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ANALYSIS OF WATER SCARCITY AND MANAGEMENT FOR SUSTAINABILITY IN MUBI METROPOLIS

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ABSTRACT :

This study assessed how landform characteristics influence water availability and security in Mubi Metropolis using Geographic Information System (GIS) analysis and household survey data from 384 respondents across eight (8) wards of Kolere, Lokuwa, Nassarawo, Gude, Yelwa, Sabon Layi, Digil and Lamurde. Topography, slope, aspect, drainage, flow direction and flow accumulation were examined to see how these factors change groundwater, surface runoff and water accessibility. The results showed that water supply is unreliable because many people relied on private water sources making them spend more money on water expenditure. Higher elevations occur in Lamurde, Nassarawo, Gude, and parts of Lokuwa, while Yelwa, Sabon Layi, Kolere, and Digil are predominantly low-lying. Steep eastern and southeastern areas generate rapid runoff and limit groundwater recharge, whereas flatter central and western areas encourage water infiltration and the recharge of groundwater. Surface runoff generally flows from elevated southern and northeastern areas toward lower central and northern zones. Lower areas were identified as major runoff convergence areas with favorable groundwater-recharge conditions, corresponding with concentrations of boreholes and water-access points. Despite favorable terrain conditions in some areas, water infrastructure remains inadequate. About 88.0% of households depend on vendors, boreholes, and tankers/trucks, with none relying on public piped water. Additionally, 60.9% reported irregular water supply, while 89.5% considered water scarcity a critical community problem. The study concludes that water scarcity results from terrain-controlled hydrological processes and inadequate infrastructure. Integrating socio-hydrological and geospatial information is therefore important for effective urban water planning, groundwater development, and sustainable water-resource management.

Keywords: Water Scarcity, Topography, GIS, Groundwater, Mubi Metropolis.

INTRODUCTION

Background of the Study

Water is essential for life, health and the growth of communities. Access to water is the base of a safe and strong society. In cities especially in developing areas water supplies are not enough to meet the needs of the people. This is a problem in cities across sub-Saharan Africa. These cities are dealing with a lot of pressure on their water systems (Lall et al., 2017). The reason for this is because more people are moving into cities, the cities are spreading out quickly and the climate is changing a lot (World Health Organization [WHO], 2023). In Nigeria the gap between what the city can provide and what people need is getting bigger. This makes it hard for people to get water. As a result many people are finding their ways to get water. They use wells and machines that pull water from deep underground via automated boreholes (Ogunbode et al., 2024; Federal Ministry of Water Resources et al., 2022). Water is needed for everything. It helps people stay healthy and the economy grow. It makes cities last longer. In places where cities are growing fast people need water than the city can give. This leads to shortages, access and people relying on private ways to get water. Mubi Metropolis in Adamawa State is one of these places where people depend a lot, on wells, water from boreholes, water vendors and other alternative sources because the public water supply is not enough or not working properly (Boniface et al., 2024).

Statement of the problem

Access to adequate, reliable, affordable, and safe water remains a major challenge in rapidly growing urban areas, with implications for public health, household welfare, economic activities, and progress toward Sustainable Development Goal 6. Globally, inequalities in drinking-water services persist, particularly in low- and middle-income countries where population growth, inadequate infrastructure, weak governance, and environmental pressures constrain water security (World Health Organization [WHO], UNICEF, & World Bank, 2022).

In Nigeria, water-service challenges are associated with inadequate infrastructure, limited investment, weak institutional capacity, and unreliable service delivery. The 2021 WASHNORM, published in 2022, reported that approximately 67% of Nigerians had access to basic drinking-water supply services while 33% of Nigerians reported lacked access to basic water supply services (Federal Ministry of Water Resources et al., 2022).

In Mubi, inadequate public water supply has encouraged households to depend on informal and self-supply sources, including water vendors, wells, and other unimproved sources (Okoro et al., 2015). Recent research on Mubi also indicates substantial household water-demand and supply challenges, while GIS and remote-sensing studies demonstrate that terrain and other environmental factors influence groundwater potential (Boniface et al., 2024; Shinggu et al., 2025).

The problem is further complicated by variations in elevation, slope, aspect, drainage, flow direction, and flow accumulation, which influence runoff, infiltration, and potential groundwater recharge. However, existing studies have generally examined household water conditions and physical groundwater potential separately. Consequently, there remains limited integrated understanding of how physical terrain conditions, water infrastructure, household characteristics, affordability, and management practices interact to produce spatial differences in water scarcity across Mubi Metropolis. This knowledge gap limits the ability of planners and water-resource managers to identify priority areas, improve infrastructure, protect groundwater resources, and develop sustainable management strategies. Therefore, this study integrates geospatial terrain modelling with household-level water-access information to provide an evidence-based basis for more equitable and sustainable water-resource management in Mubi Metropolis.

Aim and Objectives

The main goal of this study is to assess water scarcity and how it is managed in Mubi Metropolis by creating a model for sustainable water usage.

The specific objectives are to:

i. Map and examine the spatial distribution and density of boreholes in Mubi Metropolis.
ii. Model the hydrological and topographical architecture of the metropolis using Digital Elevation Models (DEM) to generate topographical, slope, aspect, flow direction, flow accumulation and drainage system maps.
iii. Evaluate household water access pathways, primary sources, consumption volumes, financial burdens, and coping mechanisms via structured community questionnaires.
iv. Combine geospatial terrain maps with socio-demographic survey indicators to isolate high-water scarcity zones.
v. Recommend sustainable and actionable water-management strategies for the metropolis.

LITERATURE REVIEW

Recent research on Mubi shows that the need for water is very high, families spend a lot on water. Each person gets much less water than they should (Boniface et al., 2024). Another study from 2025 in Mubi South Local Government Area showed that using satellites and mapping tools can help find places where groundwater can be found. This gives information for managing groundwater and planning water use in cities (Shinggu et al., 2025). These studies show that water shortage in Mubi is not about not having enough water but also about how to plan and manage water in a way that lasts (Boniface et al., 2024 and Shinggu et al., 2025).

Mubi Metropolis works as a place for business and learning in Adamawa State in the northeast of Nigeria. This city has problems with resources. In years the number of people living there has gone up a lot. This is because trade has grown and more people have come in looking for a place to live. This fast growth has made the water system break down. Because of this people are using groundwater more and more as a way to get water in Mubi. This happens especially where the public water system is not working well (Boniface et al., 2024). If there is no proper study of where groundwater is, how the land looks and how much water people need depending more on groundwater could cause problems, for managing water in a way that lasts (Shinggu et al., 2025).

Contemporary scientific work is pushing more and more to bring spatial modelling ideas and household surveys to get a better sense of the geography of urban water stress. Spatial analysis methods are very helpful in finding differences in how people use water and how resources are in different areas across sub-Saharan Africa (Addae et al., 2022). Urban water shortages are getting more connected to increase in population, infrastructures deficit, climatic issues and weak institutions. In cities in Africa families try to get water from other sources like boreholes, wells, springs and water vendors when the official water supply is not reliable (Ewang et al., 2021; World Bank, 2011). Even though, these ways can give access to water depending too much on groundwater and unsafe sources can cause problems with keeping the water supply for a long time and keeping the water clean. Groundwater can be reached because of local rock layers and the way the land is shaped and both of those things can be modeled well with GIS data. Things like areas, gentle slopes and places where water gathers are important clues for where groundwater might be found (Yusuf et al., 2021).

On the high and rough areas, water run off quickly which means less water soaks into the ground. This leaves people on hills in a bad position when the dry season is extended. Even if there is water infrastructure, it does not always mean that families have access to water. Infrastructure financing constraints, systemic malfunctioning, institutional weaknesses, and inadequate maintenance can reduce the reliability of water-supply systems, producing localized water scarcity where extraction points exist but remain non-functional (Adeniran et al., 2021).

In Northeastern Nigeria, the water supply is not always there because the electricity is not reliable. This encourages adopting a decentralized power systems, like solar-powered boreholes and backup power to improve water availability and systems sustainability (Food and Agriculture Organization of the United Nations [FAO], 2022). Also, high urban population together with shallow groundwater can get groundwater polluted from nearby sanitation facilities. This turns the amount of water availability into a public health problem (Imam et al., 2023). By looking at the physical terrain profiles and community household feedback together, researchers can tell the difference between physical scarcity caused by geography and structural scarcity caused by institutional management gaps, offering a clearer path toward sustainable regional water planning.

People living in Mubi Metropolis continue to experience irregular water supply. They get water at high costs, and depend on private sources. Many families cannot rely on public water systems and therefore depend on private boreholes and water vendors, with household water expenditure imposing a disproportionate burden on low-income households (Boniface et al., 2024). The problem is intensified because the water is not evenly spread, the groundwater is not stable and variations in terrain and drainage characteristics (Shinggu et al., 2025). The Mubi study found that each person on average uses 28.93 liters of water a day. The cost per household was 24,125.51 naira and it took 9.42% of the family's income (Boniface et al., 2024). These results show that scarcity of water is not evenly distributed and may differ depending on household income and their access to water infrastructure. Furthermore, the spatial differences in groundwater potential identified across Mubi South suggests that, terrain, drainage density, elevation, slope, soil, and land-use characteristics should be considered in water-resource planning (Shinggu et al., 2025).

The study about households in Mubi showed severe water insecurity, low water consumption, and heavy reliance on private boreholes, with water expenditure imposing a particularly significant financial burden on low-income households (Boniface et al., 2024). The 2025 study about the groundwater in Mubi South shows how important GIS and remote sensing in identifying groundwater-potential zones through the integration of drainage density, slope, elevation, soil, land use/land cover, and aspect (Shinggu et al., 2025). These methods help planners understand spatial differences in groundwater potential and provide a basis for more appropriate water resource and infrastructure planning. Spatial analysis therefore strengthens sustainable urban water management by connecting physical terrain characteristics with groundwater resource planning (Shinggu et al., 2025).

The study is further justified by the growing policy focus on water, hygiene, and sanitation in Nigeria. World Bank materials on the Sustainable Urban and Rural Water Supply, Sanitation and Hygiene Programme show that improving access to WASH services and strengthening sector institutions remain important national priorities (World Bank, 2021; World Bank, 2025). For Mubi, this means local planning should be aligned with wider sustainability and sector-strengthening goals (World Bank, 2025).

Theoretical Framework

The study is guided by two ways of looking at water. One is called Integrated Water Resources Management or IWRM. IWRM looks at how to manage water, land, nature, structures and the needs of people together. In Mubi Metropolis, IWRM helps people see if the water and the structures that hold the water are spread out in a way that everyone can reach them. IWRM also makes sure that water is used in a way and that nature stays clean (Global Water Partnership [GWP], 2000).

Socio-Hydrology adds another way of thinking by looking at how people and water systems affect each other. It recognizes that household decisions and institutional responses can influence hydrological conditions, while changes in water availability can subsequently alter human behaviour. In Mubi, this relationship can be reflected in dependence on boreholes, hand-dug wells and water vendors, variations in water expenditure, and differences in access to water infrastructure. Recent studies emphasize this coupled evolution of human and water systems (Fischer et al., 2021; Gu et al., 2021).

The two ways of thinking are brought together in this study through maps and surveys. The maps uses elevation, slope, aspect, drainage, flow direction, and flow accumulation to examine the physical factors controlling runoff and potential groundwater recharge. These maps help show how water runs off and where groundwater can be found. The surveys ask people about where they get water, how much they use, how much they pay, how easy it is to get, how reliable it is and how they deal with water shortages. Putting these parts together helps identify areas where physical water conditions and social or infrastructural constraints overlap. This way of working is also like the Mubi South groundwater study, which showed that maps and images, from the remote sensing can help find water under the ground (Shinggu et al., 2025).

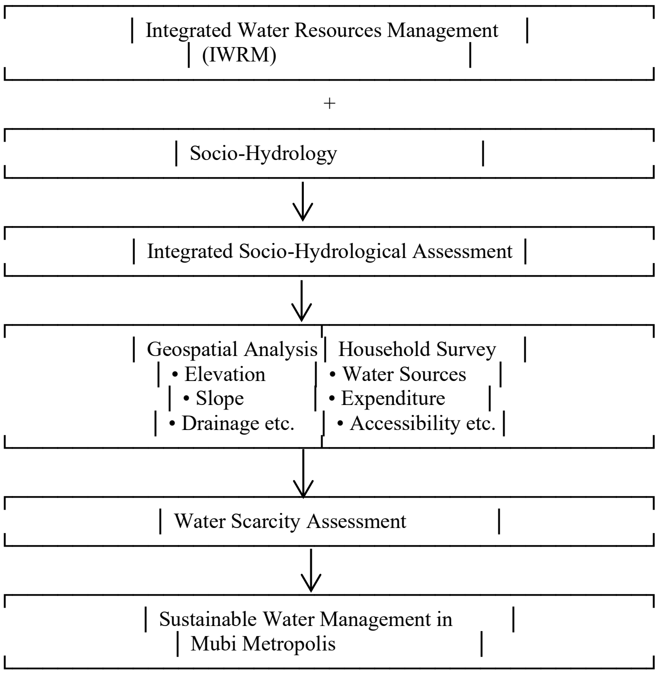

Figure 1: Integrated IWRM–Socio-Hydrology Framework for Water Scarcity Analysis in Mubi

Source: Author's construct, 2026

MATERIALS AND METHODS

Study Area

Mubi Metropolis is in Adamawa State, which is in the northeastern part of Nigeria. It includes areas from Mubi North and Mubi South Local Government Areas. The metropolis lies between latitudes 10°05′ and 10°30′ North and longitudes 13°12′ and 13°19′ East. It is a place for business and learning, in the northern part of Adamawa State. Over time it has seen a lot of growth in its city area (Boniface et al. 2024).

Mubi lies on the western bank of the Yedseram River, which flows northward toward Lake Chad, and is situated along the western flanks of the Mandara Mountains. The combination of the river system and surrounding upland terrain influences the area's drainage, surface-water movement, slope characteristics and other hydrological processes. The physical setting is therefore particularly relevant to the assessment of groundwater occurrence, runoff and water-resource management in the metropolis (Boniface et al., 2024).

Types of Data

Primary data include GPS coordinates of boreholes, field observations and questionnaire responses. Secondary data include SRTM 30-m digital elevation model (DEM), topographic maps and literature from publications.

Spatial Data and Hydrological GIS Modeling and their Sources

The physical evaluation of the landscape was carried out using two main methods. First a detailed field inventory was completed with Global Positioning System (GPS) receivers to record the coordinates of both public and private boreholes in all eight (8) wards. Secondly, a topographical map was produced to illustrate the elevation and general relief characteristics of the study area. Thirdly, terrain analysis was performed using a 30-meter resolution Digital Elevation Model (DEM) from the Shuttle Radar Topography Mission (SRTM) (Farr & Kobrick, 2000). Using analyst hydrological toolsets the DEM was processed to produce five essential thematic layers:

i. Drainage map to show stream networks and surface runoff channels throughout the wards.
ii. Slope map to calculate the steepness of each pixel highlighting areas of runoff versus infiltration.
iii. Aspect map to determine the direction each slope faces showing areas that get amounts of solar light which affects evaporation, soil moisture, plant cover and groundwater recharge.
iv. Flow direction map using the D8 algorithm to trace the path of surface water.
v. Flow accumulation map to find where upstream cells empty, into channels indicating aquifer recharge zones.

Table 1: Spatial and Non-Spatial Datasets Used in the Study

Dataset	Source	Resolution/Scale	Purpose
SRTM DEM	USGS	30 m	Terrain analysis
Borehole GPS Coordinates	Field Survey	Point Data	Infrastructure mapping
Questionnaire Responses	Field Survey	384 Respondents	Socio-hydrological assessment
Administrative Boundaries	Adamawa GIS Database	Vector	Spatial referencing

Source: Authors' Compilation (2026)

Survey Design, Sampling Matrix and Questionnaire Structure

For the purpose of this study, Mubi Metropolis was defined to include eight wards which are Kolere, Lokuwa, Nassarawo, Gude, Yelwa, Sabon Layi, Digil and Lamurde. A household survey was conducted across these wards using Cochran's (1977) sample-size formula, which produced a sample of 384 respondents at a 95% confidence level (Z=1.96), 5% margin of error (e=0.05), and an assumed population proportion of 0.50. Respondents were selected through stratified sampling based on ward household populations with random sampling employed within each ward to ensure adequate representation. The Cochran's formular for calculating sample size is:

$$n = \frac{Z^2 pq}{e^2}$$

Where: Z=1.96, p=0.50, q=0.50 and e=0.05. The resulting sample size was 384 households.

Data were collected using a questionnaire comprising four sections: (A) demographic and socio-economic characteristics, (B) water access indicators such as water sources, supply reliability, distance, to sources and household expenditure, (C) Likert-scale perceptions of water-related challenges and (D) coping strategies and sustainable water-management preferences. The collected data were analyzed using descriptive and inferential statistics and the results were compared with spatial borehole-mapping outputs to identify patterns of water scarcity and access.

DATA ANALYSIS

We analyzed the questionnaire data by looking at frequencies, percentages, and cross-tabulations. We interpreted the maps by comparing them across wards. We then put the results into a sustainability discussion.

RESULTS AND DISCUSSION

Results Presentations

Geospatial Modeling Analyses of Terrain and Drainage Networks

The physical distribution of water resources in Mubi Metropolis is heavily constrained by the interactions between surface topography and infrastructure development. The geospatial models illustrate the variations in environmental conditions across the study area.

Spatial Analysis of Number of Boreholes in Mubi Metropolis

The number of boreholes map (Figure 2) displays a highly unequal spatial pattern of water infrastructure throughout the metropolis. Core urban wards specifically Sabon Layi, Kolere, Lokuwa and parts of Yelwa exhibit dense concentrations of private and commercial groundwater extraction points. This high density is a direct response to the lack of functional municipal public water systems, prompting private households and businesses to fund self-sourcing solutions. In contrast, the peripheral wards of Digil and Gude show low borehole counts. Residents in these areas rely on a few number boreholes or wells, resulting in severe physical infrastructure gaps.

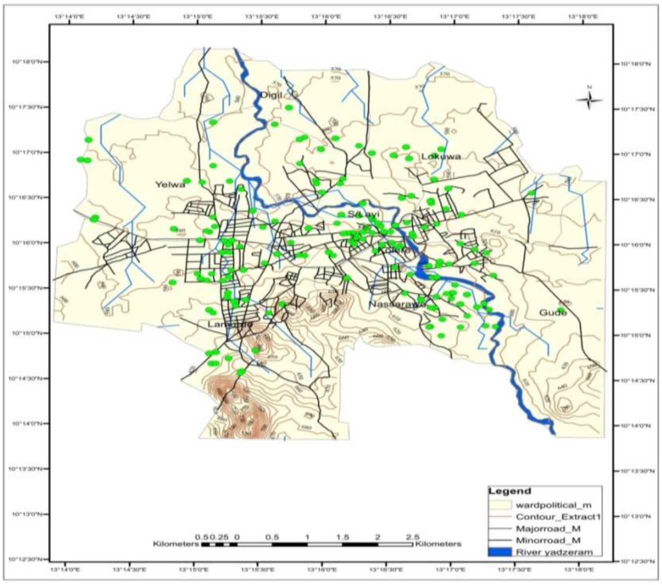

Figure 2: Borehole Location Map

Source: Author's fieldwork, June 2026

Topographical Characteristics of Mubi Metropolis

The topographical analysis of Mubi Metropolis (Figure 3) shows that higher and steeper terrains are concentrated in the southeastern wards such as Lamurde, Nassarawo, Gude and parts of Lokuwa while lower and flatter areas are mainly found in the central and western wards such as Yelwa, Sabon Layi, Kolere and Digil. These elevation differences shape surface runoff, groundwater recharge and settlement patterns. In high-elevation areas surface runoff happens quickly. Infiltration is limited which reduces groundwater availability. In low-lying areas water tends to accumulate and infiltrate more which increases groundwater recharge and makes groundwater more accessible. Consistent with studies (Machiwal et al., 2011; Rahmati et al. 2016; Nag & Ghosh 2013), the findings highlight the importance of topography in controlling groundwater occurrence, runoff patterns and land use. Thus topography is a factor for groundwater exploration, water-resource management and sustainable urban planning, in Mubi Metropolis as noted by Shinggu et al., 2025.

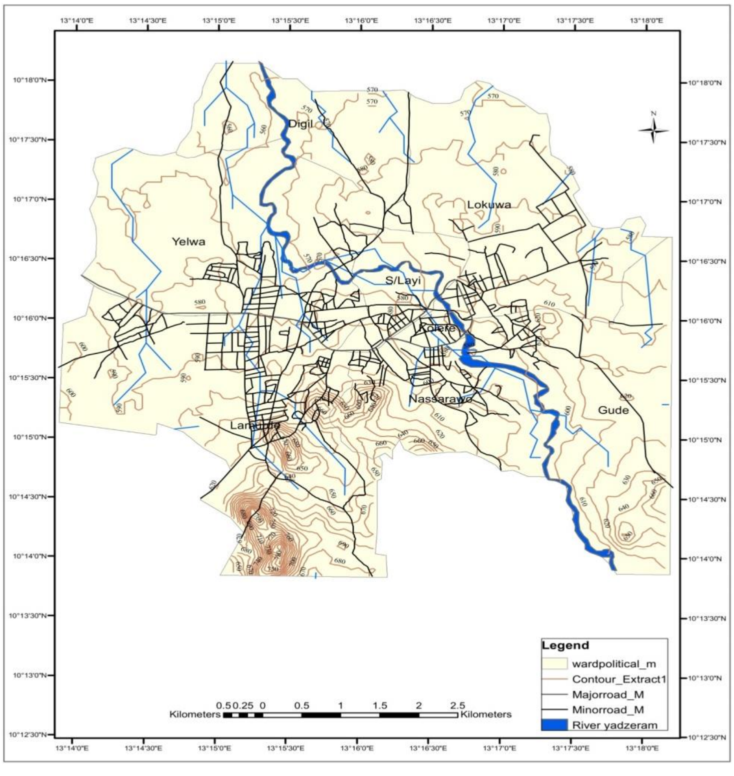

Figure 3: Topographical Map of Mubi Metropolis

Source: Author's GIS analysis, 2026

The Slope Map of Mubi Metropolis

The slope map (Figure 4) shows how steep the area is. Red spots on the slope map show the hills while white spots show the flattest ground. Looking at the slope map, it is clear that how steep the land is changes how groundwater works in the area. The eastern and southeastern parts of the city in Lamurde, Nassarawo, Gude and part of Lokuwa have very steep hills. Because these hills are steep rainwater runs off the surface very fast. This fast water moves into streams. Because of this people in these wards have to drill deeper wells, which make the cost of installing wells much higher for residents. On the hand the middle parts of the city like Yelwa, Sabon Layi, Kolere, Digil and some parts of Lokuwa, Lamurde and Gude wards sit on flat plains. These flat areas slow down the rainwater. This helps the water pool up and sinks into the ground to refill the aquifers.

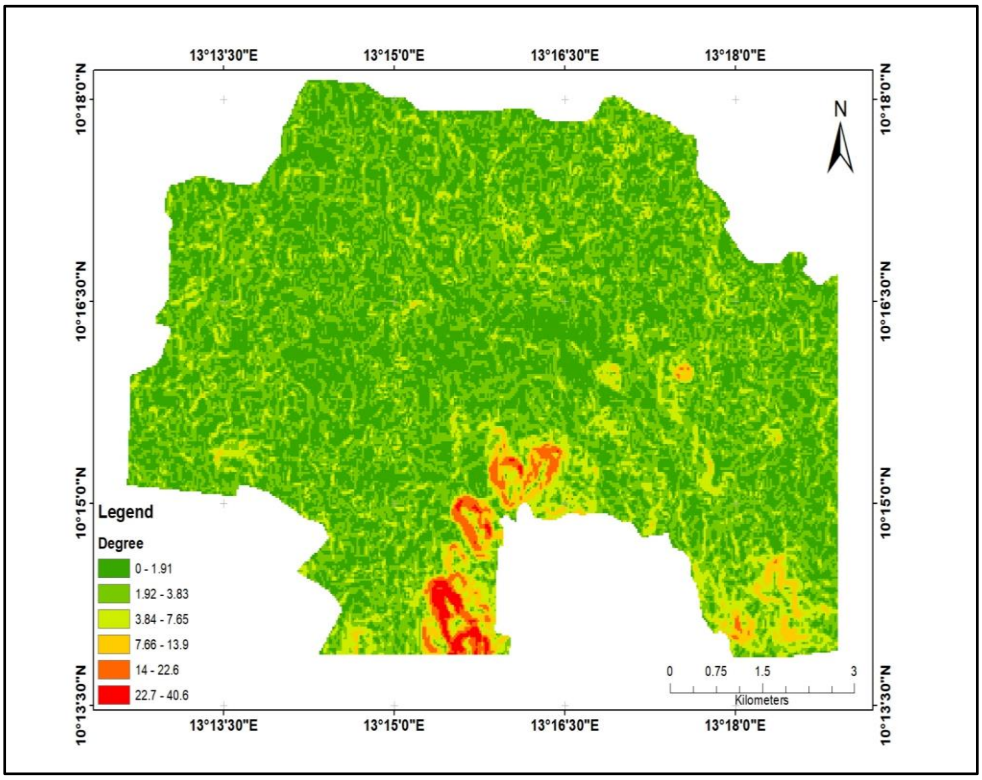

Figure 4: Slope Map of Mubi Metropolis

Source: Author's GIS analysis, 2026

The Aspect Map of Mubi Metropolis

The aspect map of Mubi Metropolis shows which way slopes face and how that influences water processes. Slope aspect affects the amount of radiation received which influences water evaporation and plant water use soil water staying in the ground plant growth and groundwater filling. Slopes that receive sunlight tend to lose moisture more quickly while shaded slopes keep moisture for longer creating more suitable conditions for groundwater filling. Previous studies have identified aspect as a factor influencing groundwater occurrence and recharge potential (Machiwal et al., 2011; Shinggu et al., 2025; Rahmati et al., 2016). In Mubi Metropolis variations in slope orientation contribute to differences in water availability and surface runoff patterns across wards. Consequently aspect is a parameter for identifying suitable locations, for groundwater development, rainwater harvesting and water-conservation measures thereby supporting sustainable water-resource management and planning.

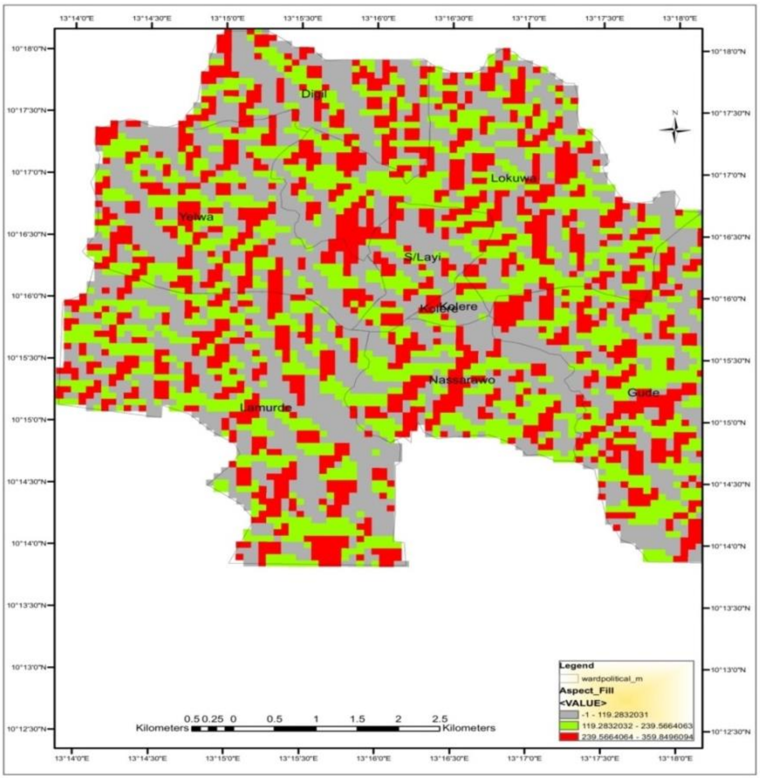

Figure 5: Aspect Map of Mubi Metropolis

Source: Author's GIS analysis, 2026

Drainage Pattern in Mubi Metropolis

The water drainage pattern in Mubi Metropolis (Figure 6) looks mostly like dendritic pattern. Most of the water flows from the highlands in the south and northeast down toward the areas in the middle and north. This drainage patterns change how surface water moves, how groundwater fills up, how soil washes away and how often floods happen. Places where there is small drainage paths water run off very fast and soak into the ground very little. This makes it hard for groundwater to refill in those spots. On the other hand, places with fewer drainage paths let more water soak into the ground but those areas might face more flooding. Like what other researchers found (Machiwal et al., 2011; Nag & Ghosh 2013; Rahmati et al. 2016; Shinggu et al. 2025), these results show that how drainage is spread out across the land really changes how much water is available and how much groundwater is there. Because of this study, drainage is a must if we want to develop groundwater, manage floods and plan for water resources, in Mubi Metropolis in a way that lasts.

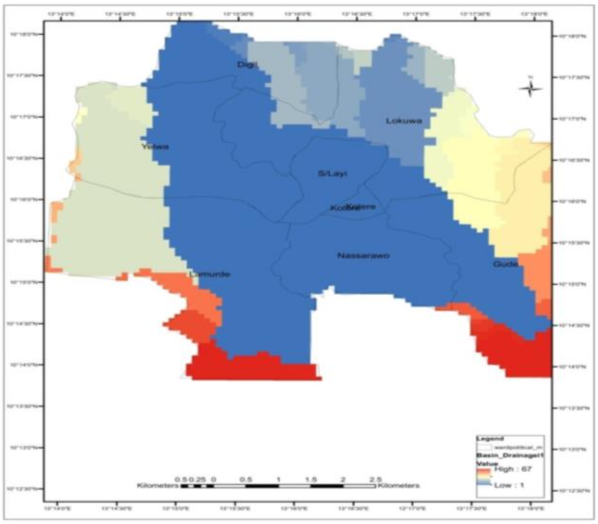

Figure 6: Stream Drainage Pattern

Source: Author's GIS analysis, 2026

Flow Direction of Mubi Metropolis

Figure 7 shows that surface runoff in Mubi Metropolis generally moves from the southern and northeastern areas toward the lower central and northern parts. This movement of surface runoff influences drainage groundwater recharge and the availability of water. In higher areas, surface runoff happens quickly and less water seeps into the ground, which means groundwater recharge is lower. In lower areas, surface runoff gathers, which can help groundwater recharge and create temporary water storage (Rahmati et al. 2020; Shingu et al. 2025). As a result low-lying areas are more likely to flood while higher areas may face shortages of water during dry seasons. These differences in surface runoff patterns affect how households rely on boreholes, hand-dug wells and water vendors. Therefore analysing surface runoff direction is essential, for developing groundwater reducing flood risk and planning water resources (Boniface et al. 2024).

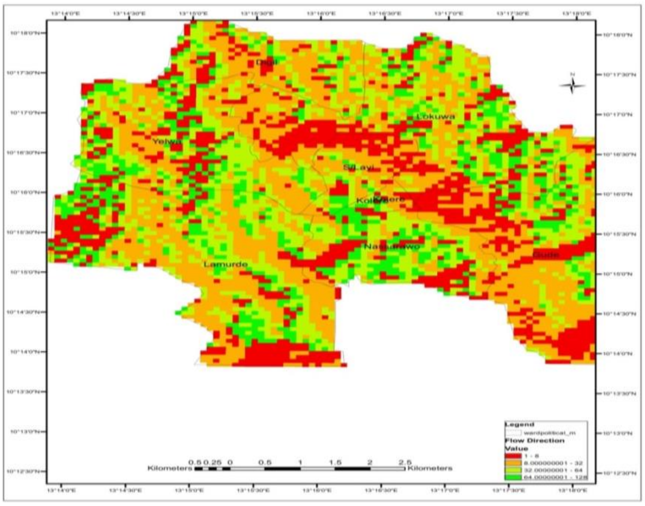

Figure 7: Flow Direction Map of Mubi Metropolis

Source: Author's GIS analysis, 2026

Flow Accumulation of Mubi Metropolis

The flow accumulation (Figure 8) analysis shows that water running off from the parts of Lamurde, Nassarawo, Gude and some areas of Lokuwa usually moves toward the lower parts of Digil, Yelwa, Sabon Layi, Kolere and some areas of Lokuwa, Lamurde and Gude. These areas where water accumulates help water soak into the ground and create shallow groundwater making them important zones for groundwater potential (Shinggu et al., 2025; Rahmati et al., 2020). However the groundwater, in these areas is not very deep. This can lead to more wells being dug. It also makes the groundwater easier to get polluted. This is especially true where there is not good sanitation and drainage systems (World Bank, 2025; Boniface et al., 2024).

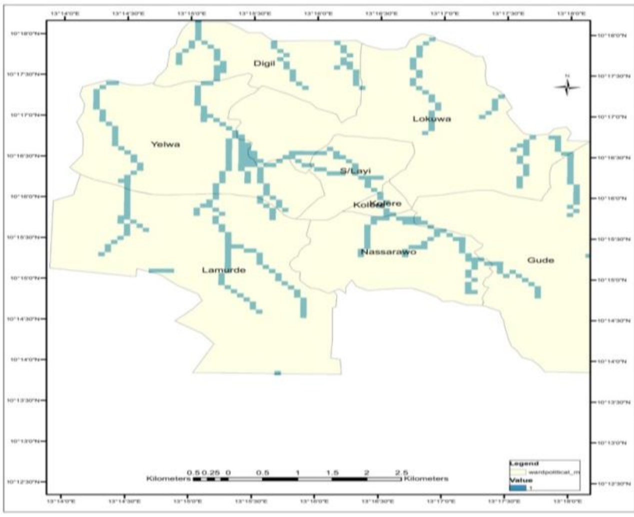

Figure 8: Flow Accumulation Map of Mubi Metropolis

Source: Author's GIS analysis, 2026

Socio-Hydrological Synthesis: Questionnaire and Water Sources Results

Integrating terrain data and household survey results together shows a link between geographic location, infrastructure density, and household water security. Our study covered all the eight wards of Mubi Metropolis. We used stratified sampling to hand out 400 questionnaires. Out of those we got 384 responses back to analyze. This means we had a 96.0% response rate, for our study.

Table 2: Household Socio-Economic and Demographic Characteristics (Sections A-D)

SECTION A: Demographic & Socio-Economic Analysis

Demographic Variable	Category/Ward	Frequency (N)	Percentage (%)
Ward Breakdown (n=384)	Sabon Layi Ward	70	18.23%
	Yelwa Ward	58	15.10%
	Nassarawo Ward	52	13.54%
	Kolere Ward	48	12.50%
	Lokuwa Ward	60	15.62%
	Gude Ward	36	9.38%
	Digil Ward	30	7.81%
	Lamurde Ward	30	7.81%
Total		**384**	**100%**
Gender	Male	210	54.7%
	Female	174	45.3%
Total		**384**	**100%**
Age Group	18 - 30 years	145	37.8%
	31 - 45 years	162	42.2%
	46 - 60 years	61	15.9%
	Above 60 years	16	4.2%
Total		**384**	**100%**
Educational Attainment	No Formal Education	24	6.3%
	Primary Education	40	10.4%
	Secondary Education	102	26.6%
	Tertiary Education (Degree/HND/ND/NCE)	218	56.8%
Total		**384**	**100%**
Household Size	1 - 3 persons	48	12.5%
	4 - 6 persons	154	40.1%
	7 - 10 persons	122	31.8%
	More than 10 persons	60	15.6%
Total		**384**	**100%**

SECTION B: Water Sources, Accessibility and Expenditure

Water Source & Accessibility Metric	Frequency (n=384)	Percentage (%)
Primary Source: Water Vendors (Mai Ruwa)	165	43.0%
Primary Source: Private/Commercial Borehole (Hand-pump/Motorized)	142	37.0%
Primary Source: Hand-dug Well	35	9.0%
Primary Source: Water Tankers/Trucks	32	8.0%
Primary Source: Steams/ Rivers	10	3.0%
Primary Source: Public Tap/Municipal Piped Scheme	0	0
Total	**384**	**100%**
Supply Reliability: Daily/Continuous	58	15.1%
Supply Reliability: 2 - 3 times a week	92	24.0%
Supply Reliability: Irregular/Severe Dry Season Interruption	234	60.9%
Total	**384**	**100%**
Distance to Source: Within Compound	98	25.5%
Distance to Source: Less than 100 meters	128	33.3%
Distance to Source: 100 - 500 meters	112	29.2%
Distance to Source: More than 500 meters	46	12.0%
Total	**384**	**100%**
Weekly Household Expenditure: Below ₦2,000	52	13.5%
Weekly Household Expenditure: ₦2,000 - ₦5,000	198	51.6%
Weekly Household Expenditure: Above ₦5,000	134	34.9%

Total	**384**	**100%**

SECTION C: Likert Scale Perception Analysis

Perception Statement	SA (%)	A (%)	N (%)	D (%)	SD (%)
Water scarcity is a critical problem in my neighborhood ward	65.1%	24.4%	4.2%	5.1%	1.2%
Severe water shortage occurs during the dry season	78.4%	15.6%	2.1%	3.1%	0.8%
Daily water supply is insufficient for household domestic needs	52.3%	33.1%	6.0%	7.0%	1.6%
Women and children bear primary physical burden of fetching water	61.5%	26.3%	5.2%	5.5%	1.5%
Household has suffered water-borne disease (typhoid/cholera)	28.6%	42.2%	11.5%	14.1%	3.6%
High vendor cost significantly affects overall monthly family budget	72.1%	19.3%	3.6%	4.2%	0.8%

SECTION D: Coping Strategies & Sustainable Management Preferences

Strategy & Management Option	Frequency (n=384)	Percentage (%)
Primary Coping Strategy: Storing water in large tanks/drums	211	55.0%
Primary Coping Strategy: Rainwater harvesting during wet seasons	98	26.0%
Primary Coping Strategy: Recycling greywater (re-use)	6	2.0%
Primary Coping Strategy: Relying heavily on alternative commercial vendors	67	17.0%
Total	**384**	**100%**
Purification Practice: Purchasing bottled/sachet water	165	42.9%
Purification Practice: Chemical treatment (Water-guard/Chlorine)	52	13.5%
Purification Practice: Boiling water	53	13.8%
Purification Practice: None (Drink directly from source)	114	29.8%
Total	**384**	**100%**
Rating Government Interventions: Ineffective/ Non-existent	298	77.6%
Rating Government Interventions: Moderately Effective	74	19.3%
Rating Government Interventions: Very Effective	12	3.1%
Total	**384**	**100%**
Sustainability Priority: Rehabilitation of public piped water systems	168	43.8%
Sustainability Priority: Solar-powered public boreholes in each ward	144	37.5%
Sustainability Priority: Community-led water management committees	42	10.9%
Sustainability Priority: Strict regulation of local private water vendors	30	7.8%
Total	**384**	**100%**

Source: Results of Field Survey, 2026

Discussion of Results

Socio-Hydrological Synthesis of Questionnaire and Water Sources in Mubi Metropolis

The results show that water scarcity in Mubi Metropolis does not just happen because there is no water. It also happens because of location, household characteristics, affordability and inadequate infrastructure. The study had a 96.0% response rate which means 384 responses was obtained from 400 questionnaires across the eight wards.

Demographic and Socio-Economic Characteristics

Respondents were well distributed across the study area. The highest numbers came from Sabon Layi (18.23%), Lokuwa (15.62%), Yelwa (15.10%). In terms of gender males constituted 54.7% while females 45.3%. Most of the people (80.0%) were between 18–45 years old. Looking at educational levels 56.8% had tertiary education and 26.6% had secondary education. Most families were quite large. In fact, 87.5% have four (4) or more members, 31.8% with 7–10 members and 15.6% with more than 10 members. These facts about the people show that there is a demand for water, in every home. These details help us understand why water-security challenges are so hard to fix in Mubi Metropolis.

Water Sources and Accessibility

The results show that people rely heavily on private ways to get water. Water vendors, known as Mai Ruwa are the way people get water serving 43.0% of households. This tells us that the official water systems are failing to give people the water they need. Relying on water vendors can be hard because it often costs money, the water quality might change and not everyone can get it easily. Private and commercial boreholes are the most common way to get water, used by 37.0% of people. Another 8.0% of people said they use water tankers/trucks. If you add up water vendors, boreholes and water tankers they make up 88.0% of all household water sources. This shows that getting water in Mubi Metropolis is becoming a matter rather than a public service. While boreholes pumping too much water from the ground might cause water levels to drop, especially during the long dry seasons. Hand-dug wells and Streams/Rivers were used by 12.0% of people as their water source. It was surprising to see that not a single person said they relied on taps or city water pipes as their main source. This total lack of use of water pipes shows that the systems are in very bad shape. It also shows that the government cannot provide water for the growing number of people living in the city. Because of this, families have had to find ways to get their daily water. Some households (9.0%) still use hand-dug wells. This shows that old ways of getting water are still around especially where there are no pipes. However, these wells can be dangerous because they can get dirty easily or dry up when the weather changes.

Water Supply Reliability

One of the problems we found is that water supply is very unreliable across the whole city. 15.1% of people said they get water every day or have a steady supply. On the hand 60.9% of people said their water comes and goes and they face major shortages during the dry season. This matches what we saw in our maps, which showed that water stress is a problem in many wards during certain times of the year. Since many people struggle with unreliable water it is clear that water scarcity is a constant problem, not just something that happens once in a while. The dry-season shortages might be happening because groundwater is dropping there is rain the population is growing too fast or the pipes are too old. It could also be due to climate changes and shifting rainfall patterns. Because the water is so unreliable, families constantly have to find ways to cope just to survive.

Distance to Water Sources

Accessibility analysis shows that 58.8% of households can get water within 100 meters of their home. Still a large part of the community must walk farther: 29.2% travel between 100 and 500 meters and 12.0% travel than 500 meters. These distances may seem small in terms but when you think about daily water needs several trips a day the difficulty of transport and the physical strain on women and children they become very important. The spread of water infrastructure likely causes these differences with some wards having boreholes than others.

Economic Burden of Water Acquisition

The cost of getting water is high. More than half of the people asked (51.6%) spend between ₦2,000 and ₦5,000 each week on water. Another 34.9% spend more than ₦5,000 a week. In total 86.5% of households spend more than ₦2,000 each week on water. For families, especially those who do not have a lot of money this money takes up a big part of what they can spend on other things. The high price is mainly because they must buy water from vendors or from privately run boreholes. The results show that water has changed from a service to an expensive item. This change hurts families the most and adds to social inequality.

Community Perceptions of Water Scarcity

The survey used a Likert scale. Found that most people agree that water is a big problem. A total of 89.5% strongly agreed or agreed that water scarcity is a critical problem in their neighborhoods. Likewise 94.0% said that the dry season is very bad. These results show that water insecurity is known by everyone in the city not in a few wards. Also 85.4% agreed that the water available is not enough for home use. This view matches the fact that people use water sources and store water. The strong agreement shows that water scarcity has become a part of daily life for residents.

Gender Dimensions of Water Scarcity

The findings show that all people (87.8%) think that women and children carry the main load of getting water. This matches patterns seen across sub-Saharan Africa where women are usually the ones to collect water. The result means that children may miss school people get tired work slows and health risks rise. These gender effects show that we need water projects that help cut down the amount of water that families have to collect.

Water Public Health Implications

The study also found a link between water scarcity and health. 70.8% of people either strongly agreed or agreed that their homes had illnesses from bad water, such as typhoid and cholera.

Household Coping Strategies

The way people cope is by storing water. More than half of households (55.0%) keep water at home to use when supply is low. The second common method is collecting rainwater (26.0%). Some people also use greywater. Only 6.0% do it so most people do not know about these conservation methods. Many households use storage because they have to deal with breaks in water supply instead of expecting water all the time. The study shows that many households use water or do not treat water enough. Almost half of the people (42.9%) buy sachet water and 13.5% add chemicals to water. However 29.8% drink water from the source without treatment. These habits expose families to health and raise health costs which add more pressure from water scarcity.

Perception of Government Intervention

People are not happy with how the government handles water problems. 77.6% think that government action is not working or does not exist and only 3.1% think government works very well. This shows that public water systems are getting worse and private options are growing. If people keep losing trust in government new water projects will fail unless big changes happen.

Sustainable Water Management Priorities

When asked what should be done first, most people chose fixing the public piped water system (43.8%). They want the water that goes through pipes to be fixed. The next choice was solar-powered boreholes (37.5%) showing that people like clean energy and local water. A few people (10.9%) said community management committees are needed and 7.8% wanted rules for vendors. The strong support for fixing water shows that residents think government projects are the best long-term fix for water problems.

Socio-Hydrological Implications

The maps and questionnaire survey together show that water scarcity in Mubi Metropolis is driven by the interaction of hydrological limitations, inadequate infrastructure, socio-economic vulnerability and population growth. The study shows a cycle: less water availability increases dependence on private sources, increased dependence raises household expenditure, higher costs intensify socio-economic vulnerability, vulnerability influences household adaptation strategies, adaptation strategies shape future water demand patterns. This cycle shows that people and water problems keep affecting each other and shape water security, in the city.

CONCLUSION

The results show that Mubi Metropolis has water security problems. These problems include water supply that is not reliable, a reliance on informal vendors, high household spending on water, widespread public dissatisfaction and recurring seasonal shortages in Mubi Metropolis. The socio-hydrological analysis confirms that water scarcity is a problem of both nature and society. Sustainable solutions must focus on repairing public water infrastructure, expanding solar-powered boreholes, promoting rainwater harvesting, monitoring groundwater and encouraging community participation in water governance. These actions will improve water security for households, reduce burdens and strengthen the long-term resilience of the water system in all eight (8) wards of Mubi Metropolis.

RECOMMENDATIONS

i. The Adamawa State Government and Mubi Local Government Authorities should improve public water supply infrastructure. They must repair existing water facilities. Expand piped water networks so that people will have affordable water services.
ii. The State Government should install solar-powered boreholes in areas that lack water. This will give an uninterrupted source of water.
iii. Government agencies, NGOs and private investors should help promote rainwater harvesting and groundwater recharge. These actions will increase water availability thereby reduce water shortages.
iv. The Adamawa State Water Board and other stakeholders should develop a GIS-based water monitoring system. This system will track boreholes, groundwater levels, water quality and water demand and it will help plan and manage water resources.
v. The Government should boost community participation, in water governance. It can do this by forming committees and running public awareness programs that teach people about water conservation and sustainable use.

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Conflict of Interest

The authors declare no conflict of interest.

Ethical Approval

All procedures involving human participants were conducted in accordance with accepted ethical standards. Participation was voluntary and informed consent was obtained from all respondents.

Data Availability Statement

The datasets generated and analyzed during this study are available from the corresponding author upon reasonable request.

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