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Analysis of Household Water Demand and Supply Challenges in Mubi Metropolis, Adamawa State-Nigeria: A Search for a Sustainable Water Security Solution

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ABTRAST

This study assesses the water demand and supply situation in Mubi Metropolis, Adamawa State, Nigeria, with a focus on identifying sustainable water security solutions. The study deployed the use of mixed method in order to achieve its specific objectives. Findings reveal a moderate willingness to pay (WTP) for improved water services, averaging ₦15,650 ($9.21) monthly, though WTP varies significantly based on household size, income, and water scarcity levels. However, household water expenditure, averaging ₦24,125.51 ($14.19) and reaching up to ₦48,000 ($28.24), constitutes 9.42% of income—far exceeding the WHO benchmark of 3-5% and imposing significant financial strain, particularly on low-income households. Per capita water consumption stands at 28.93 liters, far below the WHO-recommended 100 liters, highlighting a severe deficit of 71.07 liters per person. Income disparity and high poverty levels exacerbate water insecurity, while dissatisfaction with water quality persists, as most households rely on costly and inconsistent private boreholes (mai-ruwa) for supply. Key drivers of water demand challenges include population growth, seasonal variability, socio-economic activities, and the presence of institutions, compounded by weak policy enforcement and the effects of conflict. To address these challenges, the study recommends investment in public water infrastructure, income-based pricing, cross-subsidization for low-income households, and community-based water schemes. Additionally, improving water quality through treatment plants, fostering public-private partnerships, and strengthening policy enforcement are crucial. Enhancing resilience to seasonal variability and implementing conflict-sensitive interventions are also vital.

Key words: Water supply and demand; sustainable water security solution

INTRODUCTION

Access to safe drinking water has been universally recognized as a fundamental human right that drives social, economic, health securities, and environmental sustainability (United Nations General Assembly [UNGA], 2010). Clean water stimulates economic growth, reduces poverty, and fosters sustainable development. However, with increasing population growth, urbanization, industrialization, and climate change, the challenges confronting municipal authorities, particularly in developing countries, have intensified in complexity, scope, and severity (World Health Organization [WHO] & United Nations International Children's Emergency Fund [UNICEF], 2022). These difficulties in providing safe drinking water result in water insecurity and exacerbate health and environmental crises.

Despite global efforts to achieve Sustainable Development Goal 6 (Ensure access to water and sanitation for all), recent reports show that 771 million people still lack access to basic drinking water services, while at least 2 billion people use water sources contaminated with fecal matter, which leads to waterborne diseases like cholera, diarrhea, typhoid, and hepatitis (WHO, 2021; UNICEF, 2022). Additionally, while 6.6 billion people now have access to improved water sources, global water demand is expected to increase due to agricultural expansion, energy production, and industrial use, with freshwater availability in many regions likely to decrease as a result of climate change (UN Water, 2023). These pressures are predicted to disproportionately

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affect the poor, particularly in regions with existing water stress (United Nations World Water Development Report [UNWWDR], 2022).

Globally, agriculture remains the largest consumer of water, accounting for 70% of all freshwater withdrawals, with irrigated agriculture alone responsible for 20% of cultivated land producing 40% of global food (Food and Agriculture Organization of the United Nations [FAO], 2023). By 2050, global food demand is expected to increase by 70%, further intensifying water resource competition (FAO, 2023).

In Nigeria, despite its natural endowment of 267 billion cubic meters of surface water and 52 billion cubic meters of groundwater annually, the country faces substantial challenges in managing water resources. These challenges are exacerbated by rapid urbanization, uneven water distribution, pollution, and the impacts of climate change (Nwankwoala, 2020). The situation is particularly dire in the North East, where unpredictable climatic conditions and low rainfall contribute to severe water insecurity (Ogunbode & Ifa, 2022). In towns like Mubi, Adamawa State, access to clean water is limited, forcing residents to rely on water vendors and unsafe sources such as rivers and open wells, which expose them to waterborne diseases (Okoro et al., 2021).

This study focuses on the North Eastern region of Nigeria, where climatic and infrastructural challenges create significant disparities in water demand and supply. By examining the water resource management issues in Mubi metropolis, the study aims to highlight the urgent need for sustainable water management strategies that promote equitable access and long-term sustainability for future generations.

Statement of the Problem and Justification

In spite of the abundant water resources in Nigeria, government at all levels (federal, state and local) have not been able to successfully harness these resources to ensure a sustainable and equitable access to safe, adequate, improved and affordable water supply, and sanitation to the population (Muta'a 2012). Water problems experienced are multi-faceted depending on the extent of population, standard of living, industrialization, and urbanization. Nigeria depends on groundwater as their greatest source of water supply for more than 20 years now. Groundwater sources of water includes springs, hand-dug wells, boreholes/tube-wells. About 100 million Nigerians get their source of water from groundwater and the country has recorded a huge reduction in urban water supply since 1990 (Olajuyigbe 2010)

The challenge of achieving sustainable water security in the context of water demand and supply in Nigeria represents a multifaceted and pressing issue. Despite being endowed with abundant water resources, Nigeria faces a complex set of problems related to water availability, accessibility, quality, and equitable distribution.

This research problem encompasses the need to balance the escalating water demand resulting from population growth, urbanization, and industrialization against the backdrop of environmental sustainability, climate change impacts, water pollution, and inadequate infrastructure. Identifying viable strategies and policies to address these challenges and foster water security is essential for the well-being, health, and economic development of the nation. This study aims to contribute valuable insights and recommendations to guide Nigeria toward a more water-secure and sustainable future.

The system of water supply within Mubi metropolitan is traditionally oriented, local and outdated nonfunctional equipments are still in place for water supply. Similarly, the existing infrastructural facilities used for water supply are not maintained and erratic power supply (with the metropolitan having less than 2 hours average daily energy supply from the national grid) to run the machinery for better supply has further compounded the problem. Consequently, the statewide current water supply by public utilities is grossly inadequate as most of the population still face serious water crisis. The total water demand for Mubi metropolis as at December, 2021 was 300 million litres per day (mld) and the available supply was just 40 mld. The difference stood at 260 mld as deficit, thus the study area was only getting 13.33% of its daily requirements. The figures indicate that the existing water demand far outweighs its supply when compared with the WHO standard of 50 and 100 litres per capita water requirement for rural and urban areas respectively. (Adamawa State Ministry of Water Resources, 2022; World Health Organization, 2020).

To cover this deficit in water provision by public utilities in the state, alternative suppliers exist such as Non-

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State Water Providers (NSPs) including both formal and informal local private providers popularly known as *pure water* factories and water vendors respectively. Historically, water vending is an old practice particularly in urban and semi-urban areas of developing countries. The activities of water vending are very common in high density but low income and medium density/medium income residential areas where they serve as a copping strategy in addressing water needs of the masses (Ahmad, 2016). Small-Scale Private water provision plays an important role to the extent that Wutich *et al*.(2016) concluded that it helps in advancing the human right to water, and services of a significant number of households (Van Dijk, 2008; Nnaji *et a*l.2013) apa from serving as a means of livelihoods that sustains a number of young people.

In attempting to ensure access to water at the household level, several publications have been made on factors affecting the availability and accessibility of water across different regions using different approaches (Bello & Tuna. 2014; Ogunbode et al., 2021; Ounbode & Ifa, 2022). However, little has been achieved on the simultaneous assessment of both the demand and supply challenges at the household level, especially in the North Eastern part of Nigeria where the intensity of climate change is evidently severe.

As clearly stated in both the background to the study and statement of the research problem, the importance of water for human existence cannot be over emphasized but unfortunately, the current state of water supply within Mubi metropolis is pathetic particularly at peak off dry season (from February to April of every year).

In view of the above challenge that requires evidence based practical solutions, there was an urgent need for an intensive scientific study on the alternative supply of water resources by the private and public sectors or even the developmental Non-Governmental Organizations (NOs) which aimed at determining the best option that would ensure adequate as well as qualitative water supply to the people of the state.

This study has both theoretical and practical significance and justification. Firstly, the theoretical relevance of this study derives from the fact that it has tried to fill the gap in the existing literatures which the scholars have not satisfactorily filled and thereby providing a new framework under which the problems associated with water supply and demand challenges within Mubi metropolis, Mubi North and South Local Government Areas (LGAs), Adamawa State and perhaps Nigeria in general could be analyzed and explained. Secondly, the findings of this study will equally add to the existing stock of scholarly literature water supply and demand challenges with a view to searching for a more sustainable water security solution within the study areas. in the state. As such, it will serve as a reference material or data for scholars whose interest would eventually be aroused by the findings to undertake further studies in the area.

Furthermore, the practical application of the study will be of great importance to all the critical stakeholders in the water sector such as the Adamawa State Government, the Federal Government of Nigerian (FGN), policy makers, and other relevant bodies/international organizations interested on issues relating water supply and demand infrastructural development. This is because its findings will provide valuable data/information that will assist in articulating potent policies that will help in resolving the problems inherent in the implementation of the project, especially in infrastructural development in Mubi Metropolis.

Lastly, the study will also assist the global desire for sustainable and inclusive economic development which cannot be achieved without determining an effective and efficient water supply sector that would ensure adequate supply of clean water. Hence, a research along this line is absolutely necessary and justifiable in solving the problem identified

Research Objectives

At the centre of this research exercise is basically, to assess households' water demand and supply challenges within Mubi Metropolis, Adamawa State-Nigeria with a view to find a sustainable water security solution. The specific objectives of the study include the following:

(i) To assess the drivers of households' water demand and supply forecasting based on key socio-economics attributes of the population in Mubi Metropolis;

(ii) To analyse the effectiveness of the current households' water supply infrastructure, including sources,

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treatment, and distribution using the four pillars of water security as standardized analytical framework within the selected study area;

(iii) To evaluate the level of households' perception of current water supply quality and its implication on household health expenditure within the study area;

(iv) To ascertain the extent and determinants of willingness to pay for an improved sources of water supply that is safe and sustainable.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

The Concept of Water and Portable Water for Households' Consumption

Introduction to the Concept of Water

Water is an essential natural resource and a critical element of life on Earth. It serves multiple purposes including domestic, agricultural, and industrial uses. Globally, water has been recognized as a finite resource with its availability significantly impacted by natural and human activities such as climate change, population growth, urbanization, and industrialization (World Health Organization [WHO] & United Nations International Children's Emergency Fund [UNICEF], 2021). Despite covering about 71% of the Earth's surface, only about 2.5% of the planet's water is freshwater, and less than 1% is easily accessible for human use (United Nations [UN], 2023). This scarcity has placed enormous pressure on water resources, particularly in areas where water demand continues to grow, leading to competition among various sectors and users (Food and Agriculture Organization [FAO], 2023).

The Concept of Potable Water

Potable water, also referred to as drinking water, is water that is safe for human consumption. According to the World Health Organization (WHO), potable water is free from contaminants such as pathogens, harmful chemicals, and other pollutants that could cause diseases (WHO, 2022). Access to potable water is a fundamental human right, yet globally, 2.2 billion people lack safely managed drinking water services, and 785 million people do not have access to even basic drinking water (WHO & UNICEF, 2021). Ensuring access to potable water is critical for achieving Sustainable Development Goal 6 (SDG 6), which aims to ensure the availability and sustainable management of water and sanitation for all (UN, 2022).

Water Demand for Household Consumption

Household water consumption refers to the water used for personal and domestic activities such as drinking, cooking, bathing, cleaning, and sanitation. On average, the World Health Organization (WHO) recommends a minimum of 50-100 liters of water per person per day to meet the most basic needs (WHO, 2022). However, water demand varies significantly across regions depending on factors such as population size, economic activities, and climate change. In developing countries, water demand is often higher due to the lack of efficient water infrastructure, while water usage in developed countries tends to be higher per capita due to access to more advanced water supply systems (UN, 2023).

Challenges in Accessing Potable Water for Household Consumption

Access to potable water is affected by several interrelated factors, including geographic distribution, infrastructure, economic resources, and political will. In many developing countries, urbanization and rapid population growth have outpaced the development of water infrastructure, leading to increased competition for available water resources (FAO, 2023). Climate change has also exacerbated water scarcity by altering precipitation patterns and increasing the frequency and severity of droughts (United Nations World Water Development Report [UNWWDR], 2022). Additionally, water contamination due to industrial activities, poor waste management, and agricultural runoff presents significant challenges to ensuring safe drinking water in both urban and rural areas (UNICEF & WHO, 2022).

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In sub-Saharan Africa, including Nigeria, water insecurity has become a critical issue due to inadequate water infrastructure and the unequal distribution of water resources. Despite the abundance of freshwater sources, challenges related to poor governance, infrastructure deficiencies, and pollution have severely hindered the ability of households to access clean water (Nwankwoala, 2020). The issue is further compounded by the emergence of waterborne diseases, which remain a leading cause of morbidity and mortality in regions where access to potable water is limited (WHO, 2021).

Emerging Approaches to Address Water Scarcity for Household Consumption

In response to water scarcity and challenges in accessing potable water, governments and organizations around the world have been implementing various strategies to improve water security. These include the development of improved water infrastructure, adoption of integrated water resource management (IWRM), and promotion of water conservation practices (UN Water, 2023). Technological innovations, such as desalination, water recycling, and rainwater harvesting, have also emerged as viable solutions for addressing water shortages in water-stressed regions (UNWWDR, 2022).

Conclusion

The demand for potable water continues to grow as populations increase and climate change intensifies water scarcity in many regions. Access to clean drinking water is crucial for maintaining public health and achieving sustainable development. To address the challenges associated with water scarcity, concerted efforts by governments, international organizations, and communities are required to promote sustainable water management, enhance infrastructure, and ensure equitable access to potable water for all.

Empirical Literature

While there are considerable pieces of literature with respect to water demand and supply, only a few ones have accounted for the component of willingness to pay for improved household water supply that is more reliable and sustainable.

To begin with, Bello and Tuna (2014) in their study adopted the of use secondary data from the several institutions that are related to water supply in Kano State to evaluate factors responsible for potable water demand and supply in the state. The data collected was analyzed using simple statistical techniques such as percentages. The result established that geographical characteristics such as climate, precipitation, soil type, vegetation cover, dams, population, agriculture and industry were the main factors responsible for potable water demand and supply in Kano State. The research concluded that the water supply in the state do not meet the demand due to the problems such insufficient number of water treatment plants, power failure and shortage of fund were among some of the challenges facing the supply of water within the study area.

Furthermore, Tasi *et al*. (2016) while assessing water supply situation in Rural Areas of Kano State, Northern Nigeria sampled sixteen rural villages and interviewed 394 respondents. Their study however, employed simple percentages as a simple tool for the analysis of the data collected. The result indicated that open well was the common source of water in the rural villages of Kano with 41.4% of the total responses. In terms of usage of the water, reservoir recorded the highest responses of 30.7%. It was also established that 60.7% of the respondents were of the opinion that drinking water was inadequate in the rural villages of the state. The research findings attributed that 39.9% of the respondents said the water sources were controlled by individuals and most of the users obtained their water in less than 500 meters' trek distance according to 67.8% of the respondents. In view of their findings, they strongly recommended that government, nongovernmental organizations, wealthy individuals and community should provide more boreholes and hand pumps in the study area to avoid drinking of untreated water supply.

Similarly, Ezenwanji *et al.* (2016) replicated a similar research in Enugu Metropolitan where they investigated the residential water demand and supply. They used a cross sectional survey approach to collect data from 2,000 randomly selected households in the identified 41 residential wards of the urban areas within six months between April and September, 2014. Trend bases method was employed in the estimation of water demand and

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supply, while Principal Component regression was utilized in the analysis of the factors responsible for the quantities demanded and supplied and produced an equation that was used in the model estimation. Result shows that the quantity of water demanded and supplied in 2014 were estimated at 144,491,774 litres per day (LD), while supply was 67,091,096 LD which just satisfied 40% of demand. On the basis of the findings, the study recommended that institutional reforms, water demand management technique and supply measures as well as professional community based management option be urgently employed to meet Sustainable Development Goals (SDGs) target date of 2030 of ensuring access to water and sanitation for all.

While using a cross-sectional survey technique across 1,300 households in analysing the determinants of residential water demand in South Western Nigeria by Oyerinde and Jacos (2022) where a multiple linear regression model was used to estimate the variables of interest. Their findings revealed that access to water, household size, household monthly income, cost of payment for water used, educational level of the head of household, household type and trip or hours spent in souring water were all statistically significant. Indeed, daily water consumption was also found to be almost three times more per household.

A factor analysis was deployed by Timothy et al. (2023) in their analysis of Households daily water consumption dynamics in the tropical environment established that 12 of the 40 factors analyzed were significant determinants of daily water use in homes with about 85.80 factors explaining the variation of household daily water use. by the observations. Some of the factors in includes: closeness to water source; night time baths; households' cooking needs; Sunday's or weekend activities such as washing and excessive washing; water demands of the dry season; water use during morning; household size; respondents' attitude; water availability in the dry season; break down in water flow facilities; social/spiritual events; and proximity to the source of water.

Theoretical Framework

The daily patterns of water demand and supply of households can be well understood through various theoretical frameworks and hypothesis. Some of these popular analytical frameworks includes. Human behavior and decision-making framework that require insights from behavioral theories. The Theory of Planned Behavior (TPB), according to (Ajzen, 1991; Smith & Ali, 2006), suggests that people's intentions and behaviors are influenced by their attitudes, subjective norms, and perceived behavioral control. TPB has been applied in water resource management, especially in water conservation at households' level (Smith & Ali, 2006: Heckman, 2014). The application of this theory to household water demand, according to Kim *et al.* (2007), implies that individuals' decisions on when and how much water to use are partly and strongly shaped by certain characteristics such as beliefs, social influences, and perceived capability to control their water consumption pattern.

Conventional and pragmatic economic theories, such as cost-benefit analysis and utility maximization (Cominola, 2023), provide insights into how individuals make decisions based on the perceived costs and benefits of water use. Income levels, water tariffs, access to infrastructure, and affordability of water-related technologies influence household water use patterns (Ogundube, 2015). In addition to these, sociocultural factors also have strong influence on daily household water use pattern. Social norms, customs, and cultural practices determine individuals' attitudes and behaviors towards water use (Ogunbode et al., 2022; Rondinel et al., 2022). The World Health Organization also reiterated that culture can translate experience and assign value to knowledge, providing evaluation values for possible causes of human activity and sharing knowledge and scientific prospects. For instance, in some cultures, water may be seen as a precious resource, leading to more conservation oriented behaviors. Social networks and peer relationships can also affect the pattern of water use practices at either community or household levels. The availability and efficiency of water-related technologies and infrastructure influence daily water use dynamics. The adoption of water-efficient features, such as low-flow faucets and toilets, contributes to minimized consumption of water. The presence or absence of efficient piped water network, storage systems, and the availability of alternative water sources are significant influencers of domestic water use patterns.

Furthermore, environmental factors such as climate conditions and water availability, interact with household water demand (Molenaar, 2018). Indeed, the availability or accessibility of water resources, seasonal variations

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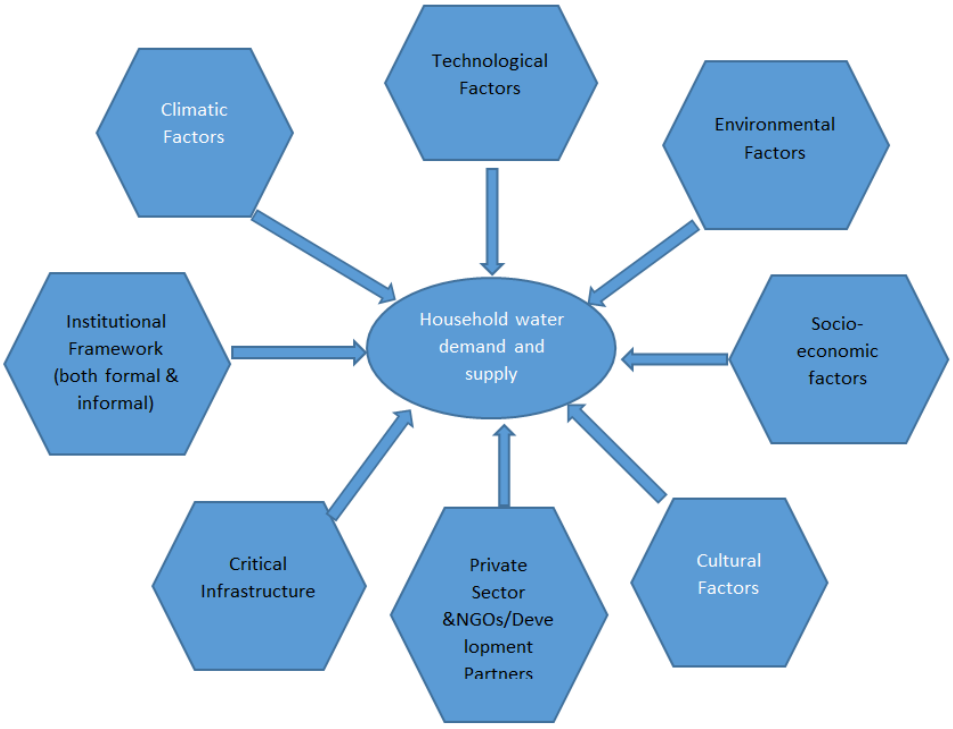
in rainfall, and perennial and occasional water shortage or drought conditions essentially influence the pattern of household daily water use (Karamperidou et al., 2021). Human consciousness of the environment and awareness of water conservation are significant determinants of individual behaviors.

The combination of all the theories outlined can provide the research team with a robust theoretical framework for understanding the complex interplay of individual choices, socioeconomic factors, cultural influences, technology, and environmental considerations that shape the daily water demand and supply of households. It is therefore, imperative to illustrate these relationships within a convincing conceptual framework presented in figure 1 below:

Figure 1: Conceptual Framework Illustrating Factors Influencing Households' Water Demand and Supply in a Typical Developing Country like Nigeria



Source: Research Team Contribution to Knowledge

All the factors outlined on figure 1 above will be systematically integrated in the empirical models of the study in order to have a comprehensive understanding of the current water needs and challenges within the study areas. This approach is expected to provide a clear road map that could provide a viable/practical sustainable water security solution for both the present and the future generation. Indeed, the framework is in line with the current global approach to addressing water needs specifically in the under developed and developing countries where the renewed effort is being tailored toward an integrated water provision approach that accommodates all the critical stakeholders.

METHODOLOGY OF THE STUDY

Description of the Study Area

Mubi Metropolis comprises two Local Government Areas (LGAs) out of the twenty-one LGAs within Adamawa State. Namely, Mubi North and Mubi South. The metropolis is located between latitude 10o 05' and 10o 30' of the equator and longitude 13o 12'and 13o 19'E of the Greenwich meridian and has a land area of 4,728.77 km^2. The temperature regime in Mubi region is warm to hot throughout the year, because of high radiation income which is relatively evenly distributed throughout the year. However, there is usually a slightly cool period between November and February; minimum temperature of 12.7°C around January and maximum temperature of 37°C around April. It is one of the urban areas in Nigeria that existed since the

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colonial era and has the second largest population in the state after Yola the State capital, with a population of 260,009 from the 2006 population census. However, the projected population of the metropolis stood at 372,305 in 2019 according to Adebayo et al., 2020 as cited in Elihu et al. (2023).

The area shares a boundary with Maiha L.G.A in the south, Hong L.G.A in the west, Michika L.G.A and Cameroon Republic in the east (Figure 2). The vegetation of Mubi and its environments fall within the Sudan savannah belt of Nigeria. The vegetation zone is referred to as cambretaceous woodland savannah. About 70% of the vegetation is grasses and weeds with few scattered woody plants which make up part of the natural vegetation and the exotic which were brought from other areas into the region.

The growth of Mubi town is traced to the agricultural, administrative and commercial functions it performs. By 1902, Mubi was a German base from where the neighboring tribes such as Fali, Gude, Kilba, Higgi, Margi and Njanyi of the region were subjugated. On 1st April 1960, Mubi was made the native authority headquarters. The same year, July 1960, the town became provincial headquarters of the defunct Sardauna province. In 1967, It was made L.G.A headquarters while in 1996, the town was splinted into two LGAs (Mubi-North and Mubi-South). Currently, the town is the seat of Mubi Emirate Council and is the headquarters of the Adamawa-North Location and Extent of Mubi Town According to Adebayo (2004),

Mubi is geographically well placed and functions not only as the centre of commerce in the region but also extends its sphere of influence to countries such as Cameroun, Central Africa Republic and Chad. Numerous banks, filling stations and hotels exist in the town to support the commercial activities. Another factor that led to growth of the town is rural-urban migration experienced from the surrounding villages. More over the town has become centre of learning with numerous tertiary and secondary institutions established in the metropolis such as the Federal Polytechnic, College of Health and Adamawa State University (Enoch, 2019).

Research Design

The research design for the proposed study adopted mixe method of using evidence from the literature that informed the choice of appropriate quantitative and qualitative methods o collecting data from the field. In other words, triangulation method was adopted as a standardized and comprehensive research design. The quantitative method of data collection wa achieved via the deployment of both structure and semi-structured questionnaires that was administered across different households within the study location. The qualitative technique on the other hand, was achieved through Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs) where by comprehensive interviews guides was designed to achieve that. Indeed, critical stakeholders in the water sector were be given priority while searching for the right persons to speak during both the FGDs and the KIIs sessions.

Source and Method of Data Collection

The data for the proposed study was purely primary source that will be collected via certified and piloted questionnaires. The process will be achieved through the use of an Information and Communication Technology (ICT) platform known as the Open Data Kit (ODK) or Kobo collect. Smartphones or android tabulates was use as the major ICT devices that assisted in collecting the data. The choice for this method was predicated on the fact it has proven to be very effective and efficient in collecting high quality data within the shortest possible time and at minimal cost. It is also environmentally friendly, since none of the questionnaire was printed. Indeed, one could also vouch for the integrity of the data because a lot of quality insurance measures were imbedded in the software. Lastly, it also simplifies the process of the data analysis since the back end of the data was duely monitored by the research team as soon as the data collection process commences.

Population of the Study

The study population comprises all the households within Mubi Metropolis. But because of the cultural disposition of the study area with respect to the role of the women (female gender) whom largely, are considered as critical stakeholders in the household water demand and supply; they will be prioritize first

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during the household survey exercise. Indeed, most households perceived water provision for the entire household as a traditional role of the women.

The National Social Safety Net Coordinating Office (NASSCO) in its 2021 National Social Register by LGAs in Nigeria reported that Mubi North and South have a total number of 2.255 and 1,132 households respectively. Table 1 provides the summary of the individual population disaggregated across gender and the number of household per LGA.

Table 1: Summary of National Social Register by LGAs (Mubi North and South)

S/N	LGA	Household	Individual	Male	Female	Proposed Sample Size
1.	Mubi North	2,255	11,082	6,299	4,783	539
2.	Mubi South	1,132	6,117	3.053	3,064	231
3.	**Total**	**3,387**	**17,199**	**9,352**	**7,847**	**770**

Source: NASSCO (2021) and Sample Size Computed by Research Team Using Dillman (2007)

Sample Size of the Study

Since research is a systematic process, the study adopts Dillman (2007 & 2011) formula which is an advancement of Krejcie and Morgan (1970) and is specified below as:

$$Ns = \frac{(Np)(p)(1-p)}{(Np-1)(B/C)2+(p)(1-\rho)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

NS = Computed Sample size needed for the desired level of precision;

Np = Size of the population of the study;

p = proportion of population expected to be sampled;

B = acceptable amount of sampling error (in this case assume +/-5 =0.05);

C = z-statistic associated with the confidence level (in this case assume a 95% confidence level =1.96).

A sample size of 770 was arrived at using the above formula to be administered on the two selected LGAs-namely, Mubi North and Mubi South with respective sample sizes of 539 and 231.

Sampling Technique

Since the study covers the metropolitan town of Mubi which has two LGAs, a total of four (4) wards each have been selected for the field survey within the metropolitan.

Furthermore, in order to achieve unbiased estimators, a multi-stage sampling technique was employed, but with specific interest to proportional stratified, cluster and systematic random sampling techniques which will be implemented in three stages.

In the first stage, the researcher used purposeful and cluster sampling techniques whereby four wards have been proposed for each of the selected LGAs. **The wards for Mubi North LGA include Sabon-Layi, Lokuwa, Yelwa and Wuro-gude/Sabon Gari. While as, Mubi south has Nassarawo, Kwacham, Gude**

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and Kabang wards. These areas were carefully selected as the first four most densely populated wards in each of the LGAs within the metropolitan and preliminary investigation also reveals severe problem of water supply.

The second stage of the sampling technique considers certain socio-economic features such as income level of households, household size, the intensity of economic activities, household residential types and population density for the selection of the sampling areas using cluster and stratified sampling techniques. That is, the questionnaires will be distributed in the proportion of 5:3:1 in low income/high density, medium income/medium density and high income/low density residential areas respectively.

The researcher, at the last stage of the sampling used systematic random sampling technique in the selection of number of households at 20^{th} interval in low income/high density, 10^{th} interval in medium income/medium density and 5^{th} interval in high income/low density residential areas.

The use of multi-stage sampling technique was adopted because of it easy implementation and could create a more representative sample of the population than the conventional single sampling technique. In other words, it is both cost and time efficient while retaining both the randomness and sufficient size of the sample particularly in a general sampling frame like this.

Data Analysis

This method of data analysis will be used at two stages. In the first stage, the researchers will utilize descriptive tools of analysis to summarize and deduce certain pieces of information from key variables of interest. Thus, measure of central tendency which include mean, median and mode was used to process and analyze the data collected. Additionally, the study deployed statistic on the degree of dispersion of the data using standard deviation (variance), minimum and maximum values. These statistics will enable the researcher to ascertain the extent of dispersion of information collected.

In contrast, the use of Nvivo and ATLAS-TI software was used for the analysis of qualitative data. The software has proven to be highly efficient in organizing and analyzing qualitative data that will rigorously built-up findings with evidence.

DATA PRESENTATION AND DISCUSSION OF FINDINGS

Outcome from the cross sectional survey across individual households shows a 100% response rate with the 770 proposed respondents successfully interviewed via the face to face survey instruments administered by the Research Assistants (RAs) or enumerators using Open Data Collect kit (ODK) application. The success of this was attributed to the flexibility and viability of the e-platform deployed. The data was analyzed using STATA version 16.

Table 2 summarizes the the socio-economic attributes of the respondents on the subject matter specifically on ke factors of water demand and supply within the study areas.

Table 2: Socio-economic Attributes of the Respondents

Variable	Observation	Mean	Std. Dev.	Min	Max
Willingness to Pay	770	15,650	6.28874	6420	23450
Percentage of Household's Income Spent on Water	770	9.415311	3.611301	2	23
Average Amount Spent on Water per month	770	24,125.511	17.0884	5,000	48,000
Average Quantity of Water Consumed by HH	770	231.4241	139.2067	50	1875

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Average Income of Household	770	103426.81	567228.63	80000	420000
Perception of Quality of Water Supplied by Public Utility	770	1.282323	1.7102189	0	5
Family size of Household	770	7.60602	4.23133	4	30
Occupation of Head of Household	770	3.095759	1.40415	1	6
Educational Level of Household	770	3.351573	1.260923	1	5

Source: Outcome of Field Survey March and August 2024

The mean willingness to pay (WTP) of ₦15,650 equivalents $9.21 per month suggests that households are moderately willing to pay such an amount for improved water services that is more sustainable. However, the wide range ₦6,420 ($3.78) to ₦23,450 ($13.79) indicates significant variability across households which largely depend on variables such as household size, income level, and intensity/severity of water scarcity within the study location. Furthermore, low income/high density, medium income/moderate density and high income/low density population were all considered during the sampling process but with more concentration on low income areas because of their vulnerability status to water insecurity. The result by implication suggest that policies should consider a tiered pricing structure based on income levels to improve access and affordability while ensuring cost recovery for sustainable water services.

On average, households spend about 9.42% of their income on water, exceeding the global affordability benchmark of 3-5% by almost three times; specifically based on the World Health Organization (WHO) recommendation that reflects affordability. This indicates a financial burden on households whom mostly are already experiencing deeply level of poverty. It is therefore imperative to initiate cross subsidization water supply programs and improved public utility services that targets the poor population thereby reducing the financial stress on households while promoting equitable water access.

The outcome of the field survey also reveals an average Amount Spent on Water per Month of ₦24,125.51K ($14.19) with Std. Dev of ₦17,088.4K ($10.5). The high average monthly expenditure on water highlights the costliness of current water sources, with some households spending as much as ₦48,000 ($28.24) per month; which is more than of half of the Nigerian minimum wage of ₦70,000 ($41.18). the implication of this finding suggest that there is dare need to invest more in public water supply infrastructure to provide cheaper and more reliable water services could alleviate high household expenses and improve water security.

The Average Quantity of Water Consumed per household 231.42 with an average household size of about 8 persons. This therefore suggests that per capita water consumption of 28.93 liters which very low compare to the 100 litres recommended by the WHO in order to meet up with the WASH requirement for persons within an urban settlement like Mubi metropolitan. Consequently, a huge water deficit of about 71.07 litres exist within the study areas thereby presenting a very severe water insecurity situation. The wide variation in water consumption (50 to 1,875 liters) suggests unequal access to water among households, possibly due to financial or logistical constrains, In order to ensure equitable water distribution through targeted interventions, such as community-based water schemes or incentives for private providers to serve underserved areas.

Household Average Income per month was also reported to be about ₦103,426.81($60) which is slightly above the Multi-Dimensional Poverty Parity Index (MDPPI) $2.15 per person per day. This result is consistent with the World Bank report of 2022 where it was reported about 133 million Nigerians are living below MDPPI. Despite the relatively high average income, the large standard deviation of ₦567,228.63K ($333.67) indicates income inequality, with many households likely earning far below the mean. There should be concerted effort policies towards addressing water security which should account for income disparities by incorporating subsidies or targeted assistance for low-income households.

Perception of Water Quality was reported to be approximately 2 on a scale of 0-5 indicating a low mean

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perception score which suggests dissatisfaction with the quality of water supplied by existing water utilities mostly dominated by the private water vending within the metropolitan. Authorities are therefore advised to to prioritize investments in improving water quality, such as treatment plants and quality monitoring systems, to rebuild public trust in utility services.

Educational Level of Household (Mean: 3.35, Std. Dev.: 1.26 on a scale of 1-5). Moderate educational attainment suggests potential awareness of water-related health and sanitation issues, but gaps remain. There is need for educational campaigns on water hygiene, conservation, and efficient usage should be incorporated into community development programs to strengthen water security.

Table 3 provides a brief summary of the common water sources for household consumption within Mubi metropolis, Adamawa State, Nigeria:

Table 3: Various Sources of Water within the Mubi Metropolis

Source of Water	Percentage Usage	Remarks
Boreholes	37.8%	Most widely used and often provided by vendors, with an increasing trend due to reliability.
Well Water	24.0%	Traditional source; usage declining due to seasonality issues.
Stream/River Water	18.5%	Declining usage due to drying up in dry seasons and concerns about safety.
Rainwater Harvesting	9.6%	Limited use, but was reported to be an essentially save supplementary source during rainy seasons. However, it is not sustainable
WaterTruck Delivery	5.8%	A supplementary source, often used in emergencies or water scarcity.
Other Sources	4.2%	Includes less common means of water access.

Source: Outcome of Field Survey March and August 2024

Boreholes mostly supplied by private informal water vending platform popularly known as *mai-ruwa* in Huasa Language have become a critical water source due to their reliability, while well water and river/stream water usage are declining due to drying out in the dry season. Rainwater harvesting and water truck delivery have also seen modest increases as supplementary sources. Seasonal variations and infrastructure reliability greatly affect household water supply in the areaThe outcome of the research finding is also consistent with the International Water Management Institute's research (2022) conducted in North Eastern part of Nigeria.

Key drivers of households' water demand within the study area have been summarized below based on the outcome of the Focus Group Discussions (FGDs) conducted across the study areas. Table 4 provides the summary of the factors responsible for the demand of household water.

Table 4: Summary of Key Drivers of Water Demand and Supply within Mubi Metropolis

S/N	Key Factors	Explanation	Frequency of Citation
1.	Population Growth	Increased in rural urban migration associated with the concentration of more economic activities	*****

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2.	Seasonal Variability	Usually high demand during dry season. But low demand during rainy season with most well having water.	*****
3.	Socio-economic Activities	Socio-economic activities such as irrigation farming, cattle fattening, fish farming, pure water production and restaurant business	****
4.	Household Level of Income	Higher-income households may afford alternative water sources, increasing competition for supply.	****
5.	Presence of Institutions of Learning	Presence of Institutions of higher like the University, Polytechnics and Colleges of Health attracts more population	***
6.	Government Policies	Ineffective policies or enforcement can hinder equitable distribution and sustainable supply thereby increasing demand for water	***
7.	Conflict and Insurgency	Displacement and damage to water infrastructure reduce availability and create localized surges in demand.	**

Source: Outcome of Focus Group Discussions (FGDs) March and August 2024

Note: ***** Highly frequently cited, **** Usually Frequently Cited, ***Frequently cited, **Fairly frequently cited, *not usually frequently cited.

The outcome of the Focus Group Discussions (FGDs) conducted in March and August 2024 highlights the key drivers of water demand and supply within Mubi Metropolis, as summarized in **Table 4**. The findings indicate varying degrees of influence by different factors based on the frequency of their citation during the discussions. Below is a brief explanation:

Population Growth was cited as the most significant driver participants emphasized that rural-urban migration, driven by concentrated economic activities, has led to increased water demand. Secondly, Seasonal Variability was equally reported to be very significant, seasonal changes strongly influence water demand and supply. Water scarcity peaks during the dry season due to reduced natural sources, while rainy seasons ease demand as wells and rivers replenish. Furthermore, Socio-economic Activities was frequently mentioned, activities such as irrigation farming, cattle fattening, fish farming, pure water production, and restaurants were identified as significant contributors to water demand. Household Income Levels was also frequently cited. The ability of wealthier households to afford alternative water sources, such as boreholes, increases competition for limited resources.

However, Presence of Institutions of Learning was moderately reported to be influential. The participants noted that universities, polytechnics, and colleges attract a growing population that are hygiene conscious thereby, heightening water demand. Government Policies was also moderately cited where the participants attributed weak enforcement or ineffective water management policies were seen as obstacles to equitable distribution and sustainable supply, indirectly increasing demand. Lastly, Conflict and Insurgency was fairly cited whereby, discussions revealed that displacement due to insurgency and damage to infrastructure have localized effects on water supply and demand.

Overall, the FGDs suggest that addressing these drivers requires integrated strategies, such as improving infrastructure, implementing effective policies, and enhancing conflict mitigation efforts.

SUMMARY OF MAJOR FINDINGS, CONCLUSION AND RECOMMENDATIONS

The following provides a brief highlight of the summary of findings:

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a. Willingness to Pay (WTP) for Improved Water Services: Households exhibit a moderate willingness to pay an average of ₦15,650 ($9.21) per month for sustainable water services. However, variability in WTP (₦6,420–₦23,450) is influenced by household size, income, and water scarcity levels. This suggests a need for tiered pricing structures based on income to improve affordability and ensure cost recovery.

b. Household Water Expenditure and Financial Burden: Average monthly water expenditure is ₦24,125.51 ($14.19), with some households spending up to ₦48,000 ($28.24), over half the Nigerian minimum wage (₦70,000). Households spend an average of 9.42% of their income on water, nearly three times the WHO affordability benchmark of 3-5%. This imposes a significant financial burden, particularly on low-income households.

c. Water Consumption and Deficit: Average per capita water consumption is 28.93 liters, significantly below the WHO-recommended 100 liters. This represents a deficit of 71.07 liters per person, indicating severe water insecurity in the area. Variability in water consumption (50–1,875 liters per household) highlights unequal access, influenced by financial and logistical constraints.

d. Income Inequality and Poverty: Average household income is ₦103,426.81 ($60), slightly above the Multi-Dimensional Poverty Parity Index (MDPPI). However, high income disparity (Std. Dev ₦567,228.63K) means many households earn far below the mean, exacerbating water insecurity among low-income populations.

e. Perception of Water Quality: Households report dissatisfaction with water quality, with a low mean perception score of 2 (scale 0–5). Private water vendors (mai-ruwa) dominate supply, but their services are often seen as inadequate.

f. Key Drivers of Water Demand and Supply:

    1. Population Growth: Rural-urban migration and economic activities drive high demand.

    2. Seasonal Variability: Dry seasons intensify scarcity, while rainy seasons ease demand.

    3. Socio-economic Activities: Activities like farming, restaurants, and pure water production increase demand.

    4. Household Income Levels: Wealthier households create competition for water through alternative sources.

    5. Presence of Institutions: Universities and colleges heighten demand due to hygiene-conscious populations.

    6. Government Policies: Weak enforcement limits equitable distribution and sustainable supply.

    7. Conflict and Insurgency: Displacement and infrastructure damage create localized shortages.

    g. Reliance on Boreholes: Private boreholes (mai-ruwa) are the primary water source, while wells and rivers are declining due to seasonal variability. Rainwater harvesting and water truck deliveries are supplementary but less reliable.

Conclusively, the study reveals significant water insecurity in Mubi Metropolis, characterized by low per capita consumption, high household water expenditure, and dissatisfaction with water quality. Population growth, seasonal variability, socio-economic activities, and income inequality exacerbate water demand and supply challenges. Private boreholes dominate as the primary water source, but their costliness and inconsistency highlight the urgent need for sustainable water solutions.

Drawing from the findings of the study, the following recommendations have been made to serve as viable

policies tools for all critical stakeholders in providing sustainable water security solution within the study area:

1. Investment in public water supply infrastructure to provide cheaper, reliable services.
2. Implementation of cross-subsidization programs to support low-income households.
3. Community-based water schemes and incentives for private providers to address inequalities.
4. Create enabling environment for an integrated water project implementation using both feasible and viable Public Private Partnership scheme that has proven to be both effective and efficient in addressing water crisis for both developed and developing economies.
5. Water Quality Improvement: Establish treatment plants and strengthen quality monitoring systems to ensure safe water supply and regain public trust.
6. Policy Reform and Enforcement: Strengthen enforcement of water management policies to ensure equitable distribution and sustainable use.
7. Resilience to Seasonal Variability: Develop infrastructure for water storage and rainwater harvesting to mitigate seasonal shortages.
8. Conflict-Sensitive Interventions: Address water-related challenges in conflict-affected areas by repairing infrastructure and ensuring inclusive access.

The findings align with the International Water Management Institute's 2022 research on water insecurity in northeastern Nigeria, confirming the critical role of boreholes and the need for sustainable water management strategies.

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