Institutional Frameworks and Household Clean Water Accessibility in Peri-Urban Communities of Northern Tanzania: A Case of the Suburban Ward

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ABSTRACT

The lack of clean water contributes to the transmission of waterborne diseases such as cholera, dysentery, and typhoid, particularly among vulnerable populations. This situation threatens public health, especially in resource-limited settings. Various regulatory and environmental factors, including bylaws and policies, water tariffs, electricity access, flooding, infrastructure conditions, pollution, and drought, significantly impact access to clean water by influencing the availability and quality of water resources. This study examines the regulatory environment factors affecting access to clean water in peri-urban communities reliant on piped systems, focusing on household clean water availability in northern Tanzania. Based on Mary Douglas's Cultural Theory, the study adopted a cross-sectional design to collect quantitative data. Questionnaires were administered to a purposive sample of 353 respondents drawn from a target population of 10,965 individuals from 3,030 households, all aged 18 years or older. Data analysis was conducted using descriptive statistics with the aid of SPSS software. Qualitative data was collected from key informants through interviews and analysed thematically. The results revealed that 51% were aware of the water and environmental policies, 84.7% participated in meetings, 23.2% paid water bills, and access to clean water throughout the year was challenging. The chi-square test indicated a significant relationship ($\chi^2 = 48.118$, $df = 12$, $p = 0.000$) between institutional frameworks and clean water accessibility. Additionally, planting trees and properly managing water sources contribute to the protection of water resources. Educating the community and protecting water sources play a significant role in preserving ecological health and ensuring the sustainability of communities. The study concludes that there is a relationship between regulatory frameworks and clean water accessibility in northern Tanzania. The study recommends continuous provision of education and awareness programs focused on the effective use, management, and protection of water sources to ensure public health and clean water accessible sustainability.

Keywords: Clean Water, Environmental Factors, Flood, Factors of Clean Water, Pollution, Regulatory Determinants

I. INTRODUCTION

Access to clean water, as United Nations mentioned is a fundamental human right and a critical component of sustainable development (UN, 2024). Lacking clean water access leads to the spread of diseases (Kapaya et al., 2025) and even death (Koua et al., 2025; Mwale et al., 2025) caused by accumulating contaminated water (World Health Organization) (WHO, 2024). Various regulatory factors, including laws and guidelines, water bills, and community involvement, significantly impact this access (Meran et al., 2021; UNICEF/WHO, 2017), influencing water resource availability and quality. According to United Nations Children's Emergency Fund and World Health Organization UNICEF/WHO (2017), the time required to walk, fetch, and return should not exceed half an hour, and clean water

should be available as needed. Economic instruments, direct limits, and the encouragement of self-regulation are the three main regulatory tools that resulted from the international conference on water and environmental issues held in Rio de Janeiro and Dublin in 1992 (Meran et al., 2021).

Direct controls encompass executive regulation that manages guidelines, interprets rules, and outlines water laws. Similarly, the requirements for permit applications must be clarified, and standards must be set to regulate water quantity and discharge requirements. These controls also mandate specific technologies and establish efficiency standards for water usage. Effective land use planning can enhance water reuse and recycling initiatives (Meran et al., 2021). These regulatory factors encompass government policies, institutional frameworks, and compliance mechanisms that govern water management and distribution. Active regulations can promote sustainable practices, ensure equitable access, and safeguard water quality (Meran et al., 2021). On the other hand, weak regulatory frameworks often lead to mismanagement, corruption, and inequitable distribution (Tshona et al., 2025), exacerbating the challenges faced by vulnerable populations. Clean water is vital for household cooking, dishwashing, drinking, laundry, sanitation, and hygiene (Ogunbode et al., 2024).

Studies indicate that billions of individuals worldwide depend on polluted water (Kapaya et al., 2025; Koua et al., 2025; Mwale et al., 2025), which leads to infection, including waterborne illnesses (Yanti et al., 2025), such as typhoid, diarrhoea (Kapaya et al., 2025; Koua et al., 2025; Mwale et al., 2025), and dysentery, and the death of numerous people each year (WHO, 2024). This is due to significant challenges faced, including climate change, which led to altered rainfall patterns (Libanda et al., 2024; Pinto et al., 2024; Sahoo & Goswami, 2024), extended droughts, and flooding (Bazaanah & Mothapo, 2023; Mapuka et al., 2024), impacting water sources and worsening water shortage (Aborode et al., 2025), especially in peri-urban communities. Deforestation of watersheds due to unsustainable agricultural practices decreases water's natural purification and increases sedimentation, further compromising water quality (Bazaanah & Mothapo, 2023), threatening water resources and ecological health. This decreases water availability (Joshua et al., 2022; Pinto et al., 2024). Pollution from industrial activities, agricultural surplus (George-Williams et al., 2024) domestic activities, and insufficient waste management systems pose a dangerous challenge (Cullmann et al., 2024; Ripanda et al., 2023). Polluted water sources can lead to serious health issues (Auma et al., 2024; Mapuka et al., 2024; Munissi & Mwalilino, 2024), distressing the communities that rely on these resources.

Access to electricity positively impacts clean water accessibility (URT-MoW, 2024). Electricity is essential for drilling wells and boreholes to support the supply of water from sources. Electricity consumption is required for pumping operations (Madrigal-Ballestero et al., 2024). Access to electricity enhances societies' access to clean, reliable water and sanitation services (Nguea, 2024). Point-of-use (POU) filtration systems rely on electricity to function and generate wastewater during the filtration process (Wu, 2024).

Indeed, obtaining clean water remains a significant health concern in lower- and middle-income nations (Aragaw et al., 2023), where access to better water sources is constrained. Most communities without clean water live in Sub-Saharan Africa (UN, 2023; UNESCO, 2022; WHO/UNICEF, 2023), including Tanzania. In Sub-Saharan Africa, however, millions still lack reliable access to safe drinking water (WHO, 2024; WHO/UNICEF, 2023). The Joint Monitoring Program (WHO, 2024; WHO/UNICEF, 2023), classified clean drinking water into three classes such as improved facilities which include piped rations like tap water in homes, yards, or shared sources, and public taps; non-piped supplies, comprising boreholes, protected wells, springs, rainwater, packaged water, delivered water, and water kiosks; and unimproved facilities, which consist of unprotected wells and springs, while no facility refers to open water sources such as rivers and lakes. The interplay between local governance, international aid, and community engagement complicates the regulatory landscape. Considering these factors is essential for developing effective strategies to enhance water access, improve public health outcomes, and foster economic development.

The government of Tanzania has ratified numerous national policies and initiatives to address water resource challenges, prioritizing community involvement in protection and management. Key actions include community engagement to increase awareness and education on water regulations. Regulatory roles include licenses and regulating water tariffs and accessibility through the Energy and Water Utilities Regulatory Authority (EWURA) (NAWAPO, 2002; URT/ewura, 2025). Similarly, the Rural Water Supply and Sanitation Agency (RUWASA) coordinates water policies and guidelines in rural areas (URT-RUWASA, 2022), while the Tanzania Bureau of Standards (TBS) establishes water quality standards, including discharge quality, that industries, including pharmaceutical and agricultural industries, need to comply with. The Ministry of Water develops water policies and regulations, while the National Basin Water Board (NAWAPO, 2002), advises on the planning and coordination of water resources.

The national policy is implemented with various timely tools and measures, including economic tools like water pricing, levies, fines, and incentives to promote marketing strategies, motivate water conservation, reduce water-based contamination, and ease water allocation. A system of clearly defined water rights, appropriate management structures, and actions, including permit applications and approvals, and pertinent laws and regulations for water

pollution, are examples of legal and regulatory tools. Tools to help with participation include discussions, sensitization, community education, and consultations (NAWAPO, 2025). According to the government of Tanzania, by the end of 2023, 79.6% of village residents will have access to clean water, compared to 90% of city dwellers. By 2025, village-level access to clean water is anticipated to have increased to 85% (URT-MoW, 2024). The effects of climate change, including prolonged drought, delayed rainfall, and flooding, continue to impact the water sector by contributing to the drying up of water sources, increasing water rationing, and damaging water infrastructure (URT-MoW, 2024). To tackle climate change challenges, the government is building rainwater harvesting dams to store water and manage flooding. The ministry also focuses on creating resilient water infrastructure and developing projects to mitigate climate change impacts (URT-MoW, 2024). Most peri-urban residents are said to lack access to safe and clean drinking water despite several government measures through water authorities to improve safe and clean water accessibility, requiring intervention to ensure water accessibility for all.

By overseeing, operating, and maintaining public waterworks and taps, community groups authorized under section 32 in local communities can guarantee their customers a safe and adequate water supply in collaboration with the RUWASA (URT-WATER-ACT, 2019). The Tanzania Vision 2025 aims to create a robust and competitive economy, promote effective leadership through legal frameworks, and enhance its citizens' living standards. Achieving these goals involves multiple forums and levels, including national conferences, technical workshops, meetings, and field consultations (NAWAPO, 2002).

This paper aims to assess the institutional frameworks and household clean water accessibility in peri-urban communities of northern Tanzania, which leads to clean water accessibility for peri-urban dwellers who depend on the piped water system. The results of this study will lead to the alignment of government institutions and communities to protect and coordinate the environment and water infrastructure to ensure water sustainability within families and communities.

II. THEORETICAL REVIEW

This study employs Mary Douglas's Cultural Theory to explore the association between water-related risks, societal values, and institutional framework. The theory categorizes four cultural orientations, including egalitarianism, individualism, bureaucracy, and fatalism (Koehlera et al., 2018). Focusing on water point services, the study emphasizes of community participation, self-supply options, and self-management. It posits that a diverse management approach encompassing multiple cultures can reduce risks. The research highlights how cultural values and social structures influence risk assessments. It advocates for pluralist institutional frameworks that enable the rethinking and redistribution of risks for rural water users (Koehlera et al., 2018). By integrating cultural theory into the study of risk, it reveals how institution framework factors shape attitudes toward risk, decision-making processes, and the distribution of societal power. The study seeks to clarify the role of institution culture in ensuring a reliable water supply and the importance of community-based egalitarianism in maintaining water infrastructure.

III. METHODOLOGY

3.1 Study Area

The investigation was conducted in the Kikwe ward of the Meru district, located in the Arusha region of Tanzania. Ten thousand nine hundred sixty-five live in 3030 families in the 77.04 square kilometer Kikwe ward (Fig. 1), with 5689 men and 5276 women (URT, 2022). The village mainly relies on conventional agriculture and irrigation, which uses rivers and irrigation canals to produce maize, beans, bananas, and vegetables. The Kikwe peri-urban ward reflects typical characteristics of Tanzania's peri-urban and rural areas, such as a strong dependence on groundwater and swift urban development (Tomasek et al., 2022). The region grapples with climate change uncertainties and restricted access to clean water, relying primarily on rivers, irrigation canals, and ponds. Few residents have direct access to piped water (Ngayaga et al., 2025).

3.2 Research Design

The study used a cross-sectional survey design. A Mixed-method approach was employed. Questionnaires were administered to the respondents from 18 years old with consent. It had open and closed-ended questions. The interview checklist was administered to the key informants for qualitative data. Purposive sampling was used to get key informants from the study area, including government representatives from the respective area, the ward water board & committees, and the rural water authority.

3.3 Targeted Population

The recent work targeted the Kikwe ward population, who were interviewed to generate data regarding household clean water accessibility in the peri-urban community. Precisely, the study targets individuals from diverse genders, age groups, and socioeconomic backgrounds, guaranteeing a broader representation of views. The study covers all four villages of Kikwe ward, including Nambala, Kikwe, Maweni, and Karangai villages, to capture potential ward variations in household clean water accessibility. This holds significant over the institutional framework in the ward. The study also concentrates on environmental factors such as drought, flood and pollution, and the presence of electricity, ensuring respondents' insights are grounded in the real world.

3.4 Sampling Procedure

To collect quantitative information on social factors such as age, sex, family structure, and educational attainment, the researchers developed a systematic questionnaire. The survey included both open-ended and closed-ended questions, with structured questions administered in person. The characterization of clean water is based on the Joint Monitoring Programme (JMP) by WHO/UNICEF (2023) based on levels as safely managed based on sources accessible on premises, available when needed, and free from contaminations, basic that use improved sources that are found within 30 minutes, limited use improved sources found over 30 minutes, unimproved, and surface water and the Household Water Insecurity Experiences (HWISE) framework (Young et al., 2019). Participants had to provide their informed consent before any data collection could begin. Participants were assured of the confidentiality of their responses and the protection of their identities. The study adhered to the ethical guidelines established by the institutional review boards. A total of 353 respondents from Kikwe ward households participated in the survey. According to Creswell and Creswell (2023), the researchers employed basic random sampling techniques during data collection to ensure that every household head had an equal chance of being selected.

Additionally, purposive sampling is employed to identify key informants for interviews, focusing on specific units within the population. Villages leaders, village and ward community water organization (NAKIMAKA), and district water authority key informants participated in the interview. NAKIMAKA was formed from four villages named Nambala, Kikwe, Maweni, and Karangai; it is a community-based organization working under RUWASA (URT-RUWASA, 2022). The researchers conducted a qualitative analysis with several respondents to gain insights into their perceptions and experiences regarding social aspects. They collected the research data through semi-structured interviews. The respondents were allowed to select more than one response. Data was collected from February to May 2024.

Equations 1 and 2 illustrate the Taro Yamane formula (Adam, 2020), used to determine the study population of 353.

$$n = \frac{N}{(1+N(e^2))} \quad (1)$$

$$n = \frac{3030}{(1+3030(0.05^2))} \qquad n = \frac{3030}{8.575} = 353 \quad (2)$$

Here, N is the population size, n is the minimum required sample size, and e is the margin of error, which is set at 0.05. A 95% confidence level and a ±5% margin of error are ideal.

3.5 Data Collection

This study combined quantitative and qualitative research methodologies in a cross-sectional survey to gather data on the regulatory determinants impacting the communities' access to clean water in the Kikwe ward. This approach allows for comprehensive data analysis, covering a wide range of societal issues and providing a deep comprehension of the regulatory and environmental factors influencing household access to clean water, as noted by earlier researchers (Creswell & Creswell, 2023). Information triangulation was conducted and collected from numerous sources. Collaboration on data was hired concurrently, and the results evaluate the general outcomes. Converging evidence from diverse sources increases the study's validity, reliability, and credibility.

3.6 Data Analysis Methods

The researchers collected data through semi-structured interviews and employed thematic analysis to study the qualitative data. They used the SPSS program and Microsoft Excel for quantitative data analysis. Descriptive statistics such as frequency, percentages, chi-square (χ^2) tests, and means and standard deviation were computed. A t-test (one-sample statistic) was used to get the mean and standard deviation. Additionally, a qualitative analysis was conducted with several respondents to gain insights into their perceptions and experiences regarding regulatory and environmental aspects affecting clean water access in the area. QGIS version 3.28 long-term release Firenze was used to get the map.

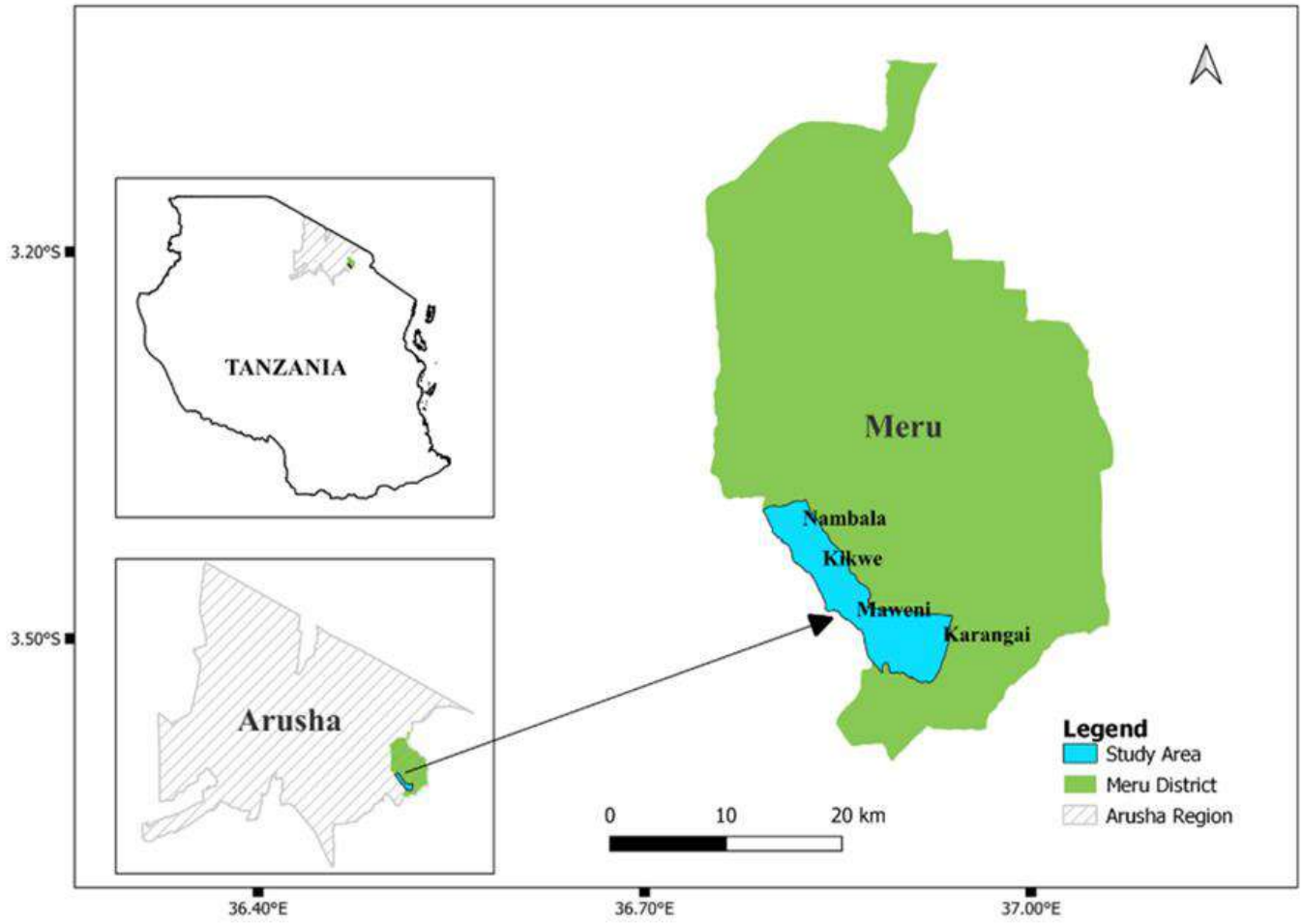

Figure 1
Map of Tanzania (Top Left) and Arusha (Down Left) Showing the Study Area, Meru District

3.7 Environmental Risks and Constraints of the Study

No ecological risks were identified in the current study; however, the temporal limitation of studies conducted over short time frames may not capture long-term environmental trends and changes. Unpredictable climate changes can affect both water availability and quality, complicating assessments. Research findings may become outdated if government policies regarding water availability continue to change.

IV. FINDINGS & DISCUSSION

4.1 Demographic Characteristics of Household Head

About 53% of respondents were male; 25.8% were 45 to 54 years old, 64% had a primary school education, and 73.7% were married. Most people do not acknowledge the significance of water availability. They feel entitled to the water source, claiming we should not pay or contribute. Additionally, they have rejected proposals for water infrastructure in their area, reflecting a misunderstanding of water resources and the current state of infrastructure, Tab. 1.

According to a survey conducted in Akoko, Nigeria, more than 78% of participants were men (Olutumise, 2024), compared to 82.5% in India (Kumar Ds et al., 2024) and 55.5% in South Africa (Vele et al., 2024). The proportion of female participants was less than 50%. Most respondents were 45–54 years old. That age range demonstrates that the respondents are responsible decision-makers in the home who were aware of the village's past water problems and regional management techniques. According to these data, the majority of people in northwestern Ghana were between the ages of 31 and 59, with 53.2% of them (Baddianaah et al., 2024) being over 40 (Kumar Ds et al., 2024). However, people under 24 could pay less attention due to their primary responsibilities, including jobs, education, or domestic duties. Nearly 63% had just completed primary school, and 3.1% of respondents had no formal education. The results were comparable to those of (Baddianaah et al., 2024), with 42.9% without formal schooling. These responders might not have had the necessary training and understanding to address issues with clean water

accessibility by processing water and using other sources (Terefe et al., 2024). According to research conducted in Mexico by Alvarado et al. (2022) 22% of respondents had completed primary school, while 43% did not. Infrastructure investment, education, and knowledge regarding access to clean water are often deprioritized in families where the primary decision-makers lack education or are ignorant of waterborne infections and treatment options.

More than 73% of those surveyed lived with their spouses. The results are 92.8% (Baddianaah et al., 2024) and 83.4% (Kumar Ds et al., 2024). Cohabitating families could require extra water for sanitation, hygiene, and everyday use. This results in more pressure on the availability of clean water. In this community, most respondents rely on rivers as their primary water source, with over 37% using rivers, canals, and ponds compared to other sources. Many homes lack water pipes, forcing residents to rely on rationed community water supplies. This situation was consistent with findings from studies in South Africa (Mapuka et al., 2024), Mexico (Alvarado et al., 2022), and Nigeria (Olutumise, 2024). The river water has been reported to be contaminated with effluents, leading to waterborne diseases, particularly affecting children, especially pupils in Karangai village, who have experienced illnesses like diarrhoea and typhoid.

Table 1

The Characteristics of the Household Head

Variable	Category	Frequency	Percentages
Gender %	Male	187	53
	Female	166	47
	Below 24	5	1.4
Age %	25-34	63	17.8
	35-44	75	21.2
	45-54	91	25.8
	55-64	63	17.8
	Above 64	56	15.9
	Non-formal ed.	11	3.1
Education %	Primary ed.	226	64
	Secondary ed.	60	17
	College ed.	30	8.5
	Bachelor's degree	18	5.1
	Masters & PhDs	8	2.3
Marital HH %	Single	26	7.4
	Marriage	260	73.7
	Divorced	12	3.4
	Widowed	44	12.5
	Separated	11	3.1
Total %		**353**	**100**

4.2 Regulatory Factors Influencing Household Clean Water Accessibility

Most respondents (222), or 62.9%, reported being informed about water accessibility in their areas, while 37.1% did not. Among the respondents, (180) 51% confirmed awareness of water and environmental policies, while the remainder indicated they were unaware. Additionally, 286 respondents, 81%, acknowledged the existence of bylaws regarding clean water, with only 19% disputing this. Furthermore, (260) respondents, 73.7%, reported that authorities actively enforced bylaws. A small number (12), or 3.4%, did not respond, and 22.9% believed the bylaws were ineffective. This may be due to the existence of infrastructure destruction and the inability to supply clean water to all, instead of some of the community members and locations. Regarding penalties for lawbreakers, (247) respondents, 70% mean of 1.81 agreed that authorities impose fines, and 1.4% were assigned community tasks Tab.2. They disseminate information to ward members through various methods, including village and ward meetings, posters, visits, and announcements via loudspeakers (pembe).

Table 2

Descriptive Analysis of Regulatory Factors Influencing Access to Clean Water

Variables	Category	Mean	Standard Deviations	Frequency	Percentage
Information on clean water	Yes	1.37	0.484	222	62.9
	No			131	37.1
Are you aware of the policies?	Yes	1.49	0.501	180	51
	No			173	49
Bylaws	Yes	1.19	0.393	286	81
	No			67	19
Is it working?	Yes	1.30	0.527	260	73.7
	No			81	22.9
	Missing			12	3.4
	Pay fine	1.81	1.291	247	70
Breakers commit	Sent to court			14	4
	Giving tasks to work			5	1.4
	Others			87	24.6
Total				**353**	**100**

Of most respondents (299), 84.7% participated in village and ward meetings, when necessary, while 15.3% did not. About 298 respondents, 84.4%, felt that the meetings were beneficial for discussing various issues, whereas 15.6% found them unhelpful. During interviews, participants noted that RUWASA educates the community on conserving water sources, paying for water services, and using clean and safe water. Additionally, chairpersons conduct seminars on clean water and related development topics. Although they claimed it would resolve clean water accessibility, it is still challenging. In a meeting conducted in February 2024 in Maweni village, the Village Executive Officer introduced researchers to the community and provided a warm welcome. This indicates the involvement of the community and having active meetings.

Most respondents (271), 76.8%, do not pay water bills for domestic use, while only 23.2% do. This indicates that residents are not motivated to pay water bills, which may result in the unsustainability of water projects. Further, the reported cost for individual connections is 250,000 Tanzanian Shillings (TZS), with charges of 700 TZS per unit and 20 TZS per bucket. Additionally, (279) respondents, 79%, did not complete the questionnaires regarding their monthly payments. Among those who did, 0.8% paid over 30,000 TZS, 1.1% paid between 20,000 and 29,500 TZS, 5.1% paid between 10,000 and 20,000 TZS, and 13.9% paid between 500 and 9,500 TZS for domestic and economic water use (Tab 3). Respondents indicated during interviews that a significant challenge is the lack of understanding about contributing to water services, especially *in areas like Nambala and Kikwe. Many believe water sources are their property; they shouldn't have to buy or contribute, as they feel a historical entitlement based on ancestral use, constructing water infrastructures, and distribution from the main sources*. They often perceive water as a right, given that the sources are in their communities. This indicates that educating the community members on the need for maintenance and repair of water infrastructure leads to the sustainability of these projects, which need funding and among the sources includes the money from the payment of water bills.

Table 3

Descriptive Analysis of Regulatory Factors Influencing Access to Clean Water Attached Directly to Household Head Participation

Variables	Category	Mean	Standard Deviation	Frequency	Percentage
	Yes	1.15	0.360	299	84.7
Participating meeting	No			54	15.3
	Yes	1.16	0.363	298	84.4
The value of meetings	No			55	15.6
	Yes	1.77	0.423	82	23.2
Adherence to Paying water bills	No			271	76.8
	500 to 9,500	4.26	1.481	49	13.9
Amount per month	10,000 to 19,500			18	5.1
	20,000 to 29,500			4	1.1
	Above 30,000			3	0.8
	Non			279	79
Total				**353**	**100**

4.3 Provision of Information on Clean Water and Policy Awareness

Village, ward, and district leaders provided information about clean water, including details on water supply, distribution, connections and leaks, bill payments, and central government incentives. Most respondents receive this information. According to the study by Koehlera et al. (2018), institutions provide information and assurance about the acts of others, offer incentives that advance the welfare of the groups, and keep an eye out for and punish opportunistic behavior. In India, the study by Sahoo and Goswami (2024) highlights how vital education and public awareness are in promoting sustainable behavior and activities that stop and lessen water pollution. The majority agreed with water and environmental policies, which included cleaning water canals and planting trees. These measures ensure that water resources are used wisely to meet current demands without jeopardizing future generations. The results are consistent with a study by Glade and Ray (2022) that protects populations from waterborne infections and guarantees public health and clean drinking water.

Community bylaws and enforcement: Community Bylaws should be enforced actively to prevent pollution and overuse. They should implement measures to monitor the water quality. Breakers committed according to their active bylaws, which most responders acknowledged. Lawbreakers face fines of 50,000 TZS for offenses such as harming water infrastructure and supplies, and making unauthorized water connections. The local community government oversees the carrying out of their agreement. According to Meran et al. (2021), laws are essential to guide and ensure water rights to the community, including water allocations.

Community involvement meeting: Additionally, many community members attend village or ward meetings to help discuss clean water issues. This study is consistent with a study by Koehlera et al. (2018) that found that the community is in charge of essential tasks like organizing meetings, handling financial contributions, creating and enforcing rules, and organizing maintenance and repairs. In rural Central America, community meetings about water-related issues allow water users to express their concerns, approve new plans, or confirm the execution of previous agreements (Madrigal-Ballestero et al., 2024). Some respondents in this community stated that there is no implementation regarding water, despite their participation in communal assemblies, and that politics in water issues impede expertise.

Adherence to the contribution of water services: However, 75% of people do not pay their water bills. The leading causes include the absence of water meters, the provision of free water, and the minimal taxation on water usage. Water infrastructure, such as communal taps, boreholes, and piped water networks, significantly accelerates access to clean water. More extensive water networks are associated with higher rates of enhanced water usage. Furthermore, research indicates that several respondents were unhappy with the quantity and quality of water provided; they made water lines, did maintenance, and bought water pipes, citing a lack of supply and irregularities as reasons why they were unwilling to pay for piped water. This is aligned with (Winkler et al., 2023) in the United States and (Burt et al., 2017).

Institutional systems greatly influence household access to sources of clean water. Centralized water distribution systems were not available to families residing in remote areas. They are, therefore, forced to rely on potentially contaminated, locally accessible water sources. The water infrastructure accessibility and quality are essential considerations. The distance to the nearest water source is one of the main barriers to the availability of clean water, especially in the village ward. In Karangai, Maweni, and a portion of Kikwe village, families that reside farther away from piped water infrastructure or protected water resources usually rely on unimproved sources such as surface water and canals; the results are consistent with (Sulley et al., 2023) in Kondoa, Tanzania, and (UNESCO, 2022) findings.

4.4 Regulatory Environmental Factors Affecting Access to Clean Water

The analysis of factors shaping an enabling environment for clean water access highlights several influential variables presented in Table 4. First, the study evaluates various variables related to access to clean water. Participants were asked to access clean water all the time. The responses varied across villages. With a total of 2.8% reporting strongly agree (SA), 10.2% agree (A), and the highest percentage was 44.2% disagree (D). The Chi-square (χ^2) analysis indicated significant differences between the villages χ^2=48.118; df=12; p=0.001, signifying that access to water varies significantly across the different locations.

In response to the statement, not accessing water all the time. In the analysis of water access across the villages, 9.1% strongly agree (SA), 24.4% agree (A), and 47% are undecided (U) as moderately effective, with higher percentages not accessing water all the time throughout the year (χ^2=236.372; df=12; p=0.000). The data exposes varying perceptions across the different villages, with Kikwe showing notably lower percentages of strong agreement compared to others. Collectively, this indicates a notable concern concerning consistent access in these communities.

In response to access to clean water during the dry season, results revealed that 10.2% of participants strongly agreed (A), while 50% agreed. Chi-square results indicated no significant differences among the villages (χ^2=20.578; df=12; p=0.057), signifying perceptions of access during the dry season were relatively consistent across the villages.

Of the absence of electricity affecting water accessibility, 14.4% of respondents strongly agreed (SA), and 14.7% agreed (A). The undecided (U) category accounted for 34.3%. The Chi-square test revealed significant differences across villages (χ^2=22.376; df=12; p=0.034), indicating variability in the experiences of electricity access among the villages.

Lastly, regarding the impact of floods on infrastructure, 52.4% of participants strongly agreed (SA), while 28.3% agreed (A). The Chi-square results were significant (χ^2=48.346; df=12; p=0.001), highlighting the widespread concern about flooding across the villages. This indicates that as agreement increases, so does the likelihood of encountering water access difficulties, emphasizing the need for targeted interventions during the dry season. Together, these findings underscore that a comprehensive approach encompassing infrastructure, community involvement, regulatory strength, financial responsibility, and fair law enforcement contributes to fostering a sustainable environment for clean water access. The interviews reported significant:

> *challenges in accessing clean water, including shortages during the dry season. This is particularly evident when rainfall occurs, leading to declining water levels in fountains and a scarcity of storage tanks.* Additionally, *pipes can become clogged due to heavy rain, as falling tree branches obstruct water sources. Furthermore, the impacts of climate change have exacerbated the issue, resulting in increased drought conditions.* Moreover, *the drillers rely on electricity; therefore, if we drill the wells, we must also use electricity.* Also, it is reported that *environmental pollution is more severe than usual. For instance, rice farmers apply pesticides to their fields, and individuals often dispose of hazardous waste in water sources.*

Table 4

Descriptive Likert Scale Analysis of Factors Contributing to Enabling the Environment for Clean Water Accessibility

		Name of the village					
Variables	**Category**	**Nambala (n=102)**	**Kikwe (n=99)**	**Maweni (n=55)**	**Karangai (n=97)**	**Total**	**Chi- Square**
	SA	1.1	0.3	0.6	0.8	2.8	
Water access all the time %	A	6.8	0.6	0.6	2.3	10.2	χ^2=48.118; df= 12; p=0.000
	UN	7.9	9.6	4.0	4.2	25.8	
	D	10.5	11.6	6.5	15.6	44.2	
	SD	2.5	5.9	4.0	4.5	17	
	SA	3.7	0.03	0.6	2.0	9.1	
	A	3.7	6.8	2.8	11	24.4	
Not accessing frequently %	UN	13	15	8.5	10.5	47	χ^2=236.372; df= 12; p=0.000
	D	7.1	2.5	2.3	3.1	15	
	SD	1.4	0.8	1.4	0.8	4.5	
	SA	3.7	3.4	1.1	2.0	10.2	
	A	13.3	17.0	6.2	13.9	50.4	
Not accessing dry season %	UN	8.8	5.1	4.8	9.1	27.8	χ^2=20.578; df= 12; p=0.057
	D	2.8	1.7	2.0	1.4	7.9	
	SD	0.3	0.8	1.4	1.1	3.7	
	SA	3.1	3.4	2.3	5.7	14.4	
	A	4.5	3.4	4.2	2.5	14.7	
Electricity impact access %	UN	9.9	8.2	4.8	11.3	34.3	χ^2=22.376; df= 12; p=0.034
	D	10.2	11.0	3.1	6.5	30.9	
	SD	1.1	2.0	1.1	1.4	5.7	
	SA	10.8	11.9	12.7	17.0	52.4	
	A	9.3	8.8	2.3	7.9	28.3	
Floods affect infrastructure %	UN	7.1	4.5	0.3	1.7	13.6	χ^2=48.346; df= 12; p=0.000
	D	1.4	2.0	0.3	0.3	4.0	
	SD	0.3	0.8	0.0	0.6	1.7	

***SA** = Strong Agree; **A** = Agree; **UN** = Undecided; **D** = Disagree; **SD** = Strong Disagree*

Clean water access throughout? Most respondents disagree with having consistent access to water throughout the year, and the findings are statistically significant. A study by Sahoo and Goswami (2024) in India highlights that climate change significantly affects water resources, resulting in more frequent and severe floods and droughts, altered rainfall patterns, and rising sea levels. Rapid population growth further strains limited water resources, while inadequate infrastructure contributes to frequent shortages. Overall, climate change exacerbates droughts and worsens water scarcity.

Environmental factors and climate change, including droughts and floods, significantly impact the quantity and quality of water, disproportionately affecting marginalized communities with limited adaptation capacity (Joshua et al., 2022; Pinto et al., 2024). Natural disasters like wars and water pollution hinder water accessibility (George-Williams et al., 2024). Additionally, a study by Libanda et al. (2024) indicates that climate change can disrupt water supply and increase the costs associated with accessing and storing water. Morogoro water supply in peri-urban areas was unreliable, exacerbated by issues such as water leakage, high connection costs to public systems, and challenges in borehole construction. Climatic and environmental factors further limited accessibility, highlighting weaknesses in water governance (Kabote, 2024). In the study area, inconsistent access to water was due to allocation issues, leakage, inadequate infrastructure, lack of storage reserves, insufficient expertise in the water sector, and climate changes that caused droughts and occasional floods, which damaged water sources.

Accessing during the dry season: Many respondents agree that accessing water during the dry season is problematic. Water scarcity during these periods results from declining rivers and groundwater, worsened by unpredictable droughts. A study by Bazaanah and Mothapo (2023) in Lepelle Nkumpi, South Africa, found that drought has led to the drying up of surface water and excavated sources, affecting agriculture, drinking water availability, and sanitation services. Insufficient storage and distribution systems and limited financial resources hinder effective management. Increased population, agricultural, and livestock demands intensify competition for scarce water, while poor governance further complicates access.

Impact of electricity on accessing clean water: The respondents' uncertainty regarding the impact of electricity on water accessibility suggests a lack of sufficient information or a perception that the effects are not significant. The importance of electricity for accessing clean water aligns with findings from studies by (Madrigal-Ballestero et al., 2024) in rural Central America and China (Wu, 2024). In a study by Nguea (2024) across 19 African nations, access to well-managed clean water and sanitation facilities positively correlates with electricity availability. Most respondents rely on electricity to pump water from wells, canals, and rivers, using various sources, including solar energy and generators. However, they noted that the water flow from sources to customers is often insufficient and unreliable. While respondents acknowledge the importance of electricity for drilling wells and lifting water, they remain ambivalent about its absence. The study recommends further investigation into the reasons behind this ambivalence.

Impact of floods on water infrastructure: Many respondents strongly agree that floods impact clean water infrastructure, threatening access to safe drinking water. Strong water infrastructure ensures a reliable supply, reduces waste, enhances quality of life, and prevents disease (Shemer et al., 2023). This aligns with findings from (Anang et al., 2024; George-Williams et al., 2024; Pinto et al., 2024). The consensus among respondents regarding the effects of floods on water infrastructure, as noted by (Joshua et al., 2022) underscores significant perceived risks and highlights the need for proactive measures to mitigate these impacts. Historical evidence from Malawi in 2015 shows that floods severely damaged essential water supply infrastructure, and the failure of responsible agencies to restore it left communities without reliable access to clean water for over six months.

Climate change-related events such as floods and droughts also lead to preventable deaths and illnesses (Pinto et al., 2024). Unpredictable precipitation patterns increase temperatures and evaporation rates, contributing to droughts and floods, water contamination, and health risks (George-Williams et al., 2024). These climate-related events can disrupt water supply and raise the costs of accessing and storing water (Libanda et al., 2024). Respondents reported that pollutants from household and industrial waste and agricultural runoff contaminate river water. However, most indicated that they do not boil or treat their water, contrary to findings from previous studies (Mapuka et al., 2024). Earlier research shows that the discharge of contaminated effluents pollutes water bodies with agrochemicals (Cullmann et al., 2024; Ripanda et al., 2021; Talema, 2023), heavy metals (Baltrocchi et al., 2024), antibiotics (Ripanda et al., 2023) microplastics (Ma et al., 2024; Miraji et al., 2023; Moto et al., 2024; Zhao et al., 2024), and other emerging pollutants (Miraji et al., 2021), all of which can adversely affect health outcomes (Aklilu et al., 2024; Auma et al., 2024; Soeters et al., 2021; Talema, 2023). In Latin America and the Caribbean, residents face extreme weather and environmental pollution, resulting in heat waves, droughts, floods, landslides, and soil contamination (Pinto et al., 2024). Water pollution contributes to avoidable health issues and increased mortality (Pinto et al., 2024). Additionally, agriculture and untreated wastewater threaten water quality by introducing harmful excess nutrients (UN, 2024). During the survey, respondents noted rising environmental pollution, highlighting that hazardous waste is frequently dumped into water sources and that rice farmers use pesticides on their fields (Fig 2).

Plate 1
The Canal that Supplied Water was Polluted, caused by Human Actions, the Picture was taken from the Field

4.4 Several Practices Employed to Protect the Environment to Guarantee Clean Water Accessibility and Ecology Reliability

Many respondents, a total of 25.5% cleaned the canals used for irrigation as they also used for domestic purposes, and another 25.5% participated in different ways to protect the environment to ensure clean water accessibility in the community; 5.1% were trying to avoid cutting down trees; 20.1% participated in cleaning and protecting water sources and surroundings; 23.8% participated by planting trees (Fig. 3). Additionally, water pollution claimed to discourage the respondents, resulting from agricultural activities, domestic uses and activities, and washing cars & motorcycles.

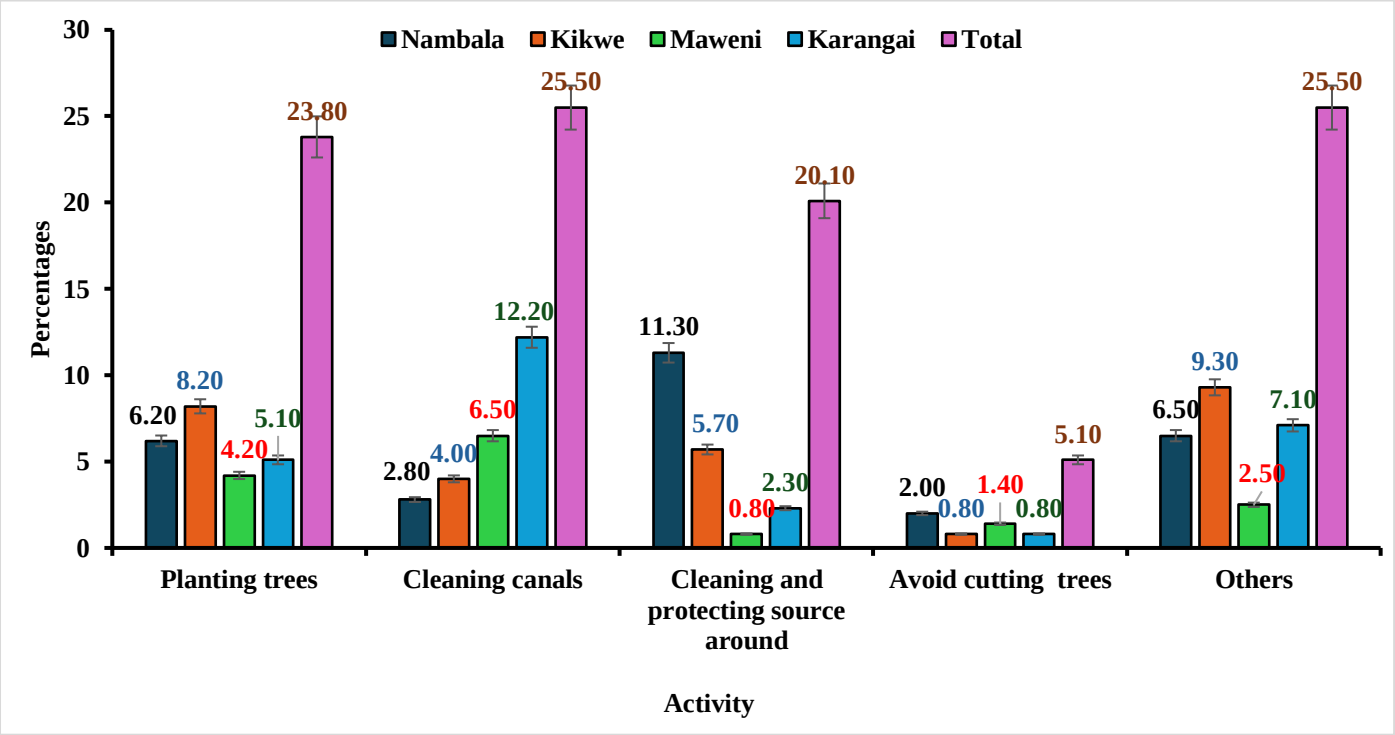

Figure 2
Ways Practiced Protecting the Environment to ensure Clean Water Accessibility

Most respondents engaged in activities such as cleaning canals, planting trees, avoiding deforestation, and promoting education and awareness regarding cleanliness and the protection of water sources. These efforts are vital for maintaining water quality and ecosystem health, and the findings were statistically significant. This aligns with (Joshua et al., 2022), who emphasize that planting trees in rural Malawi helps mitigate soil degradation caused by climate change. Tree planting aids in clearing debris and pollutants from canals, preventing contamination and resulting in healthier water sources. Trees also stabilize soil, reduce erosion, and filter pollutants, enhancing water quality and ecosystem health. Conserving forests is crucial for preserving biodiversity and protecting watersheds, which are essential for clean water. For ecological honesty, water must remain abundant and of good in the environment. It should be utilized sustainably to ensure that future generations can access it in the same manner as the current generation (Meran et al., 2021). Additionally, educating communities about the importance of clean water and sustainable practices fosters responsible behavior, contributing to water source protection and conservation efforts.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

Improving access to clean water in rural Northern Tanzania is essential for enhancing health and economic well-being. Climate change negatively impacts the environment, exacerbating water scarcity by altering rainfall patterns and reducing the reliability of traditional water sources. Deforestation and soil degradation further harm watersheds, threatening the quantity and quality of available water. A comprehensive approach is essential to tackle these challenges, including community engagement, targeted infrastructure investments, planting trees, and sustainable water management practices.

This study highlights the significant role of regulation and environmental factors in determining household access to clean and safe drinking water. Targeted investment in water infrastructure is critical to overcoming clean water accessibility challenges. To achieve sustainable development and improvements in water access, policymakers must prioritize policy development and environmental protection initiatives that foster infrastructure enhancement. Additionally, empowering local communities to manage their water resources can lead to more sustainable and practical solutions. By addressing these factors, we can significantly improve the quality of life for rural households in Northern Tanzania, contributing to broader public health and development goals.

5.2 Recommendations

The study recommended continuous provision of education on the effective use and protection of water sources for sustainable development as well as community involvement in decision-making.

Abbreviations

EWURA	Energy and Water Utilities Regulatory Authority
HWISE	Household Water Insecurity Experiences
JMP	Joint Monitoring Programme
MoW	Ministry of Water
NAWAPO	Tanzania National Water Policy
RUWASA	Rural Water Supply and Sanitation Agency
TBS	Tanzania Bureau of Standards
TZS	Tanzania Shillings
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Emergency Fund
URT	United Republic of Tanzania
WHO	World Health Organization
QGIS	Quantum Geographic Information System
χ^2	Chi-square

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