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**Dennis Okambo Ongoro, Nehemiah Kiplagat, PhD & James
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***¹Dennis Okambo Ongoro, ²Nehemiah Kiplagat, PhD & ³James Mushori, PhD**

Institute of Postgraduate Studies, Kabarak University Kenya

*E-mail of corresponding author: dennisokambo@kabarak.ac.ke

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Abstract

The sustainability of borehole water projects is a critical challenge in dry areas, where inadequate project planning undermines water service reliability and safety. Despite investment in borehole water projects, accessibility in parts of Baringo North Sub-County remains below 50% while about 25 of the 74 boreholes in the area are partially operational or non-operational, raising concerns about their sustainability. This study examined the influence of project planning on the sustainability of borehole water projects in Baringo North by examining the community needs assessment, financial planning, technical planning, risk management, and environmental and climate resilience planning. Guided by Systems Theory the study employed a descriptive correlational design. A census of 74 borehole projects across the five wards was undertaken, with the population of 1303 selected from project management committees and sub-committees, chiefs, ward administrators, county water officials, and liaison officials from various partners. Using Yamane's formula, stratified proportionate, and purposive sampling, a sample of 307 was drawn. Ethical approval was obtained from the KUREC, with research authorization granted by NACOSTI before data collection. Quantitative data were collected using structured questionnaires from 249 respondents comprising central project management committees and subcommittees, while qualitative data were collected using semi-structured questionnaires from 11 key informants including chiefs, ward administrators, county water officials, and partner liaison officials. Diagnostic tests confirmed that regression assumptions were satisfied. Project planning recorded a mean of 3.613, indicating a high implementation level; however, environmental considerations (M=3.380), climate-resilient planning (M=3.410), and risk mitigation strategies (M=3.480) recorded moderate means. The findings indicated a positive and statistically significant relationship between project planning and sustainability ($r = 0.761$, $p < .001$) with project planning explaining 57.9% of the variation in sustainability ($R^2 = 0.579$, $p < .001$). The study concludes that comprehensive project planning is essential for enhancing the sustainability of borehole water projects in Baringo North Sub-County. It recommends strengthening planning processes through rigorous community needs assessment, realistic operation and maintenance cost planning,

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technical feasibility assessment, risk management, environmental protection measures, and climate-resilient project design.

Keywords: *Project planning, Sustainability, Borehole water projects, Community needs, Financial planning, Environment and climate planning.*

1.0 Introduction

Project planning is recognized as a critical determinant of the sustainability of development projects, especially water infrastructure projects in areas facing inadequate water supply. Water is important for human survival, health, and socio-economic development, yet a large proportion of the global population do not have access to reliable safe water. Globally, approximately 2.2 billion people lacked safely managed drinking-water services in 2022, including 703 million who lacked even basic drinking-water services (World Health Organization [WHO] & United Nations Children's Fund [UNICEF], 2023). More recently, 3.4 billion people lacked safely managed sanitation services in 2024, underscoring the continuing global challenge of achieving Sustainable Development Goal 6 by 2030 (WHO & UNICEF, 2025). Women and girls remain disproportionately responsible for water collection, with many in sub-Saharan Africa and Central and Southern Asia spending more than 30 minutes per day collecting water (WHO & UNICEF, 2025). In 2023, unsafe water, sanitation and hygiene (WASH) services were associated with approximately 395,000 deaths among children under five globally, including deaths from diarrhea disease and acute respiratory infections (WHO, 2023). The scarcity of water is particularly evident in dry and remote areas, where limited access to safe water affects public health, education, gender equity, and economic productivity (WHO, 2023). These challenges have increased the importance of sustainable water infrastructure and effective project planning strategies that emphasize community needs, technical requirements, financial resources, risks, and environmental and climatic conditions, throughout the project lifecycle.

Groundwater is a key resource that provides relatively stable water supplies throughout the year and addresses water scarcity (Dawoud, 2025; Pointet, 2022). In contrast, the development of groundwater resources does not guarantee sustainable water supply. The success of groundwater resource development depends on adequate planning, good governance, appropriate regulation, adequate investment, technology innovation, and protection of groundwater resource from depletion and quality deterioration (Dawoud, 2025). Before implementation of borehole water projects, careful planning need to be conducted. The planning should include assessment of hydrogeological conditions, community water needs, environmental and climatic risks, financial requirements, technical designs, and long-term operation and maintenance plans. Poor planning can lead to wrong project locations, weak infrastructure, few resources for maintenance, and premature project failure.

In Africa, the sustainability of water projects is a major concern because climate change, high water demand, poor infrastructure, weak institutional capacity, and limited financial resources limits water service delivery. The World Bank (2023) notes that these challenges can undermine the reliability and sustainability of water initiatives across the region. Evidence from Ethiopia shows that groundwater sustainability is threatened by inadequate regulation, over-extraction, contamination, and declining water tables, particularly in areas experiencing increasing demand (Tura & Demeku, 2025). In East Africa, Namara *et al.* (2024) found that the sustainability and efficiency of water facilities were influenced by management practices and the involvement of

local cultural institutions. These findings demonstrate the importance of planning water projects around the environmental, institutional, technical, and social conditions within which they are implemented.

In Kenya, the challenge of sustainable water provision is significant because more than 80 percent of the country's land is classified as arid and semi-arid, making many communities vulnerable to drought and climate-related water shortages (World Bank, 2023). Approximately 17 million people, representing 35 percent of the population, require assistance to access clean drinking water and sanitation services (Republic of Kenya, 2023). Although groundwater development has expanded considerably, the increasing number of boreholes has also raised concerns about the sustainability of water infrastructure. By 2022, Kenya had more than 45,086 water boreholes, compared with 15,418 in 2018/19 (Kenya National Bureau of Statistics, 2023). The increase in borehole infrastructure has improved the potential for groundwater access, but functionality and long-term service provision remain challenging, particularly in arid and semi-arid areas. For example, an assessment in Turkana County, Kenya, found that 23 percent of 1,554 boreholes were non-functional, with mechanical breakdowns identified as an important cause of failure (Abungu *et al.*, 2026). These challenges highlight the need for project planning that extends beyond borehole construction to include long-term sustainability requirements.

Baringo County provides an important context for examining these challenges. The county experiences arid and semi-arid climatic conditions, with inadequate rainfall in several areas contributing to persistent water-access challenges (Safari & Wambua, 2024). Communities in the county rely on a range of water sources, including traditional river wells, while groundwater provides an important alternative for domestic, agricultural, and livestock use in areas where surface water is scarce (National Drought Management Authority 2024; KNBS, 2026). The County Government of Baringo (2026) reports that 565 boreholes have been developed across the county, including 465 constructed through development partners and 100 by the County Government. Despite this investment, some areas continue to experience water-access levels below 50%, while challenges related to borehole development and maintenance persist.

1.1 Statement of the Problem

The sustainability of borehole water projects remains a concern in Baringo North Sub-County despite continued investment in water infrastructure. The sub-county has 74 borehole water projects intended to support domestic and livestock water needs. However, about 25 of these projects are partially operational or non-operational indicating that about 33% of the projects do not consistently provide the intended water services. In addition, parts of Baringo North have water access levels below 50%, while some boreholes experience frequent breakdowns, irregular water supply, weaknesses in community management structures, and water safety concerns (County Government of Baringo, 2026). These challenges compromise the reliability, continuity, and safety of water services provided by the projects and indicate persistent sustainability challenges.

Project planning constitutes an important project management practice for establishing the conditions required for sustained project performance. It encompasses the identification of community needs, financial planning, technical planning, and risk assessment. Evidence from Baringo County indicates that project planning significantly influences the successful completion of donor-funded water projects (Ouma & Cherutich, 2026). However, successful completion does not necessarily ensure continued functionality and service provision after project implementation. Similarly, Nduta and Mungai (2024) established a significant relationship between project

planning and performance of water projects in Nairobi City County, while Maina and Kyalo (2023) found that project management practices significantly influenced sustainability of water projects in Kiambu County.

Despite growing attention to rural water project sustainability, gaps persist in the contextual, conceptual, methodological, and empirical understanding of borehole sustainability. In Baringo North Sub-County, limited evidence exists on how water access challenges, equipment failures, and maintenance problems affect borehole sustainability. Conceptually, limited studies integrate community needs, financial, technical, risk, and environmental and climate resilience planning with multiple dimensions of sustainability. Methodologically, existing studies often focus on other settings or water projects, with limited stakeholder-based approaches. Empirically, it remains insufficiently established whether these planning practices influence borehole reliability, community management, water safety, and user satisfaction. The study therefore examined the influence of project planning practices on the sustainability of borehole water projects in Baringo North Sub-County, Baringo County, Kenya.

1.2 Research Objective

To assess the influence of project planning on the sustainability of borehole water projects in Baringo North Sub-County, Baringo County, Kenya.

1.3 Research Hypotheses

- H₀:** Project planning has no statistically significant influence on the sustainability of borehole water projects in Baringo North Sub-County, Baringo County, Kenya.
- H₁:** Project planning has a statistically significant influence on the sustainability of borehole water projects in Baringo North Sub-County, Baringo County, Kenya.

2.1 Theoretical Review

The study was guided by Systems Theory, founded by Austrian Biologist Ludwig von Bertalanffy in 1945. The theory views organizations and projects as interconnected systems whose components interact to achieve a common goal. The theory emphasizes the interdependence of components, processes outputs and feedback. Building on this perspective, systems thinking provides a holistic approach the relationship and interdependencies among different dimensions of a project, particularly where sustainability outcomes emerge from interactions among social, technical, financial, and environmental factors (Weaver *et al.*, 2025). In project planning, community needs assessment, financial planning, technical planning, risk management, and environment and climate resilience planning are therefore viewed as interrelated components whose interactions influence the sustainability of borehole water projects. This perspective is appropriate because sustainability challenges are complex and interconnected and require attention to interdependence and stakeholder relationships (Weaver *et al.*, 2025). Although Systems Theory provides a broad framework for understanding the interrelationships among project components, its general systems perspective has limitations in explaining context-specific social, institutional, and human factors that influence project outcomes. Nevertheless, the theory was appropriate for this study because it helped explain how the interrelated project planning elements work together to influence the sustainability of borehole water projects.

2.2 Empirical Review

Project planning is a foundational project management practice that influences project implementation and long-term sustainability by guiding needs assessment, financial allocation, technical design, and environmental and climate risk management. Avidar (2024), using a case study in Siaya County, Kenya, developed a Holistic Integrated Framework for sustainable rural drinking-water projects, highlighting community participation, local conditions, technology, cost, environmental and climate considerations, water security, and stakeholder engagement as key sustainability drivers. However, the study provides a broad sustainability framework rather than examining specific project planning practices in borehole projects in ASAL settings. This leaves a contextual and empirical gap that the present study addresses in Baringo North Sub-County.

Financial planning is a key dimension of project planning and is important for the sustainability of rural water projects. Ndakala and Muchelule (2024) examined resource planning in donor-funded water projects in Vihiga County, Kenya, using a cross-sectional survey of 172 project managers, project members, and consultants. They found that financial resource planning had a significant positive influence on project performance and recommended clear budgeting strategies. However, the study focused on project performance rather than sustainability and did not address borehole projects in ASAL settings. The present study therefore examines financial planning as a project planning dimension and its influence on the sustainability of borehole water projects in Baringo North Sub-County.

Technical planning influences borehole sustainability through design, implementation, and maintenance. Ylenius (2026) examined governance, community involvement, ownership, and design sustainability in a community-managed water project in Marsabit County, Kenya, using a case study and semi-structured interviews. The study found that a solar-powered borehole's sustainability depended on effective maintenance and adaptation to drought and changing water demand, highlighting the importance of technical design, operation and maintenance, and capacity building. However, its focus on a single project limited evidence on the broader influence of technical planning practices on borehole sustainability, which the present study addresses in Baringo North Sub-County.

Risk management is an important project planning element for reducing borehole project failure. Ireri and Mungai (2025) examined risk identification and response planning in public water projects in Kajiado County, Kenya, using questionnaires administered to 148 project managers, supervisors, and committee members. The findings showed that risk identification and response planning significantly influenced project performance. However, the study focused on project performance rather than sustainability and did not consider environmental, climate-related, and technical risks. This leaves limited evidence on how comprehensive risk management within project planning influences the sustainability of borehole water projects in Baringo North Sub-County.

Environmental and climate resilience is an important dimension of project planning for sustainable water projects. Nyongesa (2022) examined community water projects in the Suam Catchment Area, West Pokot County, Kenya, using data from 96 stakeholders, and found that climate resilience and adaptation enhanced project sustainability. However, the study focused on climate resilience rather than specific project planning practices and was conducted in a different geographical context. This leaves a conceptual and contextual gap on how environmental and

climate considerations in project planning influence the sustainability of borehole water projects in Baringo North Sub-County.

Reliability is an important indicator of sustainability and means the ability of a borehole to remain operational and supply water consistently over time. Adeoti *et al.* (2024) examined sustainability challenges facing rural water boreholes in Nigeria, focusing on infrastructure failure and factors influencing reliable water access. Using GIS, Spearman's rho correlation analysis, and field interviews involving 1,696 communities, the study found that 49.8% of communities lacked good-quality water sources, only 25.5% had access to functional boreholes, and 24.5% experienced borehole failures. Community ownership was associated with better borehole functionality, while technical failures contributed to unreliable water access. The study emphasized technical reliability, community ownership, and post-construction monitoring as important for sustainable borehole services. However, its Nigerian context and broad community-level focus left a contextual gap regarding the influence of project planning practices on borehole reliability in rural ASAL areas of Kenya. The present study addresses this gap by examining how project planning contribute to borehole sustainability in Baringo North Sub-County.

Community management structures are important to the sustainability of rural water projects because they facilitate resource mobilization, maintenance, and oversight of water services. Chowns (2015) examined the effectiveness of community management in rural water service delivery across four districts in Malawi using a mixed-methods approach. The study found weak technical and financial performance, delayed and poor-quality repairs, and limited capacity among user committees to mobilize and save funds, with average savings at only 2% of expected levels. The findings showed that community management structures alone do not guarantee sustainable water services without adequate financial, technical, and institutional support. However, the study focused on community management in Malawi, leaving a contextual and conceptual gap on how broader project management practices influence the sustainability of borehole water projects in ASAL areas of Kenya, particularly Baringo North Sub-County.

Water safety is an essential dimension of sustainable rural water services because it determines the quality and health protection provided to users. Bazaanah and Mothapo (2024) examined rural drinking water and sanitation systems in Lepelle Nkumpi Local Municipality, South Africa, using a mixed-methods approach with 657 household and institutional respondents. The study found that pollution from agrochemicals, mining, waste disposal, sewerage, and industrial effluents affected water quality and safety. The authors recommended improved waste management, public education, capacity building, and infrastructure upgrading. However, the study was conducted in South Africa, leaving a contextual gap on water safety and sustainability of borehole projects in Kenya's ASAL areas.

User satisfaction is another important dimension of sustainable rural water services, as it reflects users' perceptions of the reliability, accessibility, affordability, and quality of water provision. Mantey *et al.* (2024) assessed water service levels and user satisfaction in Emina-Boadi, Ghana, using household questionnaires and interviews. The study found a strong preference for borehole services, with 87% of respondents using boreholes and 83% reporting reliable service. The findings indicate that service reliability, accessibility, affordability, and quality influence user satisfaction. However, the study focused on an urban setting in Ghana, leaving limited evidence on user satisfaction with borehole water projects in ASAL areas of Kenya, particularly Baringo North Sub-County.

2.3 Conceptual Framework

Independent Variable

Project planning

- Needs identification
- Budgeting
- Technical design
- Risk assessment
- Environmental safeguards and climate resilience

Dependent Variable

Sustainability

- Reliability
- Community management
- Water safety
- User satisfaction
- Environmental sustainability

Figure 1: Conceptual Framework

3.0 Research Methodology

A descriptive correlational design was employed to collect and analyze quantitative and qualitative primary data. The descriptive design was used to describe the characteristics of the study variables as they naturally occurred, while the correlational design examined the strength and direction of the relationships among the variables without manipulating the study environment (Siedlecki, 2020; Creswell & Creswell, 2018). The study was conducted in Baringo North Sub-County, an arid sub-county of Baringo County that depends heavily on borehole water for domestic, institutional (including schools), and livestock supply. A census of 74 borehole projects across the five wards of Kabartonjo, Barwessa, Saimo/Kipsaraman, Saimo/Soi, and Bartabwa was undertaken. The study population comprised stakeholders including 370 central management committee members, 370 Operations and Maintenance Sub-committee members, 222 Environmental Sub-committee members, 296 Conflict Redress Sub-committee members, 15 Chiefs, 5 Ward Administrators, 8 County Government officials, and 17 Liaison officials from partnering agencies.

To determine the desired sample size, Yamane's (1967) simplified formula was applied to the population of 1303 stakeholders at a 5% level of precision, and 95% level of confidence:

$$n = N/[1+N(e)^2]$$

Where:

n = size of the sample,

N = population (1303)

e = level of precision (0.05)

1 = Constant

Thus:

$$n = 1303 / [1 + 1303 (0.05)^2]$$

$$n = 306.048 \text{ (rounded off to 307 respondents)}$$

A target sample of 307 participants was therefore established. Stratified proportionate sampling was applied across all eight stakeholder categories to ensure representation of the different groups within the study population. Of the 307 targeted participants, 296 were allocated structured questionnaires to collect quantitative data on project planning and sustainability using a five-point Likert scale. The remaining 11 key informants were purposively selected from Chiefs, Ward Administrators, County Government officials, and liaison officials from partnering agencies based on their relevant knowledge and experience in borehole project planning and management. The key informants participated in semi-structured interviews to provide qualitative data. The study adhered to the ethical consideration by obtaining approvals from Kabarak University Research Commission, and National Commission for Science Technology and Innovation. Approval from the county government of Baringo was also obtained. Confidentiality and anonymity were maintained by avoiding the use of participants' names or other personally identifying information in the data, analysis, and reporting.

The instrument's construct validity was assessed through exploratory factor analysis, with a Kaiser-Meyer-Olkin (KMO) value of 0.86 indicating adequate sampling suitability. Pilot testing was conducted in West Pokot County using 31 respondents, representing approximately 10% of the target sample of 307 participants. The pilot study yielded Cronbach's alpha coefficients of 0.814 for project planning and 0.809 for sustainability, both exceeding the recommended threshold of 0.70 (DeVellis & Thorpe 2012). The collected data were analyzed in SPSS (Statistical Package for Social Sciences) version 26. Data were analysed using descriptive statistics, Pearson's correlation coefficient, and simple linear regression at a significance level of $\alpha = 0.05$. The following regression model was used:

$$Y = \beta_0 + \beta X + \epsilon$$

Where,

Y= Sustainability of borehole water projects in Baringo North

X= Project planning

β_0 is the constant term, or intercept while β measures the sensitivity of the dependent variable (Y) to a unit change in the predictor variables X while ϵ is the error term capturing the unexplained variations in the model.

4.0 Data Analysis and Discussion

A total of 296 questionnaires were distributed of which 249 were duly completed and returned, representing a questionnaire response rate of 84.1%. In addition, key informant interviews were conducted with all 11 informants giving a total of 260 participants. All returned questionnaires were complete and used for data analysis. The response rate exceeded the 67% threshold recommended by Wilson *et al.* (2024) as sufficient for statistical analysis.

Demographic Characteristics of Respondents

Table 1 presents the gender distribution and duration of respondents' involvement in borehole water projects. The information gives an overview of the respondents' demographic characteristics and their level of experience in the projects.

Table 1: Gender and Duration of Respondents' Involvement in Borehole Water Projects

Variable	Category	Frequency	Percentage (%)
Gender	Male	158	60.8
	Female	102	39.2
	Total	260	100
Duration of involvement	Less than 2 years	56	21.5
	3-10 Years	123	47.3
	11-20 Years	63	24.2
	Over 20 Years	18	7.0
	Total	260	100

The findings show that males constituted 60.8% (158) of the 260 respondents, while females accounted for 39.2% (102). Regarding experience, 47.3% (123) had 3–10 years of involvement, 24.2% had 11–20 years, 21.5% had less than two years, and 7.0% had over 20 years. Overall, most respondents had substantial experience in borehole water projects, suggesting adequate familiarity with project operations and sustainability issues.

4.1 Descriptive Statistics Analysis

The study sought to assess the extent to which project planning practices were implemented and the level of sustainability of borehole water projects in Baringo North Sub-County. Descriptive statistics were used to summarize respondents' ratings of the project planning and sustainability indicators. The results are presented in tables 2 and 3.

Table 2: Project Planning

Statements	SD/N (%)	D/N (%)	N/N (%)	A/N (%)	SA/N (%)	Mean	S.D
The selection of the borehole project location was based on assessed community needs.	7 (3%)	22 (9%)	30 (12%)	110 (44%)	80 (32%)	3.930	1.012
A comprehensive project budget/financial plan was developed before implementation.	12 (5%)	35 (14%)	27 (11%)	105 (42%)	70 (28%)	3.740	1.111
The project had clear technical designs and specifications before implementation.	10 (4%)	27 (11%)	37 (15%)	107 (43%)	68 (27%)	3.780	1.065
The project team conducted a comprehensive assessment to identify potential risks before implementation.	15 (6%)	42 (17%)	35 (14%)	100 (40%)	57 (23%)	3.570	1.151
The project developed clear strategies to mitigate identified risks.	17 (7%)	45 (18%)	40 (16%)	95 (38%)	52 (21%)	3.480	1.178
An environmental impact assessment was conducted before project implementation.	22 (9%)	52 (21%)	32 (13%)	92 (37%)	51 (20%)	3.380	1.234
Project planning included measures to protect infrastructure from extreme weather events.	20 (8%)	47 (19%)	42 (17%)	90 (36%)	50 (20%)	3.410	1.213
Average Mean and S.D						3.613	1.138

Key: SD/N = Strongly Disagree/Number; D/N = Disagree/Number; N/N = Neutral/Number; A/N = Agree/Number; SA/N = Strongly Agree/Number; S.D = Standard Deviation; %=Percentage.

Project planning practices recorded a composite mean score of 3.613 (S.D. = 1.138), indicating a high level of implementation among borehole water projects in Baringo North Sub-County. Community needs assessment recorded the highest mean score (M = 3.930, S.D. = 1.012), with 76% of respondents agreeing or strongly agreeing that borehole project sites were selected based on assessed community needs. Clear technical designs and specifications before implementation also recorded a relatively high mean (M = 3.780, S.D. = 1.065), while financial planning recorded a mean of 3.740 (S.D. = 1.111), with 70% of respondents agreeing or strongly agreeing that these practices were undertaken before project implementation. These findings are consistent with Avidar (2024), who demonstrated that sustainable rural drinking-water projects require a holistic planning approach that considers multiple sustainability factors, stakeholders, and local conditions. Ndakala and Muchelule (2024) also found that financial resource planning had a strong positive correlation and statistically significantly influenced the performance of water projects. Ylenius (2026) also highlighted the importance of incorporating technical design, operation and maintenance requirements, and local capacity into water-project planning.

In contrast, risk assessment (M = 3.570, S.D. = 1.151) and risk mitigation planning (M = 3.480, S.D. = 1.178) recorded moderate ratings, with 63% and 59% of respondents, respectively, agreeing or strongly agreeing. The lowest mean scores were reported for environmental impact assessment (M = 3.380, S.D. = 1.234) and planning for protection against extreme weather events (M = 3.410, S.D. = 1.213). Ileri and Mungai (2025) reinforced the importance of incorporating climate risks into the planning of water projects, particularly in addressing the effects of climate variability on water-service sustainability.

Table 3: Sustainability of Borehole Water Projects

Statement	SD (%)	D (%)	N (%)	A (%)	SA (%)	Mean	S.D
The borehole in our area is functional and regularly supplies water	22 (9%)	42 (17%)	27 (11%)	100 (40%)	57 (23%)	3.510	1.225
Users can access the water easily without long travel times	17 (7%)	37 (15%)	35 (14%)	107 (43%)	53 (21%)	3.560	1.155
The water from the borehole is safe for drinking and household use	15 (6%)	35 (14%)	32 (13%)	110 (44%)	57 (23%)	3.640	1.126
Environmental safeguards are implemented to protect the surrounding ecosystem	27 (11%)	52 (21%)	37 (15%)	90 (36%)	43 (17%)	3.270	1.254
Community committees effectively manage the borehole and related resources	20 (8%)	40 (16%)	35 (14%)	102 (41%)	52 (21%)	3.510	1.193
The community accepts and supports the borehole management system	12 (5%)	32 (13%)	30 (12%)	112 (45%)	63 (25%)	3.720	1.103
The project has mechanisms to ensure long-term financing for upkeep	35 (14%)	57 (23%)	32 (13%)	87 (35%)	37 (15%)	3.140	1.295
Average Mean and S.D.						3.479	1.193

Key: SD/N = Strongly Disagree/Number; D/N = Disagree/Number; N/N = Neutral/Number; A/N = Agree/Number; SA/N = Strongly Agree/Number; S.D = Standard Deviation; %=Percentage.

The composite mean of 3.479 (SD = 1.193) indicates a moderately positive perception of borehole sustainability. The highest-rated statement was community acceptance and support of the borehole management system, with a mean of 3.720 (SD = 1.103). A total of 112 (45%) respondents agreed and 63 (25%) strongly agreed, giving 175 (70%) positive responses, while 32 (13%) disagreed, 12 (5%) strongly disagreed, and 30 (12%) were neutral. This indicates strong community support for borehole management arrangements. However, the finding differs from Chowns (2015), who reported weak technical and financial performance among community-managed water systems in Malawi due to limited capacity of user committees to mobilize funds and undertake maintenance. This suggests that community acceptance alone does not guarantee sustainability without adequate technical and financial support. Water safety was the second-highest-rated aspect, with a mean of 3.640 (SD = 1.126). 110 (44%) respondents agreed and 57 (23%) strongly agreed, giving 167 (67%) positive responses, compared with 35 (14%) who disagreed, 15 (6%) who strongly disagreed, and 32 (13%) who were neutral. The finding is consistent with Bazaanah and Mothapo (2024), who found that pollution and inadequate environmental management affected the safety of rural water systems in South Africa. The relatively favorable rating in Baringo North indicates better perceptions of water safety, although continued water-quality monitoring remains important.

Ease of access to water recorded a mean of 3.560 (SD = 1.155), with 107 (43%) agreeing and 53 (21%) strongly agreeing, giving 160 (64%) positive responses. In contrast, 37 (15%) disagreed, 17 (7%) strongly disagreed, and 35 (14%) were neutral. This finding agrees with Mantey *et al.* (2024), who identified accessibility, reliability, affordability, and water quality as important dimensions of water-service provision. The result indicates that the boreholes generally contribute to meeting community water needs. The lowest-rated aspect was long-term financing for borehole upkeep, with a mean of 3.140 (SD = 1.295). Only 87 (35%) respondents agreed and 37 (15%) strongly agreed, giving 124 (50%) positive responses, while 57 (23%) disagreed, 35 (14%) strongly disagreed, and 32 (13%) were neutral. The finding agrees with Chowns (2015), who reported inadequate financial capacity among community water committees, resulting in delayed and poor-quality repairs. This highlights financing as a key challenge to the long-term sustainability of borehole projects. Environmental safeguards recorded the second-lowest mean of 3.270 (SD = 1.254). 90 (36%) respondents agreed and 43 (17%) strongly agreed, giving 133 (53%) positive responses, while 52 (21%) disagreed, 27 (11%) strongly disagreed, and 37 (15%) were neutral. This finding is consistent with Nyongesa (2022), who identified climate resilience, information gathering, monitoring and evaluation, and community engagement as important factors in sustaining community water projects in West Pokot County. The relatively low rating therefore points to the need for stronger environmental and climate-resilience measures in borehole projects.

Borehole functionality recorded a mean of 3.510 (SD = 1.225), with 100 (40%) agreeing and 57 (23%) strongly agreeing, giving 157 (63%) positive responses. However, 42 (17%) disagreed, 22 (9%) strongly disagreed, and 27 (11%) were neutral. This finding compares favorably with Adeoti *et al.* (2024), who found that only 25.5% of communities studied in Nigeria had access to functional boreholes and identified technical failures as a major contributor to unreliable water access. The present finding nevertheless underscores the importance of preventive maintenance and post-construction monitoring. Similarly, community committee management recorded a mean of 3.510 (SD = 1.193), with 102 (41%) agreeing and 52 (21%) strongly agreeing, giving 154 (62%) positive responses. Meanwhile, 40 (16%) disagreed, 20 (8%) strongly disagreed, and 35 (14%) were neutral. The finding partly agrees with Chowns (2015), who found that community management structures require adequate financial, technical, and institutional capacity to function effectively.

4.2 Diagnostic Tests

Project planning showed a significant linear relationship with sustainability ($R^2 = .579$, $p < .001$), while multicollinearity was acceptable (tolerance = .231; VIF = 4.329). The Shapiro–Wilk test confirmed normality of residuals ($W = .972$, $p = .081$), and the residual scatterplot indicated homoscedasticity. Thus, the assumptions for Pearson correlation and multiple regression were satisfied.

4.3 Correlation Analysis

Pearson correlation analysis was conducted to determine the strength and direction of the relationship of project planning and sustainability of borehole water projects. The results are presented in Table 4.

Table 4: Correlation Matrix

Variables		Project Planning	Sustainability
Project Planning	Pearson Correlation	1.000	0.761**
	Sig. (2-tailed)		0.001
	n	249	249
Sustainability	Pearson Correlation	0.761**	1.000
	Sig. (2-tailed)	0.001	
	n	249	249

***Correlation is significant at the 0.01 level (2-tailed)*

The correlation results show a very strong positive and statistically significant relationship between project planning and sustainability ($r = 0.761$, $p < 0.001$, $n = 249$). This finding shows that project planning practices were associated with project sustainability.

Hypothesis test results

Hypothesis testing was conducted to determine whether project planning had a statistically significant influence on the sustainability of borehole water projects in Baringo North Sub-county. Simple linear regression was conducted using the following model:

$$Y = \beta_0 + \beta X + \epsilon$$

Where,

Y = Sustainability of borehole water projects

β_0 = constant term (coefficient of intercept)

X = Project Planning

β = Regression Coefficient of X .

ϵ = Error Term.

H_0 : $\beta=0$ vs $\beta \neq 0$

Reject H_0 if $p < 0.05$ otherwise fail to reject the H_0

Table 5: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.761a	.579	.577	.42187

a. Predictors: (Constant), Project Planning

The results indicate a strong positive relationship between project planning and the sustainability of borehole water projects as indicated by $R = 0.761$. The coefficient of determination ($R^2 = 0.579$) indicates that project planning explained 57.9% of the variation in sustainability while the remaining 42.1% was attributable to factors outside the model. The adjusted R^2 of 0.577, which is very close to the R^2 value, indicates that the explanatory power of the model was largely retained after adjustment.

Table 6: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	60.447	1	60.447	339.624	.001 ^b
Residual	43.936	247	.178		
Total	104.383	248			

a. Dependent Variable: Sustainability of Borehole Water Projects

b. Predictors: (Constant), Project Planning

The results of the ANOVA show that the regression model for project planning and sustainability of borehole water projects was statistically significant, $F(1, 247) = 339.624$, $p < .001$. The significant F-statistic indicates that the regression model provides a significantly better explanation of variation in sustainability than a model without project planning as a predictor. The very small p-value indicates that the observed relationship between project planning and sustainability is unlikely to have occurred by chance.

Table 7: Coefficients

Model	B	Std. Error	Beta	t	Sig.
(Constant)	.621	.213		2.915	.004
Project Planning	.812	.044	.761	18.428	.001

a. Dependent Variable: Sustainability of Borehole Water Projects

The coefficient results in Table 7 show that project planning had a positive and statistically significant relationship with sustainability ($B = 0.812$, $\beta = 0.761$, $t = 18.428$, $p = .001$). The regression equation was:

$$Y = 0.621 + 0.812X.$$

X= Project planning

This indicates that a one-unit increase in project planning was associated with a 0.812-unit increase in the predicted sustainability score. Since $p = .001 < 0.05$, the observed relationship was statistically significant and unlikely to have occurred by chance.

Therefore, the null hypothesis (H_0) which states that project planning has no statistically significant influence on the sustainability of borehole water projects in Baringo North Sub-County, Baringo County, Kenya was rejected and the alternate hypothesis (H_1) which states that project planning has a statistically significant influence on the sustainability of borehole water projects in Baringo

North Sub-County, Baringo County, Kenya was adopted. The findings mean that stronger project planning practices are associated with sustainable borehole water projects. Effective project planning can facilitate systematic tracking of project progress, identification of implementation challenges, facilitating timely corrective action and assessing of whether project activities are achieving their intended objectives and contribute to the sustainability of borehole water projects. The finding is consistent with Ndakala and Muchelule (2024), and Ylenius (2026) who reported positive relationships between effective project planning and project outcomes.

Qualitative findings

Project planning was examined through interview questions on community needs, financial planning, and technical, risk, environmental, and climate considerations generating three major themes. Subsequently, sustainability was assessed through questions on borehole functionality and reliability, water access challenges, and community management committees. The 11 key informants comprised four chiefs, one ward administrator, two county water officials, and four liaison officials, coded KII001–KII011 for confidentiality.

Theme 1: Community Needs Assessment and Project Prioritization: Most respondents agreed that community needs assessment involved consultations with communities, leaders, and other stakeholders to identify water needs, existing sources, population, demand, and accessibility. KII003 explained that “*we engage the community through meetings to understand their water needs, population and existing water sources,*” while KII004 noted that assessment considers “*the distance people travel to existing water sources.*” However, some reported that political influence, rushed planning, and limited assessment depth affected project prioritization. KII001 observed that borehole sites are sometimes influenced by “*political considerations instead of technical needs.*” These findings correspond with the quantitative results indicating that community needs assessment was generally incorporated into project planning, although its depth requires strengthening.

Theme 2: Financial Planning for Long-Term Sustainability: The majority of respondents agreed that financial planning covered major project costs, including drilling, equipment, construction, and installation. However, most reported inadequate provision for operation and maintenance costs and future repairs. KII009 emphasized the need to consider both capital and recurrent costs, while KII008 noted that maintenance financing was not always clearly established in donor-funded projects. KII011 further indicated that major repairs were difficult without dedicated maintenance funds. These findings are consistent with the quantitative results ($M = 3.740$, $SD = 1.111$), indicating that financial planning was generally incorporated into project planning, although long-term operation and maintenance financing remained a concern.

Theme 3: Technical, Risk, Environmental and Climate Considerations: Technical feasibility and risk assessment were generally considered through hydrogeological assessments, technical designs, groundwater availability, and identification of construction and operational risks. KII006 noted consideration of “*geological conditions, expected groundwater availability and the appropriate pumping system.*” However, environmental and climate considerations received less attention. KII009 emphasized the need to incorporate “*climate risks such as drought and changing water availability*” into project design. Overall, the findings show stronger emphasis on technical planning than on environmental and climate considerations, highlighting the need to integrate climate resilience and environmental safeguards more fully into borehole project planning.

On the sustainability of borehole water projects, the qualitative findings generally support the quantitative results, which indicated a moderate level of sustainability of the borehole water projects. Borehole functionality and reliability varied across the projects, with some providing water consistently while others experienced recurrent or prolonged breakdowns. Informants identified equipment failures, inadequate maintenance, lack of spare parts, limited technical capacity, financial constraints, and delays in repairs as major causes of non-functionality. The quantitative finding on borehole functionality, which was rated moderately, is therefore explained by these operational challenges. The findings further showed that active management committees and regular maintenance contributed to faster responses to breakdowns, while reactive maintenance often resulted in longer periods of non-functionality. This suggests that the continued availability of borehole infrastructure depends not only on its installation but also on effective maintenance, technical capacity, spare parts, and financial resources.

The findings on water accessibility, reliability, and user experience further reinforce the moderate level of sustainability reported quantitatively. KII006 reported that some boreholes were partly operational or completely non-functional because of dry spells and mechanical breakdowns. Such breakdowns affected continuity of water supply and increased pressure on functioning water points. KII001 noted that users sometimes travelled long distances to access functioning boreholes, while KII002 observed that inconsistent water availability reduced users' confidence in the projects. These findings help explain the quantitative assessments of access to safe water and ease of access, showing that the availability of boreholes does not always translate into reliable and equitable water services.

Effectiveness of community water management committees was another important theme that supported the quantitative findings. The quantitative results showed relatively favorable community acceptance and support, but weaker performance in areas requiring sustained financial and institutional capacity. Qualitative findings indicated that active committees contribute to operation, maintenance, resource mobilization, financial management, and communication with technical teams. However, their effectiveness varied across projects because some committees became inactive, while others faced weak leadership, limited management and financial skills, poor accountability, weak record keeping, and difficulties mobilizing user contributions. These findings demonstrate that community structures are present and contribute to project management, but their capacity and effectiveness differ across projects. Overall, the qualitative evidence reinforces the quantitative finding of moderate sustainability, particularly by showing that technical, accessibility, management, and financial challenges continue to affect the continuity of borehole water services.

5.0 Conclusion

The study concludes that project planning is a critical determinant of the sustainability of borehole water projects in Baringo North Sub-County. The respondents comprised both male and female stakeholders with varying levels of experience in borehole water projects, with male stakeholders forming the larger proportion. In terms of experience, most respondents had between 3 and 10 years of involvement in borehole water projects, indicating adequate familiarity with project operations, planning practices, and sustainability challenges. This diversity and experience provided relevant perspectives on project operations, planning practices, and sustainability challenges. Although project planning practices were generally well implemented, weaknesses were evident in risk mitigation, environmental impact assessment, and climate-resilience planning, while the sustainability of the borehole projects remained moderate, particularly due to challenges

in long-term financing, environmental safeguards, functionality, and community management capacity. The strong positive relationship between project planning and sustainability, together with the statistically significant regression results, demonstrates that better-planned borehole projects are more likely to provide reliable and sustained water services. The qualitative findings reinforce this conclusion by showing that community needs assessment, adequate financial provisions, appropriate technical design, preventive maintenance, risk preparedness, and consideration of environmental and climate conditions influence the ability of boreholes to remain functional and accessible over time. The study therefore concludes that sustainability cannot be secured through borehole construction alone; it requires comprehensive planning that extends throughout the project lifecycle and integrates community needs, realistic operation and maintenance financing, technical feasibility, risk management, environmental protection, and climate resilience. Consequently, the null hypothesis that project planning has no statistically significant influence on the sustainability of borehole water projects in Baringo North Sub-County was rejected.

6.0 Recommendations

The study recommends strengthening participatory community needs assessment and technical feasibility studies before borehole projects are approved to ensure that project locations, designs, and capacities respond to actual community needs. County governments and development partners should establish dedicated and realistic operation and maintenance financing mechanisms, including community maintenance funds and arrangements for major repairs, to improve long-term functionality. Risk assessment, environmental safeguards, and climate-resilience measures should also be institutionalized throughout project planning, with particular attention to drought, groundwater availability, environmental degradation, and extreme weather events. Gender-inclusive participation should be strengthened in borehole project planning and management to ensure that both male and female stakeholders have meaningful opportunities to contribute to decisions affecting project sustainability. In addition, preventive maintenance and technical support systems should be strengthened through regular servicing, timely repairs, availability of spare parts, and access to qualified technicians. Further, the capacity and accountability of community management committees should be enhanced through training in financial management, record keeping, maintenance, and water safety, while routine county-level monitoring of borehole functionality, water quality, maintenance, and management performance should be established to identify and address sustainability challenges early. Finally, the study recommends further research to examine how other planning practices influence sustainability. Future studies should also adopt longitudinal designs across different arid and semi-arid areas of Kenya to assess how these practices influence borehole sustainability over time.

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