namalemba	Idinda	Bulugodha	E025	AJIA	Ochoko	Odapa	E025				
Namalemba	Idinda	Buswiga	E026	AJIA	Ochoko	Ombiz oko	E026				
Namalemba	Namale mba	Buyirima	E027	AJIA	Omboko ro	Ombo koro	E027				
Namalemba	Idinda	Bulugodha	E028	AJIA	Omboko ro	Ombo koro	E028				
Namalemba	Idinda	Nabirere A	E029	AJIA	Omboko ro	OCI	E029				
				AJIA	Omboko ro	OCI	E030				
				AJIA	Aupi	Aupi	E031				
				AJIA	Aupi	Omba mba	E032				
				AJIA	Olevu	Alio	E033				
				AJIA	Olevu	Alio	E034				
				AJIA	Olevu	Omoo	E035				
				AJIA	Olevu	Omoo	E036				