Open Journal of Social Sciences, 2025, 13(8), 708-725
https://www.scirp.org/journal/jss
ISSN Online: 2327-5960
ISSN Print: 2327-5952

Assessing the Magnitude of Household Water Demand in Makeni City Ward 121: Implications for Urban Water Resource Management in Sierra Leone

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How to cite this paper: Iortyom, E. T., Bah, S., & Kargbo, M. A. (2025). Assessing the Magnitude of Household Water Demand in Makeni City Ward 121: Implications for Urban Water Resource Management in Sierra Leone. *Open Journal of Social Sciences, 13,* 708-725.
https://doi.org/10.4236/jss.2025.138044

Received: July 1, 2025
Accepted: August 24, 2025
Published: August 27, 2025

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Abstract

Access to clean and reliable water is essential for human health and sustainable development, particularly in rapidly growing urban areas of developing nations. This study focuses on Makeni City Ward 121 in Sierra Leone, where challenges in meeting water needs persist despite various contributing factors such as population growth and limited infrastructure. The study, therefore, aims to determine the magnitude of household water demand for efficient water resource management. Through a cross-sectional survey design, data were collected from 367 households using structured interviews. Statistical analyses, including t-tests and ANOVA, were conducted to understand household water demand patterns. Results indicate significant reliance on alternative water sources, posing health risks and burdens on residents. The findings underscore the importance of localized studies in informing effective water resource management strategies. Recommendations are provided for policymakers, urban planners, and community stakeholders to enhance water accessibility, affordability, and sustainability in Makeni City Ward 121 and similar urban contexts.

Keywords

Household, Water-Demand, Water, Demand, Ward 121, Makeni City, Sierra Leone

1. Introduction

Access to clean and reliable water is fundamental to human health, economic development, and environmental sustainability (Hirai & Graham, 2019). Achieving the global Sustainable Development Goals (SDGs), particularly SDG 6, is a crucial

aspect that emphasizes access to clean water and sanitation for all (United Nations, 2018). Due to inadequate sanitation, poor hygiene, or tainted drinking water, diarrheal infections claim the lives of over 340,000 children under five every year, or about 1000 deaths every day (Iortyom & Kargbo, 2023). However, access remains unequal, particularly in rapidly urbanizing cities in developing nations, where challenges such as poor infrastructure, population growth, and governance issues worsen water management difficulties (Ahmad et al., 2016; Biswas & Tortajada, 2019). These challenges are further compounded by climate change, which alters water availability and quality, and rapid urbanization, which increases demand (IPCC, 2021; Flörke et al., 2018).

Household water demand is important for infrastructure planning and water resource management in urban areas. Factors such as family size, income, and access to water sources have a significant influence on water consumption patterns (Keshavarzi et al., 2006; Froukh, 2001). Large households or those with better incomes use more water, adding further stress on already limited supplies. Research has shown that proximity to water sources and the time required to fetch water are inversely related to the quantity of water used (Fu et al., 2016). In many sub-Saharan African cities, lack of infrastructure limits access to safe drinking water, forcing households to rely on alternative sources such as community taps, standpipes, or bore wells, which are often located far away (George-Williams et al., 2024)

Makeni City in Sierra Leone exemplifies these challenges, particularly in Ward 121. Water management systems, governance issues, and limited access to verified drinking water systems (Santos et al., 2017), as well as population growth, socioeconomic status, infrastructure development, and environmental considerations, significantly influence the magnitude and dynamics of household water demand in this ward. As a result, a large proportion of the population in Makeni City Ward 121 relies on alternative sources such as wells or standpipes for their daily water needs. This situation not only poses immediate health risks but also places a significant burden on households in terms of the time and effort required to fetch water from distant sources (Majuru et al., 2016). Additionally, many households are aware of the challenges associated with water supply and the importance of water management, yet education on sustainable practices remains limited (Basu et al., 2021; Bona et al., 2024).

Despite the evident importance of addressing household water demand, comprehensive studies specific to Makeni City Ward 121 remain scarce. Existing literature provides valuable insights into broader water management issues in urban settings (Amara & Kansal, 2021) as well as research in similar contexts has highlighted the critical role of factors such as population growth, climate change, and inequitable distribution of water resources in shaping water demand (Dalcin & Fernandes, 2020; Flörke et al., 2018); however, localized data and analyses tailored to the unique context of Ward 121 are lacking.

Therefore, this study seeks to fill this gap by focusing explicitly on determining

the magnitude of household water demand within Makeni City. By assessing household water demand in Ward 121, this study aims to contribute to the understanding of urban water resource management in Sierra Leone. The findings are expected to inform policymakers, urban planners, water utility providers, and community stakeholders in developing strategies and interventions to enhance water accessibility, affordability, and sustainability in Makeni City Ward 121 and similar urban contexts.

2. Literature Review

Urban areas face numerous water management challenges, including inadequate infrastructure, ineffective governance, and external pressures from urbanization and climate change. Ahmad et al. (2016) in a study on the household demand for water in a major industrial city in Pakistan using survey data of 1100 households and Biswas & Tortajada (2019) in their study on water quality management: a globally neglected issue, identified poor governance and limited infrastructural facilities as major barriers to equitable water distribution in developing countries. In the same vein, the UNICEF (2022) WASH-NORM report in Sierra Leone noted disparities in access to basic water and sanitation services resulting from the challenges of inadequate infrastructure and institutional constraints. The African Development Bank Group (AfDBG, 2023) also established a similar report in its Freetown Water Supply and Sanitation Master Plan, noting critical investment gaps in infrastructure, planning, and service delivery that are equally found in smaller cities like Makeni in Sierra Leone. Their studies highlight the need for efficient policy frameworks to address these pressing issues. Similarly, Flörke et al. (2018) through a quantification of the magnitude of water competition between cities and agriculture driven by climate change and urban growth using a combine dataset of urban water sources of 482 of the world's largest cities with estimates of future water demand, based on the Intergovernmental Panel on Climate Change (IPCC)'s Fifth Assessment scenarios, and predictions of future water availability, using the WaterGAP3 modelling framework and the IPCC (2021) assessment report, discussed the intensifying effects of climate change and rapid urbanization on water resources. These factors jointly contribute to water scarcity, limited access, and increased competition for limited resources, particularly in densely populated urban centers.

A successful water management strategy design requires an understanding of household water usage patterns. Socioeconomic factors, including family size, income levels, and educational attainment, have a significant influence on water consumption patterns. According to Keshavarzi et al. (2006) in their study on rural domestic water supply using a survey of 653 rural households in 33 villages of Ramjerd area, Fars Province, in southern Iran, through a simple random sampling technique and Froukh (2001), in his decision-support system for domestic water demand forecasting and management, noted that larger family units and households with higher incomes typically use more water, which puts further strain on

already limited supplies, furthermore, by finding an inverse relationship between consumption levels and distance to water sources.

Furthermore, by identifying an inverse relationship between consumption levels and distance to water sources, Fu et al. (2016) underscore the significant role that proximity to water sources plays in influencing consumption levels. In the same vein, An et al. (2021) of the gap of water supply-demand and its driving factors using the Huaihe River Basin from 2001 to 2016 as an example and use ecological water footprint to describe the demand, with the water carrying capacity representing the supply through the application of the logarithmic mean divisia index model to analyze the driving factors of the ecological water footprint, also emphasized how important it is to have easily accessible water supplies in order to meet household needs effectively. Also, Gross & Elshiewy (2019) in a study on the choice and quantity demand for improved and unimproved public water sources in rural areas in Benin by estimating the choice and quantity models using a unique data set from a household survey reveals that the distance between the household and the water source among other factors are important in the demand for water. On the other hand, dependence on alternative water sources, such as hand pumps and boreholes, is an indication of inadequate infrastructure facilities in Sub-Saharan Africa. According to Majuru et al. (2016) and George-Williams et al. (2024), such reliance leads to time wastage and health risks, particularly for women and children who are responsible for fetching water.

In light of water demand and usage patterns, water planning and distribution become paramount for enforcing sustainable solutions backed by strong policy frameworks and financial commitment. Anh et al. (2025) assessed the factors affecting people's willingness to participate in water resource protection in the agricultural Ba River basin in the highlands of Vietnam using a multivariable linear regression model. Using a sample size of 100 respondents, they observed that factors such as environmental awareness, trust in authorities, and perceived benefits had a significant influence on participation levels. Similarly, Zeng et al. (2024), using the Institutional Analysis and Development framework, explored determinants of participation in watershed management in China. They revealed that participatory outcomes are strengthened when institutional arrangements are clear and inclusive.

The foregoing is closely similar to the magnitude of household water demand in Ward 121, Makeni City. The area's challenges, including population growth, inadequate infrastructure, and socioeconomic inequality, reflected larger trends seen in other developing nations and urban areas.

3. Study Area

Makeni City Ward 121, located within the Northern Province of Sierra Leone, serves as the focal point of this study. The ward encompasses an area of 6053 km^2. It lies between 8˚52'54N and 12˚02'3W (Latitude 8.88167˚N, Longitude -12.03417˚W). It is approximately 140 km east of Freetown and is home to a di-

verse urban population characterized by varying socio-economic backgrounds and household compositions (World Bank Report, 2018) (**Figure 1**).

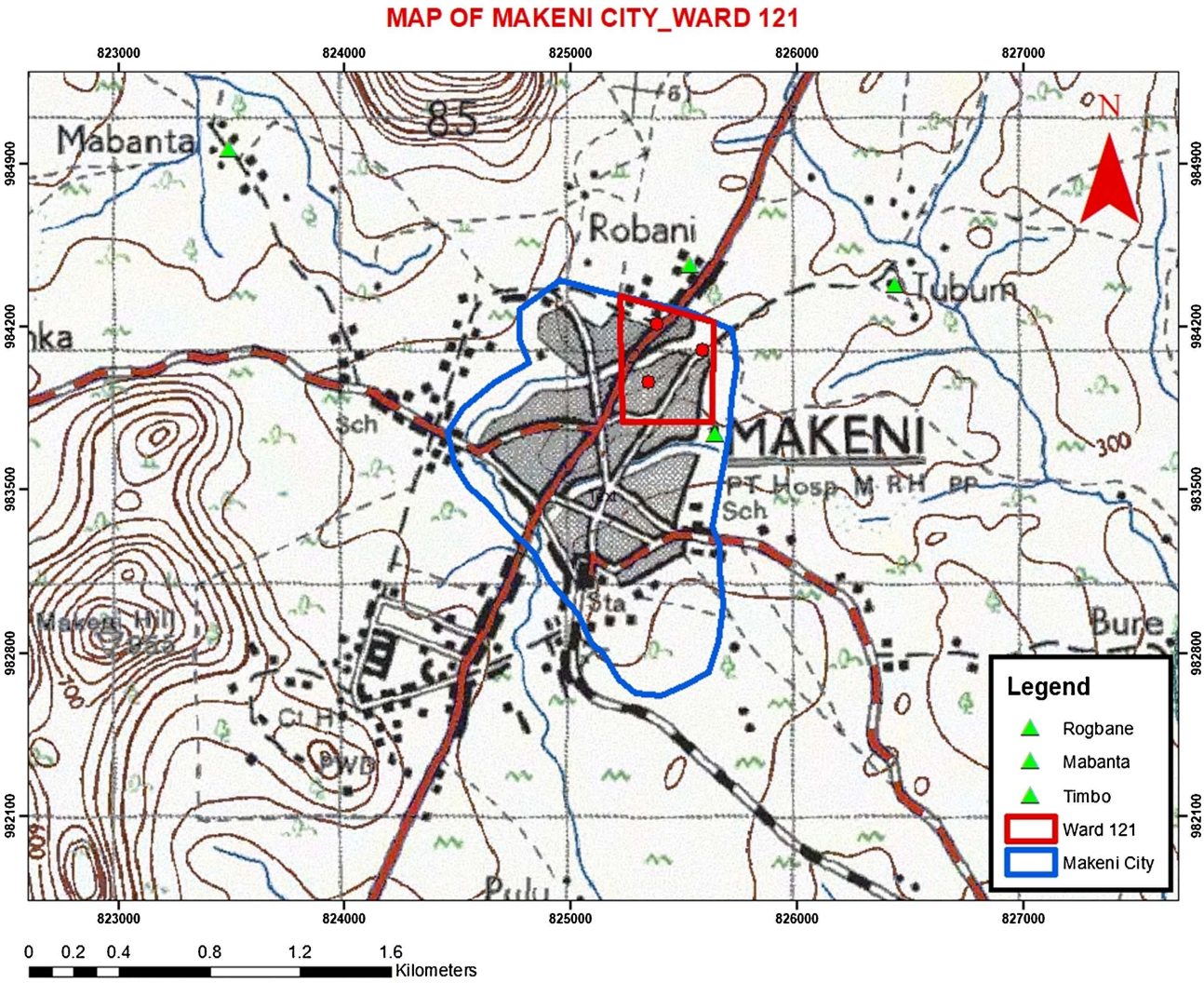

Figure 1. Map of the study area.

The area consists of Market Ward, Rogbaneh Ward, and part of Wusum Ward. The boundary of this ward begins at the PZ Roundabout or the Independence Square. It then follows Mabanta Road Northwest onto Lunsar Road. It continues, following Samuel Lane, and turns Northeast, following the ward boundary at the edge of Town. It continues in the same direction along the Fullah Town edge, passing the foot of the Wusum Hills. It then bends Southeast after Yeli Sanda Road and continues along the edge of the Town until it crosses the Kabala Main Road. It then continues South along the edge of the Town and then moves Southeast onto the edge of Arabic College Road. It then turns West, passing close by Mr. Lamin H. Kamara's house, and then joins the footpath that leads to Wusu Street. It continues along Wusu Street, then turns onto Father Street, and finally turns Southwest onto Sanda Street. Then, the boundary turns northwest along Sanda

Street, then Campbell Street, and finally Station Road. It follows Station Road North to the PZ Roundabout (Independence Square), where it ends (ECSL Ward Boundary Delimitation Report 2017).

The city of Makeni had a population of 80,840 according to the 2004 census and 125,970 according to the 2015 census (Statistics Sierra Leone, 2016). According to the Makeni City Council (2014), out of a population of 125,970, there are 20,995 households in the three Wards, and 7938 households with a population of 47,630 in Ward 121. Ward 121 is home to the University of Makeni, the largest private university in Sierra Leone. With limited industrial activities, trading is the primary source of livelihood for the residents. The population of Makeni is ethnically diverse, with the Temne people comprising the largest ethnic group in the city. The Krio language serves as the primary means of communication among the various ethnic groups in the city. The population of Makeni is predominantly Muslim, although there is a significant Christian minority in the city. The Wesleyan Methodists are the largest and main Christian denomination in Makeni (City Garden Clinic, 2024).

4. Materials and Methods

This study employed a cross-sectional survey design to assess household water demand in Makeni City Ward 121. Cross-sectional surveys are well-suited for capturing a snapshot of water usage patterns and associated factors within a defined population at a particular point in time. The study employed a quantitative research design, utilizing survey methodology to quantify the opinions of the population regarding household water demand in Makeni City Ward 121. The magnitude of household water demand was assessed in terms of daily household water usage measured in litres per capita per day. Considering the WHO (2003) guideline of 50 litres/person/day for basic needs, which is approximately two gallons of water a day, the respondents were assessed on a five-point ordinal scale representing estimated daily water use as follows: 1 = less than 50 litres, 2 = 51 - 100 litres, 3 = 101 - 200 litres, 4 = 201 - 300 litres, 5 = more than 300 litres. A sample of 367 households was statistically selected using the Cochran (1977) sample size formula below:

$$\text{Sample size} = \frac{\dfrac{z^2 xp(1-p)}{e^2}}{1+\left(\dfrac{z^2 xp(1-p)}{e^2 N}\right)}$$

where population = N (people), Q = the complement of p (proportion), the margin of error = E, Z-Score (Standard Score) = Z.

However, a total of 300 questionnaires were administered and retrieved successfully. The reduction from the 367 derived sample size using the Cochran formula is due to non-response from the selected households in the study area. Through multi-stage and convenience sampling, the samples were apportioned into three sampling units based on a standard formula to ensure representation

across different areas of the ward. Data collection involved structured interviews conducted from August 20th to August 31st, 2022, using closed-ended questionnaires grouped into four sections. The primary data collected were stored in MS Excel and analyzed using both descriptive and inferential statistical techniques, including t-tests and analysis of variance (ANOVA), with a significance level set at $p < 0.05$. A 95% confidence level was deemed appropriate and aligns with the significance level of $p < 0.05$. This ensures a reliable statistical inference despite reducing the sample and the use of convenience sampling. All statistical analyses were conducted using SPSS v26, and the results were presented in frequency tables, pie charts, and bar charts. Ethical considerations were paramount throughout the study, with prior informed consent obtained from all participants before conducting interviews. The privacy and anonymity of respondents were ensured.

5. Results

Demographic and Socio-Economic Characteristics of Respondents

The demographic characteristics of the respondents, as presented in Table 1, indicated that 73.7% were males (n = 221) and 26.3% were females (n = 79). The higher number of male respondents was because they are regarded as household heads, and the questions were directed to them. This does not reflect that there are more males in the study area than females. The reason for the presence of female respondents is that the males, who are typically regarded as the household heads, were unavailable at the time the questionnaires were administered. Hence, the questions were directed to the females who acted as the household heads. However, the participation of women (26.3%) indicates that water management

Table 1. Demographic profile of respondents (n = 300).

Variable	Category	Frequency (F)	Percentage (%)
Gender	Male	221	73.7
	Female	79	26.3
Age	Less than or equal to 30 years	21	7.0
	31 - 40 years	55	18.3
	41 - 50 years	153	51.0
	51 - 60 years	68	22.7
	Above 60 years	3	1.0
Marital Status	Single	75	25.0
	Married	225	75.0
Educational Level	No formal education	30	10.0
	Primary education	30	10.0
	Secondary education	62	20.7
	Tertiary education	178	59.3

is a household concern that affects both genders. The majority of the respondents were within the age group of 41 - 50 years, representing (51%; n = 153) of the total sample, while the lowest age bracket was within individuals aged less than or equal to 30 years and above 60 years were represented as (7%; n = 21) and (1%; n = 3) respectively. This suggests that middle-aged individuals play a significant role in household water management decisions. Most respondents had attained tertiary educational qualifications (59.3%; n = 178), while fewer respondents had either no education (10.0%; n = 30) or completed only primary schooling (10.0%; n = 30). Education plays a crucial role in water conservation efforts and awareness, as households with more educated members are more likely to adopt water-efficient practices. In terms of marital status, most respondents were married (75%; n = 225), whereas single individuals accounted for only 25% (n = 75).

Although most occupations occurred in nearly the same proportions (i.e., 12.3% for farming, 10.7% for trading, 11.3% for students, and 12.7% for others) amongst the respondents, most of them were employed as civil servants (46.0%; n = 138) (Table 2). This occupational distribution suggests a relatively stable economic situation of Makeni City in general, but with a significant segment of the population engaged in informal employment, which may affect their ability to afford water-related infrastructure improvements in their households. Nearly 58% (58%; n = 174) of the respondents earned incomes between NLE 600 and NLE 1500, while the proportions of those earning between NLE 1500 and NLE

Table 2. Socio-economic characteristics of respondents (n = 300).

Aspects	Components	Frequency (F)	Percentage (%)
Occupation	Civil servant	138	46.0
	Trading	32	10.7
	Farming	37	12.3
	Mining	21	7.0
	Student	34	11.3
	Others	38	12.7
Income	Between NLE 600 and NLE 1500	174	58.0
	Between NLE 1500 and NLE 3000	44	14.7
	Between NLE 3000 and NLE 4500	48	16.0
	Between NLE 4500 and NLE 6000	20	6.7
	Above NLE 6000	14	4.7
Family size	1 - 2 persons	55	18.3
	3 - 4 persons	104	34.7
	5 - 6 persons	89	29.7
	7 - 8 persons	36	12.0
	9 persons and above	16	5.3

3000 as well as NLE 3000 and NLE 4500 were (14.7%; n = 44) and (16.0%; n = 48), respectively, and 6.7% (n = 20) earn between NLE 4500 and NLE 6000. Given these results, those who received earnings above NLE 6000, which is ten times the national minimum wage in Sierra Leone, were equivalent to 4.7% (n = 14), while the rest (30.7%; n = 112) received monthly incomes that exceeded this minimum wage. The average income of respondents could mean that water affordability is a challenge, as most respondents (58%) earn between NLE 600 and NLE 1500. Regarding family size, (34.7%; n = 104) and (29.7%; n = 89) of respondents accounted for households occupied by three to four and five to six persons, respectively, while families with nine or more people were represented by only (5.3%; n = 16) of the respondents. Depending on the age and income levels of the respondents, family size may indicate how the magnitude of water demand and supply is managed. Both household size and composition affect water use, and household size has been found to be the most important factor affecting water consumption. This finding is similar to that of Keshavarzi et al. (2006) and Froukh (2001) in their research.

The magnitude of household water demand

Figure 2 presents the major factors influencing household water demand in

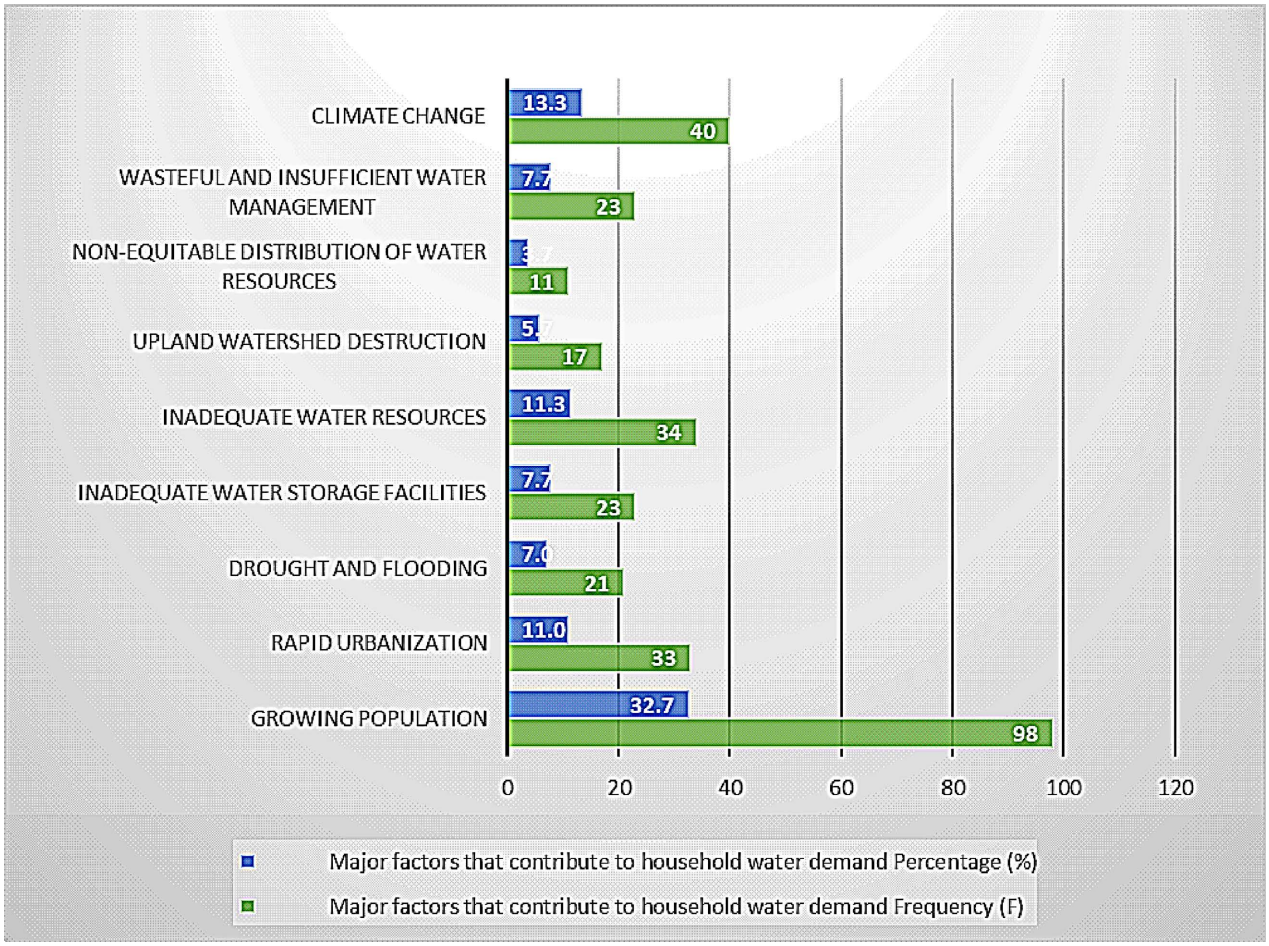

Figure 2. Major factors that contribute to household water demand mentioned by respondents.

Makeni City Ward 121. The major factors contributing to the magnitude of household water demand by household members are depicted. Most respondents mentioned both the growing population (32.7%, n = 98) and climate change (13.3%, n = 40). Nowadays, the magnitude of water demand is one of the most ubiquitous and indispensable in households, as affirmed by a study conducted by Dalcin & Fernandes (2020) in Onitsha (Nigeria). The growth of the urban population put a strain on utilities like water, as a growing population means a growing demand for water. On the other hand, a rise in temperature could lead to increased demand for water above normal household water usage. Furthermore, factors such as inadequate water resources (11.3%, n = 34) and rapid urbanization (11.0%, n = 33) were reported by nearly an equal proportion of respondents, as were inadequate water storage facilities (7.7%, n = 23) and wasteful and insufficient water management (7.7%, n = 23). According to a study conducted in Ghana (Fu et al., 2016; George-Williams et al., 2024), the increase in household water demand can be attributed to the growing population. However, our study found that respondents least mentioned some factors that contribute to water demand. Such factors include the destruction of upland watersheds (5.7%, n = 17) and the non-equitable distribution of water resources (3.7%, n = 11), as noted by Flörke et al. (2018) and McGlade et al. (2012) in their respective studies.

To assess the extent of daily water consumption, a descriptive statistical analysis was performed on responses from 300 households, as shown in **Table 3** below. The responses were categorized based on a five-point ordinal scale estimating daily water use: 1 for less than 50 liters, 2 for 51 - 100 liters, 3 for 101 - 200 liters, 4 for 201 - 300 liters, and 5 for more than 300 liters. The results showed that the average daily household water use was 3.61, with a standard deviation of 0.92 and a range of 4.00. This indicates that most households reported using between 101 and 300 liters per day, with a tendency toward higher water demand levels. These findings align with recent research in Sierra Leone, which shows that household water demand and access vary significantly based on location and infrastructure. AfDBG (2023) in Freetown observed that households using water kiosks and piped sources consume larger volumes, typically between 200 and 300 liters, while those relying on shallow wells and streams use considerably less. The standard deviation of 0.92 indicates moderate variability in household water use, with many households close to the average, although some reported significantly lower or higher levels of consumption. This variability aligns with the WASH National Outcome Routine Mapping (WASH-NORM) Report 2022, which highlights ongoing disparities in water access, particularly between rural and urban areas. The report also revealed that only 62.6% of households nationwide had access to basic water services (UNICEF, 2022). Additionally, the range of 4.00 confirms that all five consumption categories, from less than 50 liters to more than 300 liters, were included in the sample. This aligns with recent conclusions from the Freetown Water Supply and Sanitation Master Plan (2023), which noted that while multiple water points serve some urban neighborhoods, others remain underserved, result-

ing in highly variable consumption patterns (AfDBG, 2023). Overall, the results reveal a trend of moderate to high household water use in communities with improved access, while still reflecting structural inequalities in water supply, infrastructure, and reliability, particularly in less developed or rural areas.

Table 3. Daily household water use.

	N	Range	Mean	Std. Deviation
Daily Household Water Use	300	4.00	3.6133	0.92376
Valid N (listwise)	300			

The results depicted in **Table 4** indicate that 75% (n = 225) of respondents are aware of the water demand and supply situation, although 68% (n = 204) claimed that they have not received detailed education on this topic. In many developing countries, such as Sierra Leone, education on water demand and supply is often lacking due to a scarcity of resources and inadequate institutional support for disseminating relevant knowledge (Basu et al., 2021).

Table 4. Statements estimating awareness and knowledge of water demand and supply amongst respondents (n = 300).

Statements Estimating Water Demand and Supply: Awareness and Knowledge	No (%)	Yes (%)
Do you know of any water supply in this area?	25 (8.3%)	275 (91.7%)
Do you know that water requires special treatment before it can be safely drunk?	95 (31.7%)	205 (68.3%)
Do you know that an improper water supply is harmful to the environment?	149 (49.7%)	151 (50.3)
Are you aware that water contains harmful organisms?	83 (27.7%)	217 (72.3%)
Are you aware of the health risks associated with water?	75 (25.0%)	225 (75.0%)
Have you received education on water demand and supply?	204 (68.0%)	96 (32.0%)
Do you think recycling water is important for improving water management?	28 (9.3%)	272 (90.7%)

Regardless of these limitations, many of the respondents mentioned that they are aware of the water supply in their community (91.7%; n = 275) of this (72.3%; n = 217) are aware that water contains harmful organisms, highlighting general understanding of the potential health risks associated with bad water and almost half of the respondents mentioned that the improper water supply is harmful to the environment as indicated (50.3%; n = 151) which indicate the differences in the awareness regarding the broader environmental impacts of water management, and hence the results show there is less education on water demand and supply (32.0%; n = 96). By comparison, relatively higher awareness levels of water demand and supply among households have also been reported in another study

conducted in Bo, Southern Sierra Leone (Bona et al., 2024). A lack of knowledge on water demand and supply could be a contributing factor to inefficient water use and conservation efforts by households. Consequently, in the present study, 90.7% (n = 272) of respondents expressed the opinion that the recycling of water is important for improving water management (**Table 3**). This reflects a strong willingness among households to adopt sustainable water practices if provided with the necessary information and infrastructure.

Figure 3 illustrates the results regarding the different sources of drinking water and the distance required to access water at the household level in Makeni City. To a greater extent, the sources of water demand mentioned by respondents were community bore wells or hand pumps (48.0%), household taps (42.3%), and household bore wells or hand pumps (34.7%). A few respondents also mentioned public taps (3.0%). Moreover, the distance covered to fetch water corresponds to the source of water as (29.0%) of respondents mentioned that they get water between 50 metres and 100 metres, (20.0%) less than 50 metres, less than 200 metres (16.7%), and more than 200 metres (6.3%) were mentioned by fewer respondents. The distance covered to fetch water and the sources of water revealed by respondents indicate that most households get their water close to their homes. However, it indicated a risk of a harmful water supply to the household, which further threatens the health of the community. On the other hand, the proportion of respondents who get their source from a public tap corresponds to a distance

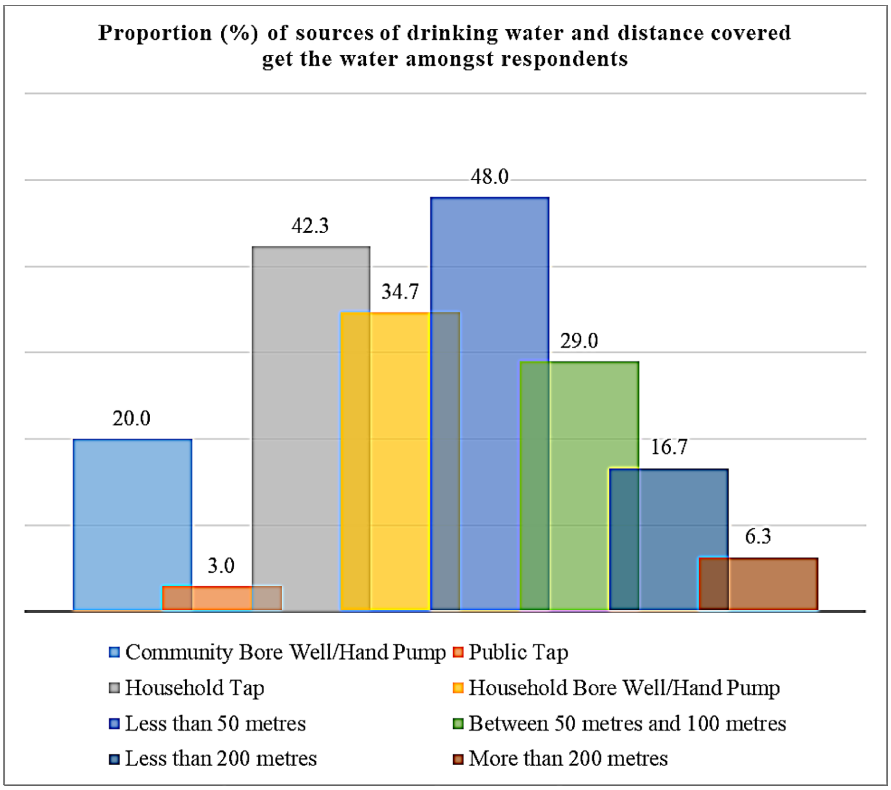

Figure 3. Sources of drinking water and distance covered to fetch the water amongst respondents.

of more than 200 metres. The time spent fetching water and the effort required to carry heavy water buckets have an opportunity cost. This implies that the further away a source is located from the house and the longer one must queue, the less water from the source will be used. Thus, it is hypothesized that the time spent fetching water (i.e., walking time plus waiting time) will be negatively related to the quantity of water used. This opinion aligns with the findings of Majuru et al. (2016) and Keshavarzi et al. (2006).

Awareness and Willingness to Participate in Water Demand and Supply Management

The independent t-test results in Table 5 below revealed no statistically significant difference between the male and female respondents in their awareness and willingness to participate in water demand and supply management. Most importantly, the mean awareness score for the male respondents (M = 1.9000, SD = 0.294) was nearly similar to that of the female respondents (M = 1.9100, SD = 0.286), with a t-value of 0.168 and a p-value of 0.737 ($p > 0.05$), which indicates the difference is not significant. In the same vein, the willingness to participate showed no meaningful gender disparity, with males reporting a mean of 1.9100 (SD = 0.288) and females 1.9000 (SD = 0.304), t = 0.281, $p = 0.576$. These findings suggest that gender does not significantly influence respondents' awareness of or willingness to engage in water management activities within the study area. This finding aligns with Anh et al. (2025), who noted that gender and education did not significantly affect community willingness to participate in water management, as indicated by p-values greater than 0.05 in their regression model.

Table 5. T-test results on awareness and willingness to participate in water demand and supply management.

	Gender	N	Mean	Std. Deviation	t	Sig.
Awareness	Male	221	1.9	0.294	−0.168	0.737 ns
	Female	79	1.91	0.286		
Willingness	Male	221	1.91	0.288	0.281	0.576 ns
	Female	79	1.9	0.304		

Note: N: Number of respondents; t-value: Awareness t = −0.168; Willingness t = 0.281; Significant at $p < 0.05$ level. (Source: Field Survey, 2022)

One-way ANOVA on awareness and willingness to participate in water management

Table 6 below presents the results of the one-way ANOVA test conducted to evaluate the differences in awareness and willingness to participate in water demand and supply management across various sociodemographic characteristics, including educational level, marital status, and age. The results show no statistically significant differences. Specifically, for educational level, the F-value for awareness was 2.075 with a p-value of 0.104, and for willingness, the F-value was 0.500 with a p-value of 0.683. Similarly, marital status yielded F-values of 0.837 (p

= 0.361) for awareness and 0.209 ($p = 0.648$) for willingness. Age-based comparisons also showed no significant differences, with F-values of 0.419 ($p = 0.795$) and 1.245 ($p = 0.292$) for awareness and willingness, respectively. The results, therefore, indicate that educational attainment, marital status, and age do not significantly influence individuals' awareness of or willingness to participate in water resource management efforts in the study area. This was also evident in Zeng et al.'s (2024) study, which noted that demographic factors do not uniformly influence willingness; rather, socioeconomic factors shape people's actual participation.

Table 6. One-way analysis of variance (ANOVA) test on awareness and willingness to participate in water management according to the education, marital status, and age of respondents.

		Sum of Squares	df	Mean Square	F	Sig.
Educational Level						
Awareness	Between groups	1.344	3	0.448	2.075	0.104 ns
	Within groups	63.936	296	0.216		
	Total	65.28	299			
Willingness	Between groups	0.254	3	0.085	0.5	0.683 ns
	Within groups	50.093	296	0.169		
	Total	50.374	299			
Marital status						
Awareness	Between groups	0.071	1	0.071	0.837	0.361 ns
	Within groups	25.316	298	0.085		
	Total	25.387	299			
Willingness	Between groups	0.018	1	0.018	0.209	0.648 ns
	Within groups	25.369	298	0.085		
	Total	25.387	299			
Age						
Awareness	Between groups	0.143	4	0.036	0.419	0.795 ns
	Within groups	25.243	295	0.086		
	Total	25.387	299			
Willingness	Between groups	0.28	4	0.138	1.245	0.292 ns
	Within groups	32.636	295	0.111		
	Total	33.187	299			

Note: N: Number of Respondents; Sig: Level of Significance at $p < 0.05$ level; df: Degree of Freedom; F: F ratio. (Source: Field Survey, 2022).

6. Discussion

Water demand in urban areas is influenced by various factors, including socioeconomic, environmental, and governance factors (Ahmad et al., 2016; Biswas & Tortajada, 2019). Our study suggests that a combination of demographic and structural issues, including population growth, climate variability, and inadequate infrastructure, influences household water demand in Makeni City Ward 121. The reliance on alternative water sources, such as bore wells and community hand pumps, indicates the inadequacy of the Makeni City Ward 121 water supply system. Population growth and urban expansion are two factors that significantly impact water demand, as identified by Flörke et al. (2018). The increasing demand fueled by a growing population and climatic variability, coupled with limited supply, further puts pressure on the available resources, leading to over-reliance on harmful water sources. The implication of this is that it heightens the health risk to households due to water contamination, as well as the time lost fetching water, which puts a financial burden on households. The study's findings directly support SDG Target 6.1, which aims to achieve universal and equitable access to safe and affordable drinking water, through the revelation that only 32% of households had received any education on water demand and supply. This underscores the need for targeted community awareness programs. Local authorities in Makeni City can utilize these results to develop ward-level water supply plans that integrate proximity-based infrastructure improvements and community engagement strategies, aligning with SDG Target 6.b, which promotes community participation in water and sanitation management.

The affordability and accessibility of water are important concerns regarding water demand and supply. Research by Fu et al. (2016) and Keshavarzi et al. (2006) highlights the influence of proximity to water sources on consumption levels. Many households in Makeni City must travel long distances to access water, which affects their consumption habits and overall health. According to George-Williams et al. (2024), women and children bear a disproportionate amount of this burden. Due to the long distance to the sources of water available to most households, water management awareness becomes a crucial aspect. The study found that, despite high awareness of water scarcity (91.7%), only 32% of respondents had received education on sustainable water management practices. This finding aligns with previous research by Basu et al. (2021) and Bona et al. (2024), which noted that a lack of education hinders the effective implementation of water conservation practices. Enhancing public education and community engagement can foster more efficient water use and sustainability.

Climate change further worsens water shortage issues in today's communities. The Intergovernmental Panel on Climate Change (IPCC, 2021) reports that changing precipitation patterns reduce water availability, necessitating the implementation of adaptive strategies, such as improved water storage and demand-side management. Studies by An et al. (2021) and Gross & Elshiewy (2019) also highlight the importance of efficient distribution networks in mitigating climate-induced

water stress. However, people's awareness and willingness to participate in water demand and supply management may be more influenced by demographic variables than by gender alone, as also noted by Anh et al. (2025). In light of this, converting awareness and willingness into action is more likely to depend on economic or institutional factors rather than demographic factors. Zeng et al. (2024) also emphasized that demographic factors do not consistently influence awareness and willingness, but rather point to socioeconomic factors as the primary drivers of these behaviors. The study therefore underscores the urgent need for improved urban water management in Makeni City Ward 121. Policy interventions should focus on expanding infrastructure, enhancing public awareness, and implementing regulatory measures to ensure equitable access to water. Further research could be tailored towards exploring innovative water conservation techniques and sustainable supply solutions.

7. Conclusion

The study examined the magnitude of household water demand in Makeni City Ward 121, Sierra Leone, with a focus on its implications for urban water resource management. Data were collected from 300 surveyed respondents and were analysed using statistical methods. The findings revealed a significant reliance on alternative water sources, such as hand-dug wells, due to inadequate or non-existent infrastructure and water supply systems. Among the prominent factors influencing water demand and supply in Makeni City Ward 121 are population increase, climate change, and urbanization. Lack of education about water management among residents was also another challenge. Despite facing water awareness challenges, most respondents lack access to water treatment or proper distribution systems, which poses significant health and environmental risks.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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