

DEMOGRAPHIC AND SOCIO-ECONOMIC INFLUENCES ON GROUNDWATER RELIANCE FOR DOMESTIC USE IN GOMBE METROPOLIS, NIGERIA

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Abstract

In a rapidly urbanizing Gombe Metropolis, where groundwater has become the primary water source for most households, understanding the demographic and socio-economic factors shaping its use is essential to mitigate an emerging water security crisis. This study investigates how demographic and socio-economic characteristics influence groundwater usage patterns and explores their implications for sustainable water management. A total of 394 respondents were selected using a multistage stratified random sampling technique across 14 wards in four Local Government Areas of the metropolis. Data were collected through structured questionnaires and field observations, capturing household income, education, occupation, household size, and water use behaviors. Descriptive statistics were employed to present frequencies and percentages, while inferential analyses including Spearman's rank-order correlation and Chi-square tests were used to examine the relationships between variables. The findings show that male respondents constituted 66.5% of the sample, with the predominant age group being 39–59 years (33%). Educational attainment was generally low, with 13.7% having no formal education and only 26% attaining tertiary education. Occupation-wise, 24% were engaged in trading, 21% in civil service, and 18.5% in farming. About 51% of households rely primarily on groundwater sources, while 23% use municipal supply, 20% depend on rainwater, and only 3% use surface water. Groundwater dependency was high, with 36% of respondents relying on it for 51–75% of their needs. A strong, statistically significant correlation was observed between household size and daily water consumption ($p = 0.92, p < 0.001$) and between income level and groundwater dependency ($p = 0.79, p < 0.001$). Chi-square tests further confirmed significant associations between income and groundwater reliance. Despite groundwater's importance, issues of reliability and treatment persist; only 25% found it very reliable, while 41% never treat it before use. The study recommends public education, regular quality monitoring, and investment in alternative municipal and rainwater infrastructure to ensure sustainable groundwater use.

Keywords: Groundwater Reliance, Domestic Water Use, Socio-Economic Factors, Gombe Metropolis

INTRODUCTION

Groundwater remains an indispensable component of global water supply systems, playing a vital role in sustaining domestic, agricultural, and industrial demands. It accounts for nearly one-third of the world's drinking water and serves as a reliable freshwater source across both rural and urban landscapes (Nickson et al., 2005; Ocheri, Odoma, & Umar, 2014). In regions where surface water is seasonally unreliable or permanently scarce, groundwater serves as a critical buffer, particularly during droughts and dry seasons (Bassey, 2003; Wada et al., 2010; Treidel et al., 2012). However, pressures, especially in densely populated urban settings, exacerbate groundwater degradation, posing severe

public health risks and undermining access to safe water (Raju, Shukla, & Ram, 2011).

In sub-Saharan Africa, groundwater constitutes the primary source of drinking water, particularly in arid and semi-arid environments (Yang et al., 2024; UNICEF, 2013). Nigeria exemplifies this trend, with urban Centre increasingly dependent on groundwater due to the inadequacy of piped water infrastructure. Gombe Metropolis, in Nigeria's northeast, illustrates the convergence of demographic expansion, insecurity-driven in-migration, and infrastructural deficits. These factors have left most households relying heavily on groundwater for their domestic needs. Despite the misconception that groundwater is naturally protected by subsurface filtration, it remains

highly vulnerable to contamination from unregulated boreholes, septic tanks, and agricultural leachates (Sabo & Abubakar, 2013; Lapworth et al., 2023; Mbae et al., 2024).

Theoretically, demographic and socio-economic characteristics such as age, gender, household size, education, income, and occupation play an essential role in shaping household water access, use patterns, and adaptation strategies. These variables influence not only the demand for water but also perceptions of water quality, affordability, and willingness or capacity to invest in alternative water sources, such as boreholes or storage tanks (Ocheri, Odoma, & Umar, 2014). In a context like Gombe Metropolis, where formal water infrastructure is limited and unevenly distributed, such human dimensions are important determinants of groundwater reliance. Yet, despite this theoretical and practical relevance, there is a surprising lack of empirical research investigating how demographic and socio-economic factors influence groundwater dependence in Gombe. This oversight represents a serious gap in knowledge that undermines the formulation of evidence-based, equitable, and sustainable water governance

strategies. Without a clear understanding of who uses groundwater, how, and why, policymakers are ill-equipped to manage growing demand, ensure water quality, or protect vulnerable populations.

This study, therefore, seeks to address this gap by examining the demographic and socio-economic influences on groundwater reliance for domestic use in Gombe Metropolis. The findings will guide local authorities and stakeholders in developing informed, inclusive, and sustainable water management interventions that enhance water security and public health resilience in Gombe and similar urbanizing contexts.

MATERIALS AND METHODS

Study Area

Gombe Metropolis, situated in northeastern Nigeria, lies between latitudes 10°14'N and 10°19'N and longitudes 11°07'E and 11°12'E (Geodatos, 2024). It is bordered by Kwami LGA to the north, Akko LGA to the southwest, and Yamaltu Deba LGA to the east. The metropolis spans approximately 54 km² at an altitude of 500 meters above sea level (Gombe Master Plan 2003-2030, 2003; Maina et al., 2016).

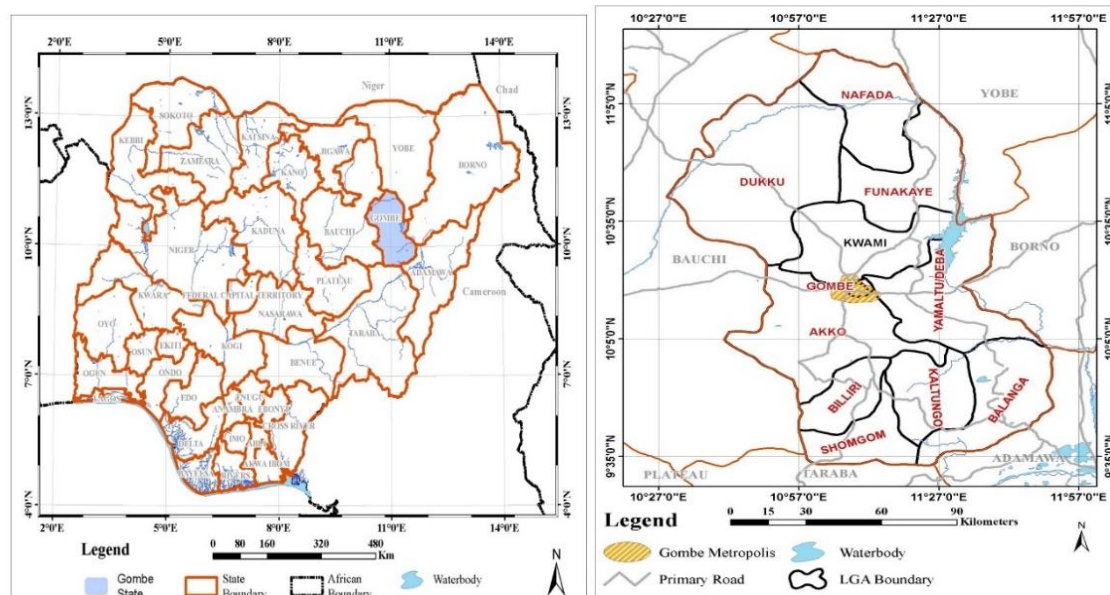


Figure 1: Nigeria, Gombe State

Source: Gombe State Geographic Information System (GOGIS), 2024

The geology and hydrogeology are underlain by cretaceous sandstone formations, overlain by tertiary and quaternary deposits. The hydrology is shaped by ephemeral streams and ravines, influenced by ferruginous soils derived from basement rock

weathering (Amos et al., 2015; Hati et al., 2011). Hydrogeological conditions are governed by crystalline and sedimentary formations impacting groundwater availability (Sabo et al., 2013; Mayomi et al., 2016). Relief and drainage, the elevation ranges

from 330 to 721 meters, with conical hills from late Cretaceous deposits. Gully erosion is a concern, altering groundwater recharge, particularly in high-susceptibility zones identified through GIS studies (Mayomi et al., 2018; Igwe et al., 2020; Abashiya & Sule, 2024).

Climate and soils fall within the Sudan Savannah zone, experiencing a wet season (April-October) and a dry season (November-March). August records the highest rainfall (264.78 mm), while March-April sees peak temperatures up to 35°C (Mbaya et al., 2017; Maina & Ezeashi, 2015). Sandy soils promote infiltration, whereas clay soils restrict it, affecting groundwater recharge (Danladi & Ray, 2014; Mbaya et al., 2012). The Study area population grew from 169,894 in 1996 to 312,467 in 2006, with a projected 573,000 by 2024 (NPC, 2006). Economic activities include agriculture, commerce, and services, supporting the region's role as a commercial hub (Ahmad et al., 2018; Maina et al., 2006).

Methodology

This study employed a cross-sectional research design to investigate the demographic and socio-economic influences on groundwater reliance for domestic use in Gombe Metropolis, Nigeria. A multi-method approach was adopted, combining structured household surveys, field observations, and reconnaissance assessments. Data were collected from both primary and secondary sources. Primary data included responses from a structured questionnaire administered to selected households, which captured information on demographic variables (e.g., age, gender, marital status, and education level), socio-economic status (e.g., income, occupation, and housing), and water usage patterns, including groundwater dependency, consumption levels, and treatment practices. Field observations provided additional insights into land use, surface and groundwater interactions, vegetation cover, and potential sources of contamination, while

the reconnaissance facilitated the creation of a sketch map, photographic documentation of water sources, and refinement of the survey instruments.

A multistage sampling technique was employed to ensure representative coverage. In the first stage, 14 wards were purposively selected across four Local Government Areas, Gombe, Akko, Kwami, and Yamaltu-Deba, based on spatial distribution. One community was then randomly selected from each ward for household-level data collection, yielding a total sample size of 394 respondents, proportionally distributed based on ward population (see Table 1).

Quantitative data analysis was conducted using both descriptive and inferential statistical techniques. Descriptive statistics, including frequencies, percentages and rankings, were used to summarize demographic profiles and groundwater usage patterns. To examine relationships between variables, Spearman's rank-order correlation was applied to assess the strength and direction of association between ordinal variables such as household size and daily water consumption, and income level and groundwater dependency. In addition, Chi-square tests of independence were employed to test for statistically significant associations between categorical variables, such as income group and level of reliance on groundwater. These statistical analyses provided a robust basis for understanding the complex interplay between socio-demographic factors and groundwater use in the study area.

The population of the study area was estimated at 385,770, translating to 58,010 households using the mean urban household size of 6.65 persons (Maina & Eziashi, 2017). The Yamane formula was used to calculate a sample size of 394 households, which was proportionally allocated across the selected wards (see Table 1). Structured questionnaires and observation checklists were utilized to collect household-level data.

Table 1: LGAs, Selected Wards, Population, Number of Households, Sample Size, and Percentage in Gombe Metropolis

LGAs	Selected Wards	Population	Number of Households	Sample Size	Percentage (%)
Gombe	Pantami	39,875	5,996	30	8
Gombe	Shamaki	64,164	9,649	47	12
Gombe	Herwagana	18,088	2,720	21	5
Gombe	Ajiya	6,522	981	8	2
Gombe	Bolari-East	27,734	4,171	33	8
Gombe	Bolari-West	46,692	7,021	54	14
Gombe	Dawaki	31,701	4,767	36	9
Gombe	Nasarawo	22,083	3,320	25	6
Gombe	Bajoga	25,481	3,832	30	8
Gombe	Jekadafari	31,701	4,767	36	9
Gombe	Kumbia-Kumbia	23,665	3,559	27	7
Kwami	Kwami	14,724	2,214	12	3
Y/Deba	Kwadam	2,818	424	6	2
Akko	Garko	30,522	4,589	29	7
Total	14 Wards	385,770	58,010	394	100

*Source: NPC, Gombe State Office, 2022;
Author Analysis, 2024*

RESULTS AND DISCUSSION

Demographic characteristics of the Residents of Gombe Metropolis

A demographic survey of Gombe Metropolis reveals that the household heads are predominantly mature individuals, with 33% of respondents falling within the 39–59 age group. This trend aligns with Wahl and Oswald (2010), who assert that older adults are often more aware of environmental changes due to their extended exposure and accumulated experience over

time. The implication of this age distribution suggests that the respondents may possess a more informed perception of the access and availability of groundwater, which could influence their water usage behaviors and responsiveness to water-related challenges see Figure 2. This is important because household heads are responsible for decision making in the households even related to water availability and usage.

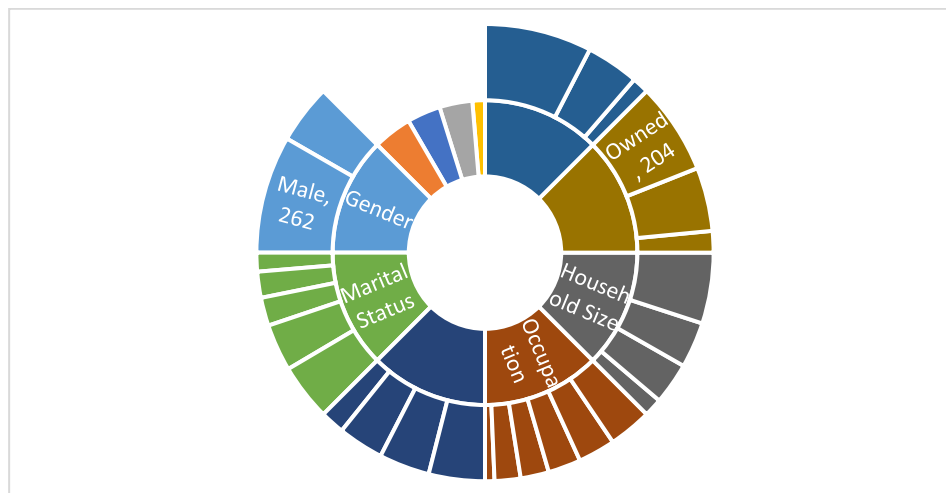


Figure 2: Demographic and Socio-economic Characteristics
Source: Author's analysis, 2024

The gender distribution presents a notable disparity, with 66.5% male and 33.5% female respondents. This imbalance may have implications for understanding groundwater reliance and management, as women traditionally serve as primary managers of household water in many rural and peri-urban communities (Greno, 2018). The underrepresentation of female voices could limit the depth of insights into household-level water use, particularly regarding the collection, storage, and treatment of groundwater.

Marital status data reveal a diverse population, with married individuals constituting the highest proportion (32%), followed by single (26.7%), divorced (15.9%), widowed (14.7%), and separated respondents (10.7%). This diversity in household structures underscores varying water needs and domestic usage patterns, influencing overall groundwater demand. Education levels further highlight the socio-economic variation in the metropolis, with 13.7% having no formal education, 31.7% completing primary school, and 26% attaining tertiary education. According to UNESCO (2009), higher levels of education are typically associated with greater environmental health awareness, which could positively impact how residents perceive and manage groundwater safety.

Occupationally, the respondents are engaged in farming (18.5%), trading (24%), animal husbandry (15.9%), and civil service (21%). The dominance of agriculture-related occupations indicates high vulnerability to groundwater contamination, particularly when such water is used for irrigation or livestock consumption, as affirmed by the Food and Agriculture Organization (1997). This economic dependence on water-intensive activities emphasizes the need for sustainable groundwater management strategies to safeguard livelihoods.

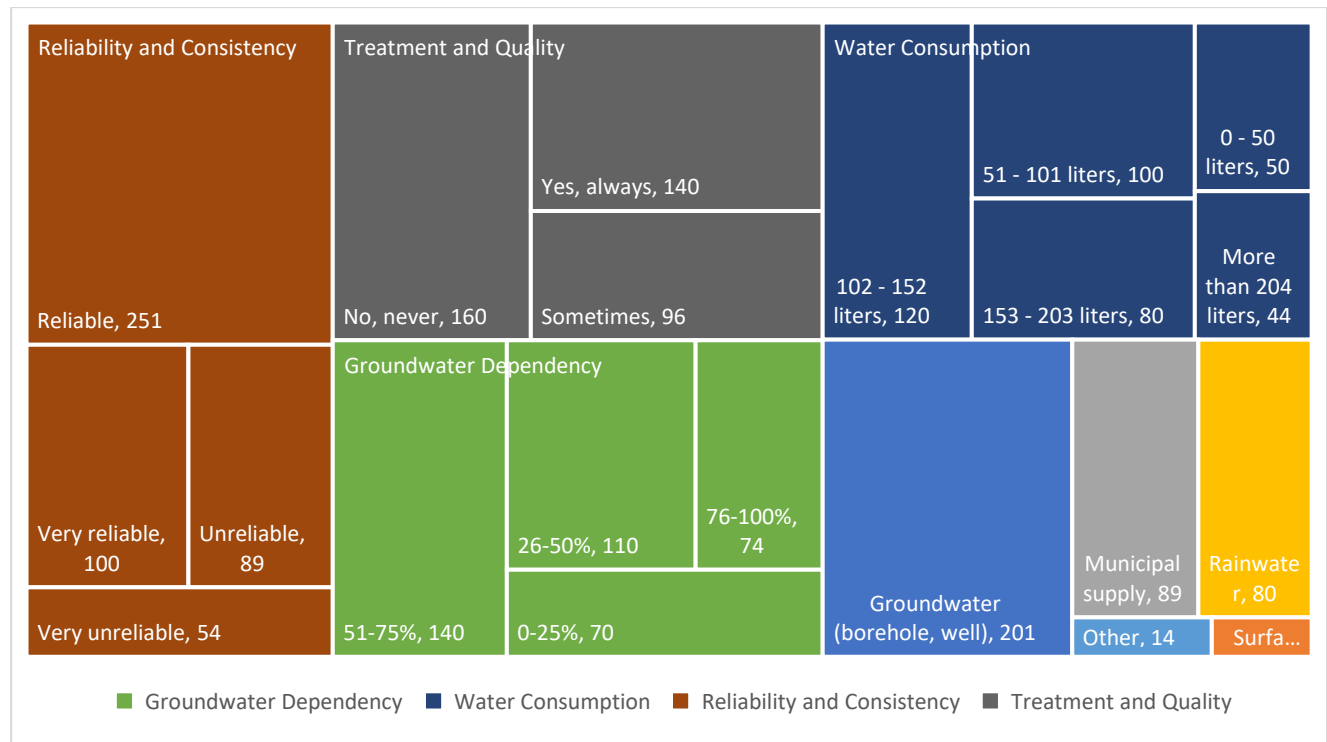
Household sizes further suggest that 40.1% of respondents live in homes with 1–5 members, while

a substantial 59.9% live in larger households exceeding six persons. Larger households are likely to exert increased pressure on groundwater resources for cooking, sanitation, and drinking. As Chand et al. (2023) note, such heightened demand can lead to over-extraction, reduced aquifer levels, and increase concentration of contaminants. The variation in housing types owned (52%), rented (36%), and informal (12.1%) also reflects socio-economic disparities, which may limit residents' control over water infrastructure and the ability to implement water quality interventions.

The income distribution shows that 61% of households earn between ₦1,000 and ₦5,000 per day, a figure that illustrates the financial constraints many families face. These economic limitations can affect the affordability of alternative safe water sources, compelling reliance on potentially contaminated groundwater. This socio-economic reality reinforces the significance of the study's findings in addressing how demographic and economic factors shape reliance on groundwater for domestic use. Therefore, the study provides critical insights into the local dynamics influencing water behaviour and affirms the necessity of context-specific interventions to ensure safe and sustainable groundwater use in Gombe Metropolis.

Contribution of Groundwater in Gombe Metropolis' Domestic Water Supply

The findings from this study reveal that groundwater is the dominant water source for households in Gombe Metropolis, significantly shaping domestic water use patterns. According to the survey data, 51% of respondents identified groundwater (including boreholes and wells) as their primary source of water, surpassing other sources such as municipal supply (23%), rainwater (20%), surface water (3%), and other sources (3%) (See Tree map 1).



Tree Map 1: Groundwater Contribution to Domestic Use in Gombe Metropolis

Source: Author's analysis, 2024

This dominance highlights groundwater's central role in meeting the households' needs for drinking, cooking, sanitation, and other domestic uses. Such reliance underscores the need for robust quality assurance and sustainable management, especially in urban areas where municipal water systems often fall short (Pineo, 2022).

The degree of dependency on groundwater varies across households. Notably, 36% of respondents reported using groundwater for 51–75% of their total water needs, while 28% depend on it for 26–50% of their needs. These findings resonate with studies in semi-arid regions, where groundwater serves as a supplementary source due to the irregularity or insufficiency of surface water (Stonestrom, 2007). Moreover, the diversification of water sources, although limited, reflects a resilience strategy among residents in response to fluctuating water availability. However, this partial diversification may not be sufficient to offset the adverse impacts of over-extraction and contamination, especially in rapidly growing urban centres (Kulkarni & Patil, 2017), such as Gombe metropolis.

Water consumption data shows that most households consume between 51–152 liters per day, which places considerable demand on available groundwater

resources. Importantly, only 25% of respondents consider their groundwater sources "very reliable," while 64% describe them as merely "reliable," and a significant portion (37%) find them unreliable or very unreliable. This suggests potential challenges related to groundwater recharge, seasonal variability, and infrastructural deficiencies.

In terms of water safety, 41% of households report never treating their groundwater before use, while only 36% treat it consistently. This lack of treatment poses significant public health risks, especially in communities where microbial and chemical contamination is a concern. The implication is clear: despite its centrality to daily life, groundwater is not uniformly safe or reliable, and efforts to monitor and improve its quality are urgently needed.

Overall, the study highlights the indispensable role of groundwater in Gombe Metropolis' domestic water supply. However, the findings also point to critical sustainability and health concerns. These issues must be addressed through targeted policy interventions, including regular water quality assessments, public education on safe water practices, and the implementation of integrated water resource management frameworks. The heavy reliance on groundwater, in line with global urban trends,

demands proactive governance to ensure long-term access to safe, adequate water

Inferential Analysis of Groundwater Reliance and Socio-Demographic Variables

Spearman's rank-order correlation was used to assess the strength and direction of association between groundwater reliance and key demographic and socio-economic factors. The analysis focused on two primary relationships: Household size and daily

(UNESCO, 2015).

water consumption with income level and groundwater dependency

Spearman's correlation is a non-parametric test appropriate for ordinal or ranked data (Table 2). It evaluates the extent to which increases in one variable correspond to increases or decreases in another, without assuming a linear relationship

Table 2: Groundwater Reliance and Socio-Demographic Characteristics

Variable	Category	Assigned Rank
Household Size	1–5 persons	1
	6–11 persons	2
	12–17 persons	3
	18 and above	4
Water Consumption	0–50 litres	1
	51–101 litres	2
	102–152 litres	3
	153–203 litres	4
	>204 litres	5
Income Level (₦/day)	₦1,000–₦5,000	1
	₦6,000–₦11,000	2
	₦12,000 and above	3
Groundwater Dependency	0–25%	1
	26–50%	2
	51–75%	3
	76–100%	4

Source: Author's analysis, 2024

Correlation between Household Size and Daily Water Consumption

H₀: There is no correlation between household size and daily water consumption while H₁: There is a significant correlation between household size and daily water consumption. Spearman's $\rho = 0.92$, p-value < 0.001. The result indicates that there is a very strong, and statistically significant correlation between household size and daily water consumption. This implies that as household size increases, so does the volume of water consumed. The result aligns with findings by UNICEF (2013), which indicate that larger households require more water for sanitation, cooking, cleaning, and drinking, placing increased pressure on groundwater sources in urban areas with poor municipal supply coverage. Household sizes are often large due to extended family living arrangements, this high demand may intensify the risk of groundwater depletion.

Correlation between Income Level and Groundwater Dependency

H₀: There is no correlation between income level and groundwater dependency while H₁: There is a significant correlation between income level and groundwater dependency. Spearman's $\rho = 0.79$ and p-value < 0.001

The result indicates a *positive, and statistically significant correlation* was observed between income level and groundwater dependency. Contrary to conventional assumptions that low-income groups rely more heavily on natural water sources, the data suggest that *higher income households can exhibit high reliance on groundwater*. This may be due to their capacity to invest in boreholes, tanks, and generators, thus bypassing unreliable or absent municipal water services. This finding is supported by Lapworth et al. (2023) and Kulkarni & Patil (2017), who note that even in urban Africa and South Asia, affluent households often turn to private groundwater systems as a coping strategy when public supply fails. This pattern poses a dual

challenge: while groundwater improves water access equity.

Table 3 reveals a very strong, positive, and statistically significant relationship between household size and daily water consumption ($\rho = 0.92$, $p < 0.001$), indicating that larger households tend to consume more groundwater. Similarly, a

strong, positive, and significant correlation exists between income level and groundwater dependency ($\rho = 0.79$, $p < 0.001$), suggesting that higher-income households rely more on groundwater sources. These findings confirm that both demographic and socio-economic variables significantly influence groundwater reliance patterns in Gombe Metropolis.

Table 3: Summary of Correlation Results

Variable Pair	Spearman's ρ	p-value	Strength & Direction	Conclusion
Household Size vs. Daily Water Consumption	0.92	< 0.001	Very strong, positive	Significant correlation
Income Level vs. Groundwater Dependency	0.79	< 0.001	Strong, positive	Significant correlation

Source: Author Analysis, 2024

CONCLUSION AND RECOMMENDATIONS

This study explored the demographic and socio-economic influences on groundwater reliance for domestic use in Gombe Metropolis, Nigeria. The results reaffirm that groundwater remains the predominant water source for the majority of households, primarily due to the inadequacy of municipal water infrastructure. The degree of reliance, however, varies significantly across demographic and socio-economic strata. The inferential analysis revealed a very strong, positive, and statistically significant correlation between household size and daily groundwater consumption ($\rho = 0.92$, $p < 0.001$), confirming that larger households exert greater pressure on available water resources. Likewise, a strong and significant correlation was found between income level and groundwater dependency ($\rho = 0.79$, $p < 0.001$), indicating that higher-income households, despite their financial capacity, are also reliant on groundwater sources often through privately owned boreholes and pumping systems.

The study also noted critical public health concerns, with only a minority of respondents consistently treating their water before use, leaving a significant portion of the population vulnerable to microbial and chemical contamination. The combination of high dependency, irregular reliability, and low treatment rates underscores the need for urgent, inclusive water governance.

To ensure the sustainability, safety, and equitable management of groundwater resources in Gombe Metropolis, the following policy actions are recommended:

- i. **Public Awareness and Behavioral Change Campaigns:** Targeted education programs should be intensified to promote safe water use, particularly among low-income and low-education households.
- ii. **Household Demand Management:** Water efficiency strategies should be introduced for large households through subsidized access to water-saving devices and promotion of rainwater harvesting, thereby reducing excessive drawdown on aquifers.
- iii. **Community-Based Monitoring and Regulation:** Local authorities should implement community-led groundwater quality monitoring systems and establish water user associations to regulate private borehole development, particularly among higher-income groups.
- iv. **Infrastructure Investment:** Expand and rehabilitate the municipal water supply network to reduce the population's overdependence on groundwater. Integrating alternative water sources such as rainwater harvesting systems can diversify supply and ease pressure on groundwater resources.

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