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Rural Water Supply Management and Sustainability: A Case Study of Katsina State, Nigeria

Yahaya Sani, Adamu Tukur

Department of Environmental Resource Management, Federal University Dutsin-Ma, Katsina State, Nigeria

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***Corresponding Author:** Dr. Yahaya Sani

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Abstract **Original Research**

Sustainable access to safe and reliable water supply remains one of the most critical developmental challenges confronting rural communities in sub-Saharan Africa. This study investigates the management and sustainability of rural water supply systems in Katsina State, northwestern Nigeria, a region characterised by semi-arid climate, high population density, and chronic water scarcity. Employing a mixed-methods research design, data were collected through structured questionnaires administered to 200 respondents across six selected rural communities three local government areas (LGAs) of the state, complemented by in-depth interviews with 25 key informants comprising water management officials, community leaders, and non-governmental organisation (NGO) representatives. Findings reveal that only 29% of rural households in the study area have access to pipe-borne water, while 56% depend on boreholes and hand pumps, many of which are non-functional due to inadequate maintenance, poor funding, and institutional failures. Critical sustainability challenges identified include limited community participation in water governance, absence of a vibrant maintenance culture, seasonal water scarcity, and inadequate capacity of implementing agencies. The study recommends the institutionalisation of community-based water management (CBWM) frameworks, decentralisation of water governance, sustained financial investment, and robust inter-agency collaboration as pathways toward achieving Sustainable Development Goal 6 (SDG 6) targets in the state.

Keywords: Rural water supply, water sustainability, Katsina State, community-based water management, Nigeria, SDG 6, water governance.

1. Introduction

1.1 Background of the Study

Water is a fundamental human right and an essential prerequisite for sustainable development. The United Nations General Assembly, through Resolution 64/292, recognised access to safe drinking water and sanitation as a human right essential to the full enjoyment of life and all other human rights (United Nations, 2010). Despite this global recognition, hundreds of millions of people in developing countries continue to lack access to safe, adequate, and reliable water supplies, with rural communities bearing a disproportionate burden of water insecurity (WHO/UNICEF, 2021).

In Nigeria, the water sector is characterised by a wide urban-rural disparity in water access. While urban areas record relatively higher rates of piped water coverage, rural communities predominantly rely on unimproved water sources such as open wells, unprotected springs, rivers, and rainwater harvesting (Adeyemi et al., 2020). The Federal Ministry of Water Resources (2021) estimates that only about 20% of Nigeria's rural population has access to safe drinking water, well below the national target and far short of the SDG 6 goals. This situation is particularly acute in the arid and semi-arid zones of northern Nigeria, where Katsina State is located.

Katsina State, one of the 36 states of Nigeria, is situated in the northwestern geopolitical zone and shares an international boundary with the Republic of Niger to the north. With a population of approximately 9.8 million people (National Population Commission [NPC], 2022), over 70% of whom reside in rural areas, the state faces a severe water supply deficit exacerbated by its semi-arid climate, erratic rainfall, high evapotranspiration rates, and declining groundwater tables (Aliyu & Bununu, 2017). Seasonal surface water sources dry up for several months annually, leaving communities vulnerable to water stress and waterborne diseases.

Rural water supply systems in Katsina State have historically been developed through government-led programmes, donor-funded projects, and more recently, community-based approaches. However, many of these schemes have failed to achieve long-term sustainability due to poor planning, inadequate stakeholder participation, weak institutional frameworks, and insufficient post-construction support (Isah et al., 2019). The challenge of sustainability — ensuring that water infrastructure remains functional, equitable, and responsive to community needs over the long term — has therefore emerged as a central concern in water resource management discourse in the state and across rural Nigeria.

1.2 Statement of the Problem

Despite significant investments by government agencies, multilateral organisations, and NGOs in rural water infrastructure in Katsina State over the past three decades, the sustainability of these systems remains highly precarious. A substantial proportion of water facilities constructed or rehabilitated in the state are either non-functional or operating below capacity within a few years of installation (Katsina State Rural Water Supply and Sanitation Agency [RUWASSA], 2020). This paradox of investment without corresponding sustained access to water represents a significant policy and management failure that demands rigorous scholarly investigation.

The literature reveals that while technical and financial dimensions of rural water supply have received considerable attention, the governance, institutional, and socio-cultural factors that underpin sustainability have been inadequately studied within the specific context of Katsina State (Okafor & Hassan, 2021; Garba, 2018). This gap motivated the present study, which seeks to provide empirical evidence on the management practices, sustainability challenges, and community participation dynamics shaping rural water supply outcomes in the state.

1.3 Research Objectives

This study aims to assess the rural water supply in Katsina state, evaluate its management, identify challe223nges, examine community participation and recommend strategies for sustainability.

1.4 Research Questions

This study seeks to answer several key questions; it determines the current coverage and functional status of rural water supply infrastructure in Katsina State. It explores the institutional and management that governs the provision of rural-water in the state, and identifies the main challenges hindering the sustainability of the water supply systems. Additionally, it investigates how community participation impacts the sustainability of the water supply schemes and explores policy management interventions that can enhance rural water supply sustainability in Katsina State.

1.5 Significance of the Study

This study makes several important contributions to the literature and to policy practice. Theoretically, it advances understanding of the sustainability dimensions of rural water supply management within a semi-arid African context, enriching existing frameworks such as the Community-Based Water Management model and the WASH Sustainability Framework. Empirically, it provides original data from Katsina State — a region that has received limited scholarly attention relative to its magnitude of water insecurity — thereby filling a critical knowledge gap. From a policy perspective, the findings and recommendations offer practical guidance to RUWASSA, the State Ministry of Water Resources, development partners, and community-based organisations engaged in water governance in the state and across comparable contexts in West Africa.

1.6 Scope and Limitations of the Study

This study is geographically delimited six selected rural communities within the three LGAs in Katsina State, namely: Dutsi, Kankia and danja. These LGAs were purposively selected to reflect variation in ecological zones, population characteristics, and water supply infrastructure. The study focuses primarily on community-level water supply schemes including boreholes, hand pumps, mini-waterworks, and earth dam systems. Urban water supply and sanitation systems are excluded from the scope of this research. Possible limitations include respondent bias in self-reported survey data, limited access to institutional records, and the dynamic nature of water infrastructure status, which may vary seasonally.

2. Literature Review

2.1 Conceptual Framework

2.1.1 The Concept of Rural Water Supply

Rural water supply refers to the provision of water for domestic, livestock, and small-scale agricultural purposes in non-urban settings, typically through infrastructure such as boreholes, hand pumps, gravity-fed systems, rainwater harvesting structures, and protected wells (Schouten & Moriarty, 2003). Unlike urban water supply systems that are typically managed by formal utilities, rural water supply in developing countries is frequently characterised by fragmented institutional arrangements, limited financial resources, and greater reliance on community-based management (Harvey & Reed, 2007).

The distinction between rural and urban water supply is not merely geographical but extends to socio-economic, governance, and technical dimensions. Rural communities generally exhibit lower population densities, dispersed settlement patterns, and weaker economic bases, all of which constrain the commercial viability of centralised water utilities and necessitate alternative management models (IRC International Water and Sanitation Centre, 2012). The appropriate scale, technology, and management model for rural water supply must therefore be carefully matched to the specific context of the communities served (Lockwood & Smits, 2011).

2.1.2 Sustainability in Rural Water Supply

Sustainability, in the context of rural water supply, has been defined as the continued delivery of an adequate, safe, and affordable water service at a level commensurate with user demand, without depletion of the resource base or institutional capacity needed to maintain the service over time (Kleemeier, 2010; Lockwood & Smits, 2011). This definition encompasses multiple dimensions including technical, financial, institutional, social, and environmental sustainability (Baumann, 2006).

Technical sustainability concerns the durability and reliability of water infrastructure, appropriate technology selection, and the availability of spare parts and skilled technicians for operation and maintenance (O&M). Financial sustainability relates to the capacity of users and systems to generate sufficient revenue to cover the full recurrent costs of service delivery, including O&M, management, and eventual capital maintenance

(Brikké & Bredero, 2003). Institutional sustainability refers to the existence of capable, accountable, and empowered organisations at local and national levels with clear mandates and resources to manage water services. Social sustainability involves equitable access, community ownership, and cultural appropriateness of the service. Environmental sustainability requires that water abstraction does not exceed natural recharge rates and that water quality is protected from contamination (World Bank, 2017).

The IRC (2012) and Lockwood and Smits (2011) propose the 'service delivery approach' as a framework for achieving sustainability, arguing that sustainability requires a shift from project-based thinking to professionalised, long-term service delivery supported by enabling national and sector-level conditions. This approach emphasises the role of the enabling environment — including policies, legal frameworks, financing mechanisms, and sector coordination — in determining local service sustainability outcomes.

2.2 Theoretical Framework

2.2.1 Community-Based Water Management (CBWM) Theory

Community-Based Water Management (CBWM) has emerged as the dominant paradigm for rural water supply management in developing countries since the International Drinking Water Supply and Sanitation Decade of the 1980s. Rooted in participatory development theory and Ostrom's (1990) framework for commons governance, CBWM posits that communities are best placed to manage local water resources when provided with appropriate training, legal authority, and financial support. The theory argues that community ownership of infrastructure promotes greater willingness to pay for services, invest in maintenance, and resolve conflicts over resource use, thereby enhancing sustainability (Cleaver, 1999; Sara & Katz, 1998).

However, a growing body of literature has challenged the effectiveness of CBWM in practice. Hutchings et al. (2015) conducted a systematic review of evidence on CBWM performance across Sub-Saharan Africa and South Asia, finding high rates of system failure and noting that communities are frequently left to manage complex technical and financial responsibilities without adequate support. Whaley and Cleaver (2017) further argue that the 'community management fix' tends to underestimate structural inequalities within communities and overestimate the capacity of voluntary management committees to sustain complex services. These critiques have inspired calls for 'professional support' models and 'hybrid' governance arrangements that combine community agency with state and market actors (Lockwood & Smits, 2011).

2.2.2 The Lifecycle Approach to Water Services

The lifecycle approach, advanced by Smits et al. (2013) and the IRC Water and Sanitation Centre, provides a comprehensive analytical framework for understanding rural water supply sustainability. This approach recognises that water service sustainability requires attention throughout the service lifecycle — from planning and design through implementation, post-construction support, and eventual rehabilitation or replacement. It emphasises the need for 'service delivery support' mechanisms that provide ongoing technical, managerial, and financial assistance to community managers, in contrast to the conventional project cycle which typically terminates support after construction.

The lifecycle approach aligns with the SDG 6 monitoring framework's emphasis on 'safely managed' drinking water services — a standard that requires water to be on-premises, available when needed, free from contamination, and sustainably managed. Applying this framework to Katsina State, this study examines both the immediate functionality status of water systems and the longer-term structural conditions that determine whether services can be reliably sustained.

2.3 Empirical Review

2.3.1 Rural Water Supply in Nigeria

Nigeria's rural water supply sector has been the subject of considerable scholarly attention, reflecting both its developmental significance and the persistence of access deficits. Adeyemi et al. (2020) assessed rural water supply coverage across six geopolitical zones and found pronounced regional disparities, with the northwest and northeast zones exhibiting the lowest access rates attributable to arid climate conditions, limited groundwater resources, and weaker institutional capacity. The authors identified inadequate recurrent funding as the foremost constraint, noting that federal and state budgetary allocations to the water sector consistently fall below the internationally recommended minimum of 0.5% of GDP.

Adekunle et al. (2018) examined the performance of community water management committees (WMCs) in rural Ogun and Niger states, finding that the majority of WMCs lacked formal registration, transparent financial management systems, and regular meeting schedules — all factors associated with poor maintenance outcomes. Similarly, Okafor and Hassan (2021) conducted a governance analysis of rural water supply in Sokoto and Kebbi states and concluded that unclear jurisdictional boundaries between federal, state, and local government water agencies created accountability gaps and duplicated efforts, undermining programme coordination and sustainability.

2.3.2 Rural Water Supply in Northern Nigeria and the Northwest Zone

The literature on rural water supply in northwestern Nigeria underscores the compounding effects of climatic vulnerability, rapid population growth, and institutional fragility on water access. Aliyu and Bununu (2017) investigated the spatial dimensions of water poverty in Katsina State using the Water Poverty Index (WPI), finding that the majority of rural LGAs scored in the lowest quartile on access and capacity sub-indices, reflecting severe deficiencies in both physical infrastructure and community empowerment. Their analysis highlighted the spatial concentration of water poverty in the central and northern zones of the state, coinciding with the areas most severely affected by desertification and seasonal drought.

Garba (2018) examined the role of RUWASSA in Katsina State and found that despite its mandate to coordinate rural water supply and sanitation, the agency was hampered by chronic underfunding, inadequate field staff, and limited monitoring capacity. The study documented a pattern of project implementation without commensurate post-construction support, resulting in rapid deterioration of installed infrastructure. Isah et al. (2019) complemented these findings with a facility-level assessment across four LGAs, reporting that approximately 45% of boreholes installed within the previous decade were non-functional at the time of survey, a figure consistent with continental estimates for Sub-Saharan Africa reported by Foster et al. (2020).

2.3.3 Community Participation and Water Sustainability

A substantial body of empirical evidence links community participation to improved sustainability outcomes in rural water supply, though the relationship is more nuanced than early CBWM proponents suggested. Carter et al. (1999) found that communities involved in the planning, design, and implementation of water schemes in sub-Saharan Africa demonstrated higher willingness to contribute labour and cash for maintenance, longer service life, and stronger social ownership of infrastructure. More recently, Whaley and Cleaver (2017) used institutional bricolage theory to argue that sustainable water management often depends on creative adaptation of formal institutional rules to local social norms, customary arrangements, and practical problem-solving capacity.

In the Nigerian context, Musa et al. (2020) surveyed 300 households in rural Kaduna State and found that communities where water users were actively involved in tariff-setting and management

committee elections reported higher rates of regular fee payment and lower rates of system breakdown. These findings reinforce the importance of procedural fairness and community voice in generating the social capital necessary for sustained collective action around water management.

2.3.4 Climate Change and Water Security in Arid Zones

Climate change poses an escalating threat to rural water security in the semi-arid zones of West Africa, including Katsina State. Hulme et al. (2001) projected significant reductions in annual rainfall and increases in inter-annual variability across the Sahel region, with adverse consequences for groundwater recharge and surface water availability. More recent analyses by the IPCC (2022) confirm these projections, indicating that without adaptation measures, climate-related water stress will intensify in the region over the coming decades.

Umar et al. (2019) modelled the impact of climate variability on groundwater levels in northern Katsina and found statistically significant declining trends in piezometric levels in 14 out of 17 monitored boreholes over a 20-year period. These findings have direct implications for the long-term viability of borehole-based water supply systems, which constitute the majority of rural water infrastructure in the state. Climate-resilient water planning — including rainwater harvesting, aquifer recharge schemes, and demand management — is therefore identified in the literature as an increasingly urgent component of sustainable water management strategy (Bates et al., 2008).

2.4 Policy and Institutional Framework

Nigeria's water sector is governed by a complex multi-level institutional architecture. At the federal level, the Federal Ministry of Water Resources (FMWR) sets national policy, coordinates sector-wide programmes, and oversees federal water infrastructure through the River Basin Development Authorities (RBDAs). The National Water Supply and Sanitation Policy (NWSSP) of 2000, revised in 2004, provided the foundational framework for decentralising water services to states and local governments, emphasising demand-responsive approaches and community management. The National Action Plan for Revitalization of the Water Supply, Sanitation and Hygiene (WASH) Sector (2021–2030) further aligns Nigeria's water governance with the SDG 6 agenda.

At the state level, RUWASSA serves as the principal implementing agency for rural water supply in Katsina State, operating under the State Ministry of Water Resources. RUWASSA was established to plan, implement, and monitor rural water and sanitation schemes, as well as build the capacity of community water management committees. However, as documented by Garba (2018), RUWASSA's operational effectiveness is constrained by insufficient recurrent budgetary allocations, limited technical manpower, and weak monitoring and evaluation systems.

The local government tier, under Nigeria's 1999 Constitution, has concurrent responsibility for water supply, yet LGAs in Katsina State generally lack the financial, technical, and administrative capacity to fulfil this mandate effectively (Bakare & Abdullahi, 2016). This multi-level governance fragmentation creates coordination challenges and blurred accountability, which this study seeks to investigate empirically.

3. Methodology and Materials

3.1 Research Design

This study adopts an explanatory mixed-methods research design, integrating quantitative survey methods with qualitative interview data. The mixed-methods approach is particularly appropriate for this study because it enables triangulation of data sources, allows the strengths of quantitative breadth to be complemented by the depth and contextual richness of qualitative inquiry, and is well-suited to investigating the multi-dimensional and socially embedded nature of water supply sustainability (Creswell & Plano Clark, 2017). The quantitative component establishes the prevalence and

distribution of key variables, while the qualitative component explains the mechanisms, processes, and contextual factors underlying observed patterns.

3.2 Study Area

Katsina State is located between latitudes 11°08'N and 13°22'N and longitudes 6°52'E and 9°20'E. It is bounded to the north and northwest by the Republic of Niger, to the east by Kano and Jigawa states, to the south by Kaduna State, and to the west by Zamfara State. The state has a total area of approximately 24,192 km² and is divided into 34 LGAs. The climate is semi-arid, characterised by a short rainy season (June–September) and a prolonged dry season, with mean annual rainfall ranging from 500 mm in the north to 900 mm in the south. The predominant vegetation is Sudan Savanna, transitioning to Sahel Savanna in the northernmost LGAs.

The three Local Government Areas selected for this study were Dutsi, Kankia and Danja, collectively represent span the principal ecological and socio-economic gradients within the state. The selection criteria included variation in water infrastructure density, and past participation in government and donor-funded water programmes.

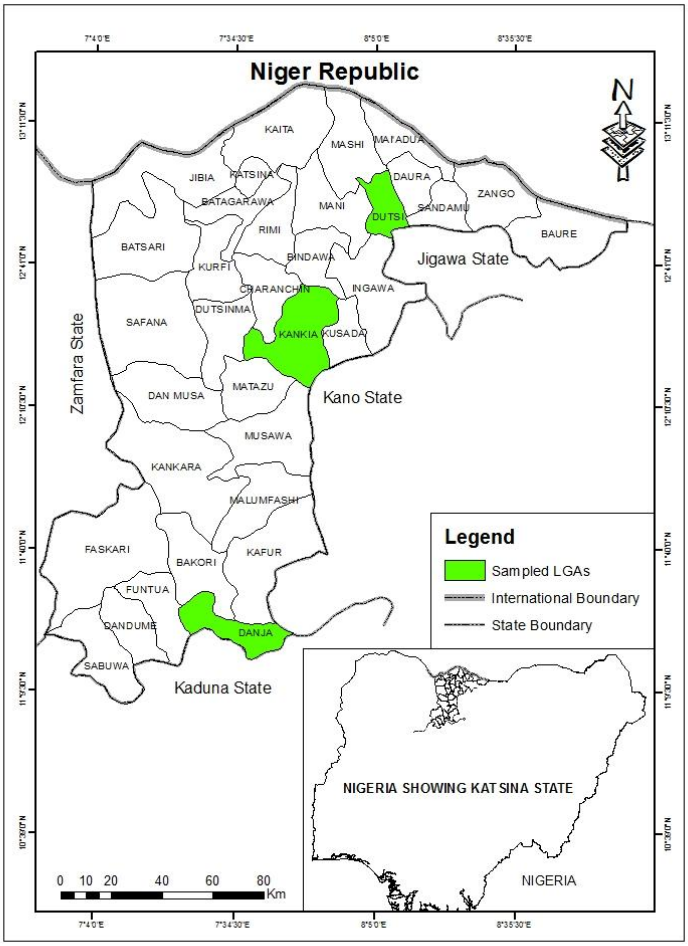

Figure 1: Map of Katsina state showing sampled Local Government Areas

3.3 Research Instruments

3.3.1 Questionnaire Design

A structured questionnaire was developed to collect quantitative data from household respondents. The instrument was designed in English and subsequently translated into Hausa (the predominant local language) by a bilingual research assistant with expertise in environmental science, to ensure cultural appropriateness and linguistic accuracy. The questionnaire comprised five sections: (a) sociodemographic characteristics of respondents; (b) current water access and sources; (c) perceptions of water quality, quantity, and reliability; (d) community participation in water management; and (e) willingness to pay for improved water services. The questionnaire was pre-tested on 20 respondents in Kankia LGA (not included in the main study) to assess clarity, flow, and reliability, and revisions were made based on the pilot feedback. The internal consistency of the scale items was assessed using Cronbach's alpha coefficient, which yielded a value of 0.81, indicating high reliability (Nunnally, 1978).

3.3.2 Interview Guide

In-depth semi-structured interviews were conducted with 25 key informants selected through purposive and snowball sampling. The key informants comprised eight water sector officials from RUWASSA and the State Ministry of Water Resources, six community water management committee (WMC) chairpersons, five LGA-level WASH officers, four representatives of NGOs and donor-funded projects operating in the sector, and two representatives of the Katsina State Environmental Health Officers' Association. The interview guide was designed to explore institutional arrangements, management challenges, inter-agency coordination, funding mechanisms, community participation practices, and perceptions of sustainability constraints. Interviews lasted between 45 and 90 minutes, were conducted in Hausa or English according to informant preference, and were audio-recorded with informed consent, then transcribed verbatim for analysis.

3.4 Population and Sampling

The target population consisted of adult household heads (or their proxies) in rural communities within the three selected Local Government Areas. Based on the 2022 NPC population projections and an estimated average household size of 6.5 persons for Katsina State (NPC, 2022). Using Yamane's (1967) formula for sample size determination at a 95% confidence level and 7% margin of error, a minimum sample size of 196 was computed. The study rounded this up to 200 respondents.

A three-stage sampling procedure was employed. In the first stage, six communities (two per LGA) were selected using simple random sampling from the enumerated list of rural communities. The rural sampled communities were Yamel an Kayawa (Dutsi LGA); Gachi and Kunduru (Kankia LGA); Jiba and Tandama (Danja LGA). In the second stage, 33–34 households per community were selected using systematic random sampling. In the third stage, one adult respondent per household was selected through a Kish grid technique to ensure gender representativeness.

3.5 Data Collection

Quantitative data were collected between February and April 2026 by six trained field enumerators, each assigned to one LGA. Enumerators received three days of training covering the objectives of the study, questionnaire administration protocols, informed consent procedures, and quality control standards. Completed questionnaires were reviewed daily by the lead researcher for completeness and consistency, with follow-up visits conducted where necessary to resolve missing or contradictory entries. Qualitative data (interviews) were collected concurrently, with the lead researcher personally conducting all interviews to ensure consistency of approach.

3.6 Data Analysis

Quantitative data were entered into IBM

SPSS Statistics (version 26) and analysed using descriptive statistics (frequencies, percentages, means, and standard deviations) and inferential statistics. Chi-square tests of association were employed to examine relationships between categorical variables, and a multiple linear regression model was fitted to identify predictors of household water access. Qualitative data were analysed using thematic analysis following the six-phase procedure described by Braun and Clarke (2006): familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. NVivo 12 software was used to manage and organise the qualitative dataset. Member checking and peer debriefing were employed to enhance the credibility of qualitative findings.

4. Results

4.1 Sociodemographic Profile of Respondents

Of the 200 respondents whose questionnaires were analysed, 58.2% were male and 41.8% were female. The age distribution revealed that the majority (62.4%) were between 30 and 55 years of age, with a mean age of 41.3 years (SD = 11.7). Household size ranged from 2 to 21, with a mean of 7.2 members, consistent with national rural household size averages for the region (NPC, 2022). In terms of educational attainment, 39.2% had no formal education, 28.4% had primary education, 21.6% had secondary education, and 10.8% had post-secondary or higher education. The predominant occupation was subsistence farming (71.6%), followed by petty trading (14.4%), artisanship (8.2%), and civil service (5.7%).

4.2 Current Status of Rural Water Supply Infrastructure

4.2.1 Water Access and Sources

Table 1 presents the distribution of household water sources across the study area. The findings reveal a significant deficit in access to improved water supply, with only 29% of households having access to pipe-borne water. The majority of households (56%) depend on boreholes and hand pumps, while 15% rely on open wells or surface water sources — all of which are considered unimproved or at-risk sources under WHO/UNICEF (2021) classification criteria.

Table 1: Distribution of Household Water Sources (n=200)

Variable	Frequency	Percentage (%)
Access to pipe-borne water	58	29.0
Access to borehole/hand pump	112	56.0
Access to open well/surface water	30	15.0
Total	200	100

Source: Field Survey, 2025

4.2.2 Functionality Status of Water Infrastructure

Table 2 presents data on the operational status of various water supply infrastructure types as assessed through facility audits and community informant reports. The findings are alarming: across all infrastructure types, a substantial proportion of facilities were found to be non-functional at the time of data collection. Pipe-borne water systems recorded the highest non-functionality rate (52.4%), primarily due to dilapidated distribution networks, power outages, and pump failures. Boreholes had a non-functionality rate of 38.7%, consistent with the 40% average reported for Sub-Saharan Africa by Foster et al. (2020). Only earth dams and reservoirs showed relatively higher functional rates (60%), though their water quality is frequently compromised during the dry season.

Table 2: Functionality Status of Water Infrastructure by Type

Water Source	Functional (%)	Non-functional (%)	Under repair (%)
Boreholes	42.1	38.7	19.2
Hand pumps	55.3	31.4	13.3
Pipe-borne systems	28.6	52.4	19.0
Earth dams/reservoirs	60.0	30.0	10.0

Source: Field Survey and Facility Audit, 2025

These findings are consistent with and corroborate the observations of Isah et al. (2019) and Garba (2018) regarding the rapid deterioration of water infrastructure in Katsina State. Key informant interviews with RUWASSA officials confirmed that the agency lacks the staff and logistical capacity to conduct regular facility monitoring across all 34 LGAs, resulting in breakdowns going undetected and unrepaired for months or even years:

"We have only about 12 field technicians covering the entire state. We cannot monitor and repair 2,000-plus facilities with that capacity. Many communities report faults and wait for months before anyone comes." (RUWASSA Official, Interview, March 2026)

4.3 Institutional and Management Arrangements

Key informant interviews revealed a complex, multi-tiered governance architecture for rural water supply in Katsina State. RUWASSA, operating under the State Ministry of Water Resources, is the primary state-level implementing body, though its authority and resources overlap with the LGA Department of Water and Sanitation, creating institutional ambiguity and coordination challenges. At the community level, Water Management Committees (WMCs) are the designated bodies responsible for day-to-day management, tariff collection, and routine maintenance of water schemes.

The study found that while 81.4% of communities with functional water schemes reported having a WMC, only 44.3% of these committees had formal registration, clear constitutions, or regular meeting schedules. Financial management within WMCs was particularly weak: fewer than 30% of WMCs maintained written financial records, and only 22% had formal bank accounts for water user fees. These institutional deficiencies mirror findings from Adekunle et al. (2018) in other Nigerian states and underscore the gap between policy intent and

implementation reality in community water management.

Interview data further revealed that political interference in the appointment of WMC leadership — with committee positions sometimes allocated along partisan or patronage lines rather than competence and community trust — was identified by 8 of 13 community-level informants as a significant governance problem that undermined management accountability and user confidence in water scheme management.

4.4 Key Challenges to Sustainability

4.4.1 Survey Findings on Challenges

Table 3 presents respondents' ratings of the principal challenges to water supply sustainability. Inadequate funding was identified as the most pervasive challenge (87.0%), followed by the absence of a maintenance culture (81.0%), poor community participation (74.0%), seasonal water scarcity (78.0%), and lack of trained technicians (67.5%).

Table 3: Principal Challenges to Rural Water Supply Sustainability (n=200)

Challenge	Respondents (n=200)	Percentage (%)
Inadequate funding	174	87.0
Poor community participation	148	74.0
Lack of trained technicians	135	67.5
Political interference	122	61.0
Absence of maintenance culture	162	81.0
Vandalism/theft of infrastructure	98	49.0
Seasonal water scarcity	156	78.0

Source: Field Survey, 2025

4.4.2 Financing and Funding Challenges

The financing deficit identified in Table 3 was elaborated in qualitative interviews with state officials and NGO representatives. State budgetary allocations to the rural water sub-sector in Katsina State have averaged less than 1.8% of the total state budget over the 2018–2025 period, far below the recommended minimum of 5% for water and sanitation (Adeyemi et al., 2020). Donor-funded projects — primarily from the World Bank, UNICEF, and bilateral agencies — have filled part of this gap, but their project cycle approach, often limited to 3–5 years, means that long-term recurrent cost obligations are frequently unplanned for and unfunded, leading to post-project infrastructure collapse. This pattern of 'build-neglect-rehabilitate' has been identified as a recurrent cycle in Nigerian rural water supply (Okafor & Hassan, 2021).

4.4.3 Seasonal Water Scarcity and Climate Drivers

The challenge of seasonal water scarcity (78.0% of respondents) reflects the compounding effects of reduced and erratic rainfall on groundwater recharge and surface water availability in the state's semi-arid environment. Qualitative data from interviews with community leaders corroborated the

quantitative findings, with multiple informants describing dry-season borehole failures attributable to declining water tables:

"Every dry season, some of our boreholes go dry. The community is left to walk several kilometres to fetch water. By April and May, before the rains come, the situation is very bad." (Community Leader, Dutsi LGA, Interview, February 2026)

These observations align with the modelling results of Umar et al. (2019), who documented declining groundwater levels in northern Katsina, and with the broader literature on climate-induced water insecurity in the Sahel (IPCC, 2022; Hulme et al., 2001).

4.5 Community Participation and Sustainability

Bivariate analysis using chi-square tests revealed a statistically significant association between the level of community participation in water scheme management and the functional status of the scheme ($\chi^2 = 28.4$, df = 4, $p < 0.001$). Communities that reported high participation in the selection of WMC members, tariff-setting, and maintenance decision-making were significantly more likely to have functional water schemes than those with low participation levels. This finding is consistent with the participatory development literature (Musa et al., 2020; Whaley & Cleaver, 2017; Carter et al., 1999) and confirms the importance of genuine community voice in water governance.

Multiple regression analysis further indicated that community participation ($\beta = 0.38$, $p < 0.001$), regularity of external technical support ($\beta = 0.29$, $p < 0.01$), and availability of locally trained technicians ($\beta = 0.24$, $p < 0.05$) were the strongest predictors of water scheme functionality, together explaining 62.3% of the variance ($R^2 = 0.623$). These findings underscore that sustainability is not a function of any single variable but emerges from the interaction of community agency, technical capacity, and external support structures — consistent with the lifecycle approach articulated by Smits et al. (2013).

Interview data revealed that while communities generally expressed willingness to participate in water management, their actual participation was frequently constrained by inadequate information from RUWASSA, gender exclusion from decision-making processes (particularly for women and youth), and lack of clear legal frameworks empowering WMCs to enforce water-use regulations and sanction free riders. Seven of eight female community informants reported that women, who bear primary responsibility for household water collection, were rarely consulted in management decisions, a finding that reflects broader structural gender inequalities in water governance across Nigeria (Bakare & Abdullahi, 2016).

5. Discussion

The findings of this study paint a sobering picture of the state of rural water supply management and sustainability in Katsina State, while also identifying actionable pathways for improvement. Four overarching themes emerging from the data are discussed below in relation to the theoretical frameworks and empirical literature reviewed in Chapter 2.

5.1 The Governance-Sustainability Nexus

The institutional complexity documented in this study — characterised by overlapping mandates between RUWASSA and LGA water departments, weak WMC capacity, and political interference in community governance — represents a fundamental obstacle to sustainability that cannot be resolved through technical or financial interventions alone. These findings resonate strongly with Okafor and Hassan's (2021) governance analysis and with the broader literature arguing that institutional arrangements are the primary determinants of rural water service continuity (Lockwood & Smits, 2011; IRC, 2012).

The evidence suggests that the current institutional architecture in Katsina State embodies what Cleaver (1999) terms 'institutional bricolage' in its negative manifestation — a patchwork of formal

and informal governance arrangements that are individually inadequate and collectively incoherent. Addressing this requires deliberate institutional restructuring, including the legal clarification of roles and responsibilities at each governance tier, the professionalisation of community water management through accreditation and remuneration of WMC secretaries and treasurers, and the establishment of district-level water management entities with dedicated technical support functions.

5.2 The Financing Gap and Its Consequences

The centrality of inadequate financing to sustainability failure — identified by 87% of respondents and elaborated in all institutional interviews — confirms that the 'build-neglect-rehabilitate' cycle observed by Okafor and Hassan (2021) is deeply entrenched in the Katsina State water sector. The evidence suggests that existing tariff systems are both underpriced and poorly enforced, failing to generate revenues sufficient even for routine maintenance. At the same time, state budget allocations are insufficient and irregularly disbursed, creating a structural financing gap that no amount of donor project support can sustainably bridge.

A shift toward a full cost-recovery model — even if phased and differentiated by wealth quintile to protect equity — is essential. This would require, as recommended by Brikké and Bredero (2003), transparent community financial management, regular tariff review processes, and the creation of state-level escrow funds for capital maintenance that are accessible to functional WMCs on a matching-grant basis.

5.3 Climate Vulnerability and Adaptive Strategies

The seasonal water scarcity experienced by communities in the study area is not merely a temporary inconvenience but reflects a deepening structural vulnerability to climate change that will intensify under projected warming and drying trends for the Sahel (IPCC, 2022; Umar et al., 2019). Current rural water supply planning in Katsina State appears to give inadequate attention to climate risk, with borehole sitting and design often based on historical hydrogeological data that may no longer reflect current groundwater dynamics.

Climate-resilient water planning — including investment in managed aquifer recharge (MAR) schemes, solar-powered water systems to reduce dependence on diesel-fuelled pumps, and multi-source water supply designs that can switch between borehole, surface water, and rainwater harvesting depending on seasonal availability — is urgently needed. These strategies are consistent with recommendations emerging from the global WASH sector (Bates et al., 2008) and should be mainstreamed into RUWASSA's infrastructure planning guidelines.

5.4 Gender, Equity, and Social Sustainability

The marginalisation of women from water management decision-making documented in this study is not only a matter of social justice but a practical sustainability risk. Given that women in Katsina State's rural communities are the primary water users and carriers, their exclusion from governance means that management decisions are systematically disconnected from the lived realities of the most intensive service users. Evidence from other African contexts (Musa et al., 2020; Carter et al., 1999) consistently shows that gender-inclusive WMCs achieve better maintenance compliance, higher tariff payment rates, and more equitable water distribution. Formalising gender quotas for WMC membership — as recommended under Nigeria's WASH Gender Mainstreaming Strategy — and providing targeted training for female committee members are therefore critical sustainability measures.

6. Conclusion and Recommendation

6.1 Conclusion

This study has provided comprehensive empirical evidence on the management practices, sustainability challenges, and community

governance dynamics shaping rural water supply outcomes in six selected LGAs of Katsina State, Nigeria. The findings confirm that despite significant public and donor investment in water infrastructure, the sustainability of rural water supply in the state remains critically compromised by a convergence of institutional, financial, technical, environmental, and socio-cultural factors. The majority of installed infrastructure is non-functional or at risk of failure, access deficits remain severe, and the institutional frameworks nominally responsible for sustaining services lack the capacity, resources, and coordination to fulfil their mandates effectively.

The study has demonstrated, consistent with the theoretical frameworks of community-based water management and the lifecycle service delivery approach, that sustainable water supply outcomes require not only the physical construction of infrastructure but a sustained investment in the institutional, financial, and social conditions that enable communities and agencies to manage and maintain services over the long term. Community participation, when genuine, structured, and supported, is a significant determinant of water scheme functionality — but it must be embedded within enabling governance frameworks and supported by technical capacity and adequate financing if it is to generate lasting results.

6.2 Recommendations

Based on the findings and analysis of this study, the following recommendations are advanced:

1. The State Government should enact a Rural Water Supply and Sanitation Law that clearly delineates the roles and responsibilities of RUWASSA, LGA water departments, and WMCs, eliminates jurisdictional overlaps, and establishes enforceable accountability mechanisms at each tier of governance.
2. The Katsina State Government should progressively increase budgetary allocation to the rural water sub-sector to at least 5% of the annual state budget, with a dedicated capital maintenance fund established and ring-fenced for water infrastructure replacement and rehabilitation.
3. RUWASSA should partner with technical and vocational training institutions in the state to establish a certified rural water technician training and licensing programme, with trained technicians deployed at the community or ward level.
4. Climate risk assessments should be integrated into all future water infrastructure planning and sitting decisions, with adaptation measures including managed aquifer recharge, multi-source supply designs, and solar-powered pumping systems prioritised in capital investment plans.
5. All WMCs in Katsina State should be required to reserve a minimum of 40% of committee positions for women, with dedicated training and mentoring support provided to female members to build their technical and governance capacity.
6. Community consultations should be formalised as a mandatory stage in the planning and design of new water schemes, with documented evidence of community input required before project approval.
7. RUWASSA should establish a state-wide WASH management information system (MIS) with georeferenced facility-level data updated at least annually, and linked to an automated maintenance request tracking platform accessible to communities via mobile phone.
8. Regular sector performance reviews, involving RUWASSA, LGAs, civil society, and development partners, should be institutionalised annually to assess progress towards SDG 6 targets and adjust programme strategies based on evidence.

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