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SOCIOECONOMIC AND ENVIRONMENTAL DETERMINANTS OF ACCESS TO SAFE DRINKING WATER IN NIGERIA: A MAXIMUM LIKELIHOOD ESTIMATION APPROACH FOR THE CASE OF NORTHEASTERN STATES

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Abstract

This study investigates socioeconomic and environmental determinants of households' access to safe drinking water in Nigeria using data from the 2024-NDHS for the Northeastern region. The population comprises 5977 households surveyed across the six Northeastern states, and of these, 2310 households were reported to have no access to safe drinking water, thereby constituting the event of interest for this study. Also, Maximum Likelihood Estimation (MLE) is used to estimate parameters that best fit the observed data within the framework of the binomial logistic regression model. The findings revealed that economic status has a positive and significant influence, such that as households' economic status rises, access to safe drinking water also improves. Similarly, households located in urban centers are, on average, three times more likely to have access to safe drinking water than their rural counterparts. The results further revealed that households whose water source is located outside are nearly six times more likely to have access to safe drinking water compared to those who have water on premises. However, the level of education reveals a negative and statistically significant relationship with safe water access, indicating that households with higher education are less likely to have access compared to those with no education which sharply contradicted the a priori expectation of this study. Finally, households whose water source is located outside are nearly six times more likely to have access to safe drinking water compared to those who have water on premises. Hence, the study recommends for reduction of financial barriers for low-income households by government as well as integrating government's policy focus on 'access' with 'quality assurance' when making effort to expand safe water points closer to underserved communities.

Key Words: Economic status, Environmental factors, Households, Access, Safe drinking water, Northeast.
JEL Classification Codes: C25, O15, Q25, H54, R20

1.0 Introduction

Inadequate access to safe drinking water remains a critical public health and development challenge at both global and local levels. According to the World Health Organization (WHO, 2017), approximately 9.1 percent of the global disease burden and

6.3 percent of all deaths are attributed to unsafe water, poor sanitation, and inadequate hygiene. Waterborne diseases alone claim nearly one million lives annually, affecting an estimated 37.7 million people through various forms of infection and exposure (Ocholla et al., 2022). These alarming statistics underscore the critical role of safe water access in preventing disease, improving quality of life, and fostering human development.

In Nigeria, despite abundant natural water resources, the challenge of accessing safe drinking water remains a persistent issue. The country's geographic position between latitudes 4° and 14° N and longitudes 2° and 15° E places it within the tropical zone, characterized by significant freshwater potential from rivers, streams, lakes, and groundwater reserves. However, this potential does not translate to equal access across the country. According to the 2024 Nigeria Demographic and Health Survey (NDHS), approximately 61% of Nigerian households have access to safe drinking water, implying that nearly two out of every five households still rely on unsafe sources (National Population Commission [NPC], 2025). This is close to the assertion of Ishaku et al. (2011) that by the year 2025, water shortages could affect two out of three persons globally, with developing countries being the most vulnerable. Moreover, pronounced regional disparities exist across the country, with southern geopolitical zones recording higher access levels compared to northern regions.

Northeastern Nigeria, comprising six states - Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe - continues to experience comparatively lower access to safe drinking water relative to several other geopolitical zones. Evidence from the 2024-NDHS shows that of 5,977 households surveyed in the Northeast, a substantial proportion still rely on unsafe water sources, reinforcing the region's vulnerability in national water access outcomes. These disparities are influenced by a combination of urbanization patterns, infrastructural development, regional insecurity, and governance capacity (NPC, 2025).

The region is characterized by a diverse but fragile landscape, including semi-arid plains and mountainous terrain, which contributes to environmental vulnerability (Adeoti, 2017). Recurrent droughts in some areas, climate variability, population displacement due to insurgency in some parts of the region, and infrastructure decay have all compounded water access challenges. Consequently, many communities continue to depend on unsafe water sources such as rivers, ponds, and

shallow wells (Abubakar, 2021). In addition, households in the Northeast grapple with a range of socioeconomic barriers that increase their vulnerability to unsafe water. Factors such as low income, limited education, unemployment, and inadequate infrastructure not only restrict access but also affect already disadvantaged populations, especially those in rural and semi-urban communities. The socioeconomic implications of this situation are profound. Households without safe water face higher risks of waterborne diseases such as cholera, dysentery, and typhoid, which in turn increase healthcare costs and reduce productivity (Balogun & Redina, 2019). Time spent fetching water - often borne disproportionately by women and children - reduces opportunities for schooling, income-generating activities and childcare. These dynamics reinforce poverty cycles and inequality within already disadvantaged communities. Evidence suggests that socioeconomic factors such as income, education, gender of household head, and household size play significant roles in determining a household's likelihood of accessing safe drinking water (Tumala, et al., 2025).

While institutional efforts exist, including federal and state-level water policies, many remain inadequately implemented and underfunded, particularly in regions such as Northeastern Nigeria, as reflected in the continued reliance of a substantial proportion of households on unsafe water sources despite these policy frameworks. Development partners have also launched targeted programs such as the Sustainable Urban and Rural Water Supply, Sanitation and Hygiene (SURWASH) program, supported by the World Bank and implemented in states including Borno and Adamawa (Federal Ministry of Water Resources, 2021). However, 2024-NDHS further shows that access to safe drinking water in the Northeast remains comparatively low, indicating that the geographic reach and effectiveness of these interventions remain limited, while concerns about long-term sustainability persist. Figure 1 shows that the Northeast records lower access rates than the North West, North Central and South West regions, highlighting persistent regional inequality in water access outcomes across Nigeria.

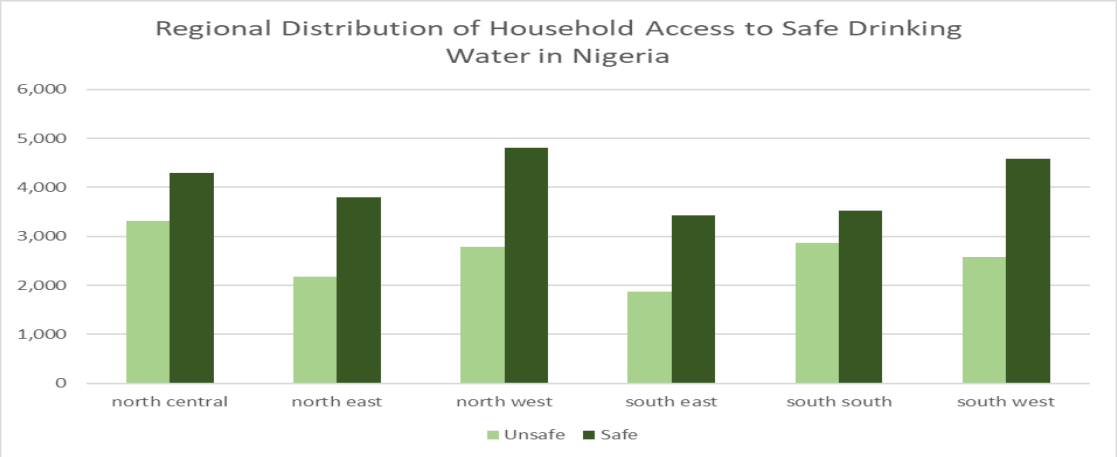

Figure 1: Proportion of Households with Access to Safe Drinking Water by Geopolitical Zone (NHDS 2024)
Source: Author's computation (2025)

Moreover, environmental conditions further exacerbate the problem. The Northeast is ecologically diverse and some of the states are vulnerable to climatic extremes, particularly droughts and irregular rainfall patterns. Groundwater sources, which form the backbone of rural water supply through boreholes and wells, are increasingly under stress due to over-extraction and poor recharge rates. Moreover, the shrinking of Lake Chad and declining river levels reduce surface water availability, pushing communities toward less safe alternatives (United Nations Development Programme [UNDP], 2020). Also, the persistence of inadequate water access in Northeastern Nigeria is closely linked to underlying socioeconomic conditions. Wealthier households are more likely to invest in private boreholes, water storage systems, or packaged water supplies. By contrast, poorer households, especially those headed by individuals with little or no formal education, may be unable to afford these options and are forced to rely on unimproved sources. Evidence from the 2024-NDHS suggests that household wealth is a key determinant of access to safe drinking water, with wealthier households being more likely to have water located on their premises than to poorer households (NPC, 2025).

In view of the above, a number of empirical studies (e.g. Osabuohien et al., 2012; Abdu et al., 2016; Abubakar, 2019, 2021; Lukman et al., 2016; etc.) have explored the impact of socioeconomic and environmental conditions on access to safe drinking water in Nigeria. However, most of these studies adopted a country-wise analysis and do not fully address the socioeconomic realities unique to specific regions, notably the Northeast region. As a result, the specific socioeconomic and

environmental factors shaping household access to safe drinking water in Northeastern Nigeria remain underexplored in the literature. This remains a significant knowledge gap in understanding how localized socioeconomic factors such as wealth status, educational level, household characteristics, and spatial location influence access to safe drinking water. In addition, little attention has been paid to the development of predictive models that can help quantify these factors and guide evidence-based decision-making. Without such models, stakeholders may lack the necessary tools to target interventions effectively and design solutions suited to the unique needs of the region. This gap in knowledge and tools may not only impede the achievement of SDG 6 in the Northeast but will also undermine the broader development objectives in health, education, and economic inclusion in the region.

Given the preceding, the need to evaluate the socioeconomic determinants of accessibility to safe water supply in developing countries such as Nigeria cannot be over-stressed. Therefore, this study investigated the socioeconomic and environmental factors that influence households' access to safe drinking water in the Northeastern region of Nigeria using data from the 2024-NDHS. Specifically, how factors such as economic status, level of education, geographical location and distance to water sources have been examined and recommendations that will refine access to safe drinking water and lower the burden among at-risk households with on-premises sources in the region were offered.

2.0 Literature Review

2.1 Theoretical Framework

The theoretical basis upon which this study is conducted is Water Poverty Index (WPI) developed by Sullivan (2002) to reflect both physical and socioeconomic dimensions of water access. The WPI consists of five components: Resources (R), which refers to the availability and reliability of water sources; Access (A), which measures the ease and proximity of accessing water; Capacity (C), which includes household income, education, and health; Use (U), which assesses how water is used for domestic, agricultural, or productive activities; and Environment (E), which reflects the sustainability and ecological conditions affecting water supply (Sullivan et al., 2006). Hence, WPI theory aligns with the study's objective of identifying the socioeconomic and environmental determinants of water access in a region marked by environmental

vulnerabilities and socioeconomic inequalities such as Northeastern Nigeria.

2.2 Review of Empirical Literature

Empirical literature on access to safe drinking water is extensive and spans across developed and developing countries. Abdu et al. (2016) examined the socioeconomic determinants of household access to safe drinking water in Nigeria, employing Ordinary Least Squares, probit regression, and Blinder–Oaxaca decomposition techniques. Their findings revealed that age, marital status, household size, regional location, gender, awareness, and access to electricity significantly influence access to safe drinking water. The study further highlighted the persistence of urban–rural disparities in water access.

Similarly, Abubakar (2019), using the 2013 Nigeria Demographic and Health Survey and logistic regression analysis, found that household access to safe drinking water is significantly influenced by place of residence, geopolitical zone, education, wealth index, ethnicity, access to electricity, and gender. The study also identified water collection time, number of rooms, and state of residence as important predictors of access to improved water sources. Evidence from other African countries corroborates these findings. Adjei et al. (2015), utilizing data from the Ghana Demographic and Health Survey and generalized linear models, established that income, education, household size, and regional location are dominant predictors of access to improved water and sanitation facilities. Similarly, Koskei et al. (2013) found that education and occupation of the household head significantly influence the type of water source used by households. Cole et al. (2017) also demonstrated substantial spatial inequality in water access across towns, districts, and provinces in South Africa.

Furthermore, geographic and regional disparities are equally important in shaping water access. In Nigeria, Xu (2025) attributed rural–urban inequality in water access largely to disparities in household wealth. Lukman et al. (2016) also found significant inter-state variation in access to safe water, identifying Taraba State as one of the states with the lowest access rates. Similar patterns have been observed in Vietnam (Tuyet-Hanh et al., 2016) and Nepal (Wang et al., 2019), where households in rural or remote regions face structural disadvantages while Nkiata (2022) highlighted governance, GDP per capita, and female education as key determinants of water security across developing regions. Again, Morain and Anandhi (2022) found that climate change,

population growth, and income increase water demand, while education and technology reduce pressure on water resources. Maneesh (2015) and Simelane et al. (2020) also emphasized the combined effects of environmental change, household size, and wealth on access to improved water sources.

Although the empirical literature is extensive, several gaps remain. First, Northeastern Nigeria is underrepresented in existing studies, despite its unique socio-political and environmental challenges, including conflict, displacement, and infrastructure limitations. Second, few studies integrate socioeconomic, demographic, and geographic factors within a single analytical framework, limiting the ability to capture their combined influence. While several studies have explored these determinants in different parts of Nigeria and beyond, few have specifically examined the Northeastern region (Tumala, et al., 2025). Therefore, given the distinct context of Northeastern Nigeria, further investigation is essential for evidence-based interventions, hence the need for this study.

3.0 Data and Methods

3.1 Data Source and Sample Size

The data for this study were sourced from the 2024 Nigeria Demographic and Health Survey 2024-NDHS published by National Population Commission (NPC, 2025) for the six Northeastern states, namely Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe. The use of 2024-NDHS is premised on being the most recent and comprehensive nationally representative dataset available for assessing household-level access to safe drinking water and related socioeconomic characteristics. However, for the purpose of this study, the population covers 5977 households surveyed across the six Northeastern states; and out of this population, 2310 households were reported to have no access to safe drinking water, thereby constituting the event of interest for this study (NPC, 2025).

3.2 Estimation Technique

Maximum Likelihood Estimation (MLE) is used to estimate parameters that best fit the observed data under binomial logistic regression framework using STATA econometric software version 17. The model is generally expressed as:

$$logit\ (Y) = In\ \left(\frac{\pi}{1-\pi}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 \quad 3.1$$

and that , π = Probability (Y= outcome of interest | $X_1 = x_1, \quad X_2 = x_2$) = $\frac{e^{\alpha+\beta_1 x_1+\beta_2 x_2}}{1+e^{\alpha+\beta_1 x_1+\beta_2 x_2}}$

Where:

π= probability of the event

α= intercept

β_s= regression coefficients

X_s= set of predictors

However, the analysis of results is conducted using odds ratio which compares the odds of an event occurring in one group to the odds of it occurring in another group. It is a useful tool for comparing the probability of an outcome between different group or when analyzing binary outcomes.

3.3 Variables and their measurements

The socioeconomic and environmental variables, which are assumed to influence access to safe drinking water in the study area are presented, described and measured in Table 3.1:

Table 3.1: Variables Description and Measurement

Variables	Description	Measurement
Dependent variable		
Access to safe drinking water	Safe drinking water sources and unsafe drinking water sources	Binary: 1 = safe drinking water sources, 0 = if otherwise
Socioeconomic variables		
Economic status	Ranked into five: poorest, poor, middle, rich, richest	Ordinal scale
Household's level of Education	Ranked into four: No education/informal education, Primary, Secondary, Higher education	Ordinal scale
Environmental factors		
Geographical Location	Place of residency: Urban and Rural	Binary: 1 = urban, 0 = rural
Location of source of water (Distance)	Location of water source	Binary: 1 = in premises, 0 = elsewhere

Source: Author's computation (2025)

4.0 Results and Discussion of Findings

This section presents descriptive statistics, results of logistic regression, model diagnostics, and a detailed discussion of the findings.

4.1 Descriptive Statistics

Table 4.1: Descriptive statistics of variables used (Total Households surveyed = 5997)

Variable	Categories	Frequency	Percentages
Source of drinking water	Safe	3687	61.35
	Unsafe	2310	38.65
Economic Status	Poorest	2544	42.56

	Poor Middle Rich Richest	1503 1050 626 254	25.15 17.57 10.47 4.25
Educational level	No education Primary Secondary Higher	3073 659 1379 866	51.41 11.03 23.07 14.49
Geographical location	Urban Rural	1972 4005	32.99 67.01
Location of source of water (Distance)	Elsewhere On premises	5219 758	87.32 12.68

Source: Author's computation (2025)

Table 4.1 provides descriptive statistics of all variables of interest in the study. Specifically, a summary of households' sources of drinking water divided into two categories: safe and unsafe sources is presented. Out of the 5977 households surveyed, 61.35% (3687 households) have access to safe drinking water while the remaining 38.65% (2310) rely on unsafe drinking water sources. This suggests that a substantial portion of the population in Northeast Nigeria remain vulnerable to health risks associated with unsafe water. The disparities in water access could highlight the inequalities that exist due to socioeconomic and geographical disparities. Also, the statistics of households in terms of economic status, ranging from the "poorest" to the "richest" is presented. The results showed that 2455 household representing 42.56% of the total surveyed households fall within the poorest category, while 25.15% which stood for 1503 households are poor. Together, these two categories represent 67.71% of the population. The results further revealed that, 17.57% of households fall in the middle-income category; 10.47% are classified as rich, while only 4.25% belong to the richest group. This highlights the prevalence of poverty in Northeast Nigeria, with about 68% of households being either poor or poorest, thereby widening the gap in access to safe drinking water on ground of economic-based disparity.

Again, the descriptive statistics of educational attainment showed that majority of the surveyed households (3073 out of 5997), representing 51.41%, have no formal. Only 11.03% have completed primary education which equips individuals with basic literacy skills. A slightly higher percentage of 23.07% have attained secondary education which may offer more advanced skills and knowledge, potentially leading to better employment opportunities and the ability to afford safe water sources. However, only 14.49% have completed

higher education, representing the most likely category to have higher incomes and better access to resources, including safe drinking water. Furthermore, the statistics presents the geographical distribution of households between urban and rural areas in Northeast Nigeria. Majority of the surveyed households (4005 out of 5997), representing 67.015 reside in rural areas, while 32.99% of the total households were located in urban areas. This reflects the predominantly rural nature of the region, indicating that any policy intervention regarding water access and other infrastructural development must prioritize rural populations.

Finally, the location of source of water (distance) as shown in table 2 revealed 758 out of 5997 households (representing 12.68% of the total) have their primary source of drinking water on the premises, notably within the dwelling or the immediate compound, while majority of the households (87.32%) accessed water from sources located elsewhere, beyond the confines of their household premises. This highlights a substantial disparity in physical accessibility to drinking water among households in Northeastern Nigeria. The limited share of households with on-premises water indicates that the burden of water collection (including time, energy, and exposure to unsafe environments) may fall heavily on members of households with off-site water sources.

4.3 Inferential Statistics

4.3.1 Binomial Logistic Regression

Table 4.1: Results of Binomial Logistic Regression

	Odds Ratio	P-value	Significance Level
ECS			
Poorer	2.5307	0.000	1%
Middle	5.2179	0.000	1%
Richer	8.0534	0.000	1%
Richest	8.8512	0.000	1%
Edu			
Primary	0.5762	0.000	1%
Secondary	0.5384	0.000	1%
Higher	0.6437	0.000	1%
Urban	3.0480	0.000	1%
Distance	5.7872	0.000	1%
N=5977, log likelihood=-3359.4041, pseudo-R^2=0.2, LR chi² =1256.28, Prob. > chi square =0.0000			
Significance levels: 1%, 5% and 10%.			

Source: Author's computation (2025)

Table 4.2 presents the results of the logistic regression analysis estimating the determinants of access to safe drinking water among households in Northeastern Nigeria. Economic status (ECS) shows a strong and positive relationship with access to safe drinking water. Compared to the poorest households, those in the poorer (OR = 2.53; $p < 0.01$), middle (OR = 5.22; $p < 0.01$), richer (OR = 8.05; $p < 0.01$) and richest (OR = 8.85; $p < 0.01$) economic categories are significantly more likely to have access. This indicates that access to safe water improves consistently as household economic status rises. This effect is statistically significant at 1% level. This aligns with the findings of Abubakar (2019) and Adjei et al. (2015), who noted that wealthier households tend to afford private water infrastructure or improved public sources.

Contrary to expectations, education level (Edu) demonstrates a negative and statistically significant relationship with safe water access. Households headed by individuals with primary **(**OR = 0.58; $p < 0.01$**)**, secondary (OR = 0.54; $p < 0.01$) and higher education (OR = 0.64; $p < 0.01$) are less likely to have access compared to those with no education. This may reflect higher exposure of more educated households to urban informal settlements or displacement-affected areas. This effect is significant at 1% level. This finding contrasts with earlier studies such as Pal et al. (2018), and Tuyet-Hanh et al. (2016), who found positive association between education and improved water access. This counterintuitive result suggests that higher education alone does not ensure better water access in the region, possibly due to infrastructural deficiencies and the settlement patterns of educated populations in areas lacking improved water systems.

Place of residence (Urban) has a strong and positive effect (OR = 3.05; $p < 0.01$), indicating that urban households are approximately three times more likely to have access to safe drinking water than their rural counterparts. Place of residence has a statistically significant influence on access to safe drinking water. Households located in rural areas are less likely to have access to safe drinking water compared to those in urban areas. This conforms with the findings of Egbinola (2017), and this disparity can be attributed to infrastructural gaps and inefficient water supply systems in rural communities.

Finally, water source location (Distance) was found to significantly influence access (OR = 5.79; $p < 0.01$).

Households whose water source is located outside are nearly six times more likely to have access to safe drinking water compared to those who have water on premises. This may not be unexpected because water within household premises may not meet safety standards largely due to unseen contaminations from sewage or faulty infrastructure. Although this result contradicted the "common sense" assumption and also differs from what has been reported in some previous studies (e.g. Egbinola et al., 2017; Tuyet-Hanh et al., 2016), it however, reflects the unique context of Northeastern Nigeria. In many communities especially rural or conflict-affected areas improved water infrastructure such as communal boreholes and protected standpipes are typically situated away from residential houses, and therefore enjoyed better oversight, shared maintenance and treatment. Thus, considering proximity to water sources should not taking as a major metric of success, rather the quality of the water itself is equally important.

The model's log likelihood values of -3359.4041 indicates the goodness of fit compared to a null model. A higher (less negative) value suggests a better fit (see table 4.2). The likelihood ratio chi-square (χ^2=1256.28, df=13, p< 0.01) shows that the full model is statistically significant overall and it performs better than a model with no predictors. The pseudo-R^2 of 0.2 implies that approximately 20% of the variation in household access to safe drinking water is explained by the included variables. While lower than R^2 in linear regression, such values are common and acceptable in logistic regression models (Hosmer et al., 2013).

5.0 Conclusion and Recommendations

This study investigated the socioeconomic and environmental determinants of household access to safe drinking water in Northeastern Nigeria, a region facing significant water access challenges. Using 2024-NDHS data, the research employed a binomial logistic regression model to analyze how factors such as wealth index, educational attainment, place of residence, and physical access indicators influence access to safe drinking water. Based on the empirical findings, this study concludes that access to safe drinking water in Northeastern Nigeria is significantly influenced by socioeconomic and environmental factors. Overall, the study confirms that socioeconomic disparities and infrastructural deficits remain the key barriers to achieving universal access to safe drinking water in Northeastern Nigeria. Overcoming these challenges is

not only crucial for protecting public health but also accelerating Nigeria's efforts toward achieving Sustainable Development Goal 6.1, which aims for universal and equitable access to safe and affordable drinking water for all. Therefore, this study recommends for reduction of financial barriers for low-income households by government through effective social protection strategies such as subsidies, and distribution of water treatment technologies. Also, governments at all levels should expand water supply networks such as boreholes and protected wells, as well as rehabilitate the existing but non-functional water systems. This bridges the gap in urban-rural access to safe drinking water in the Northeastern states. Finally, given that distance and time to water sources are found to be strong predictors of access to safe drinking water in the studied region, the study recommends for integrating the government's policy focus on 'access' with 'quality assurance' as well. Therefore, while making effort to expand safe water points closer to underserved communities in order to reduce the distance and time taken to fetch the water, promoting household water treatment and safe storage for at-risk households with on-premises sources should not be compromised.

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