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SOCIOECONOMIC DETERMINANTS OF HOUSEHOLDS' ACCESS TO SAFE DRINKING WATER IN NORTH EASTERN NIGERIA: A BINOMIAL LOGISTIC REGRESSION APPROACH

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Abstract
Access to safe drinking water is a critical factor in determining public health and socioeconomic development, particularly in developing countries like Nigeria. This study examines the socioeconomic determinants of household access to safe drinking water in Northeastern Nigeria, using data from the 2021 Nigeria Demographic and Health Survey (NDHS). Employing a binomial logistic regression model, the research identifies the influence of factors such as, educational level, geographical location, wealth index, gender and age of household heads, location of water source, time spent getting water and household size on access to safe drinking water. Descriptive statistics reveal that 65% of households have access to safe drinking water while 35% do not have access, 91.16% of households are male-headed, with the majority (82.93%) having no formal education. Rural households constitute 67.56% of the sample, and nearly two-thirds of the population fall within the poorest and poor economic categories. The logistic regression analysis indicates that higher education level, urban residency, middle-age and water located on-premises significantly increase the likelihood of accessing improved water sources, while lower wealth index and male headed households reduce this likelihood. The findings highlight critical disparities in access to safe drinking water, emphasizing the need for targeted policies that prioritize rural and low-income households, encourage educational empowerment, and promote infrastructure development to ensure equitable water access. The study contributes to the growing body of knowledge on the determinants of water access and provides actionable insights for policymakers and stakeholders in Nigeria's water and sanitation sector.

Keywords: households, access, safe drinking water, binomial logistic regression, Northeast.

JEL Classification Codes: C25, O15, Q25, H54, R20

1 Introduction

Access to safe drinking water is a fundamental human need and a critical driver of public health, economic development, and environmental sustainability. Globally, billions of people still lack access to improved water sources, particularly in low- and middle- income countries. In recognition of this challenge,

Sustainable Development Goal 6.1 aims to ensure universal and equitable access to safe and affordable drinking water for all by 2030. Despite abundant natural water resources, Nigeria continues to face persistent gaps in safe water access; data from the 2021 Nigeria Demographic and Health Survey (NDHS) indicate that only about two-thirds of Nigerian households use improved water sources, with wide disparities across geographic and socioeconomic groups (NDHS, 2021).

The Northeastern region of Nigeria comprising Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe states experiences pronounced water access challenges. The region's diverse but fragile landscapes (particularly in Borno and Yobe), including semi-arid plains and seasonal river systems, together with recurrent droughts, climate variability, population displacement from conflict, and weak water infrastructure, compound the problem (Adeoti, 2017). Many communities still rely on unsafe sources such as surface water, unprotected wells, and shallow boreholes. Even where improved sources exist, reliability is often undermined by intermittent supply, poor maintenance, and limited institutional capacity.

The socioeconomic implications of inadequate water access are far-reaching. Households without safe water face higher risks of water borne diseases (e.g., cholera, dysentery, typhoid), increased healthcare costs, and reduced labour productivity. Time spent fetching water disproportionately borne by women and children reduces opportunities for schooling and income generation, thereby reinforcing cycles of poverty and inequality. Empirical evidence suggests that household characteristics such as wealth, education, household size, gender and age of household head, and proximity of water source influence the likelihood of accessing safe drinking water (Abubakar, 2019; Oyekale, 2017). Yet, much of the existing research focuses on national averages or other regions, leaving the Northeastern context less examined.

Given these factors, there is a need for region-specific analysis to identify the socioeconomic determinants that shape access to safe drinking water in the Northeast. This study addresses that gap by modelling the socioeconomic factors influencing household access to safe drinking water in Northeastern Nigeria using the 2021 NDHS. Employing a binomial logistic regression framework, the study examines how variables such as wealth index, educational attainment of household heads, household location (urban/rural), household size, gender and age of household heads, location of water source, and time spent fetching water affect the probability of using an improved water source.

The main objective of the study is to model the socioeconomic determinants of household access to safe drinking water in Northeastern Nigeria. Specifically, the study aims to: (i) investigate the impact of household wealth

status on access to safe drinking water, (ii) examine the effect of the household head's educational attainment, and (iii) assess the influence of household location (urban vs rural) on access. By focusing on the Northeastern region and using recent nationally representative data, this study provides timely, policy-relevant evidence to inform targeted interventions. The findings are intended to guide policymakers, public health practitioners, and development partners in designing equitable and sustainable water supply strategies that prioritize vulnerable rural and low-income households.

2. Literature Review

2.1 Conceptual Review

Access to safe drinking water is defined by the World Health Organization (WHO, 2017) as the availability of water that is free from contaminants, safe for human consumption, and adequate for daily needs. Safe drinking water is essential for good health, preventing the spread of waterborne diseases such as cholera, typhoid, and diarrhoea. The WHO and UNICEF Joint Monitoring Programme (JMP) classify water sources into "improved" and "unimproved." Improved water sources include piped water into dwellings, public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection. Unimproved sources include unprotected wells, unprotected springs, vendor-provided water, packaged water (if secondary use is from unimproved sources), and surface water from rivers, dams, lakes, ponds, streams, canals, or irrigation channels.

The concept of access involves both the availability and quality of water as well as the proximity and reliability of the source. The United Nations Development Programme (UNDP, 2020) suggests that access implies the source is located within 1 kilometre of the home and that the quantity available meets basic human requirements. In many rural communities, access is not only a question of physical availability but also affordability, cultural acceptability, and the stability of supply.

Socioeconomic determinants of access to safe drinking water include factors such as household wealth, education level, location (urban or rural), household size, gender and age of household head, time taken to fetch water, and location of water source. Households with higher income are more likely to afford the cost of improved water sources, while education influences awareness of health risks and adoption of safe water practices. Urban households often have better infrastructure and more diverse water supply options compared to rural households. Similarly, proximity to water sources reduces the time and effort needed to collect water, which has implications for household productivity and welfare (Abubakar, 2019).

In the Nigerian context, the challenge of ensuring access to safe water is compounded by population growth, climate change, poor

infrastructure, and inadequate policy implementation. Particularly in the Northeastern region, conflict and displacement have worsened existing disparities. This context shapes the determinants of access, as households in rural and conflict-affected areas face more severe limitations.

2.2 Theoretical Framework

Among the reviewed theories, the Water Poverty Index (WPI) developed by Sullivan (2002) most directly aligns with the research focus because it provides a holistic lens for examining how natural resource availability intersects with economic, social, and institutional constraints to determine access to safe drinking water. This study adopts the Water Poverty Index (WPI) framework to explain household access to safe drinking water, using its five dimensions. It comprises five key components: Resources (availability of water), Access (proximity and ease of reaching water sources), Capacity (household income, education, and health status), Use (purposes of water usage), and Environment (sustainability and ecological factors).

This theory supports the inclusion of variables such as wealth index, educational level, household size, source type, and location in the empirical model, and aligns with the study's objective of identifying the socioeconomic determinants of water access in a region marked by vulnerability and inequality. In the context of Northeastern Nigeria, where both environmental scarcity and socioeconomic inequality are prevalent, this framework provides a comprehensive basis for analysing the determinants of access to safe drinking water.

2.3 Empirical Review

Several empirical studies have examined the socioeconomic determinants of household access to safe drinking water in Nigeria and beyond. Abdul et al. (2016) investigated factors driving urban–rural inequalities in Nigeria's access to safe drinking water, using regression models and Blinder–Oaxaca decomposition. Their results showed that age, marital status, household size, gender, awareness, nodal region, and access to electricity significantly influenced access to improved water sources.

Also, Abubakar (2019), using the 2013 Nigeria Demographic and Health Survey, applied logistic regression and descriptive statistics to investigate the factors influencing household access to drinking water in Nigeria. The study found that place of residence, geopolitical zone, education, wealth index, ethnicity, access to electricity, and gender significantly influenced household drinking water sources. Water collection time and housing conditions were also strong predictors of access to improved water.

Similarly, Simelane et al. (2020) examined access to improved drinking water in Eswatini using 2010 and 2014 data. Their analysis revealed that larger household size reduced the likelihood of safe water access, while higher

household wealth and urban residence were positively associated with access. At the regional level, Osisiogu et al. (2024) conducted a systematic review of 137 studies on safe water access in Sub-Saharan Africa. Governance, education, gender, wealth, poverty, and climate change consistently emerged as key drivers influencing household access to safe drinking water. In another study, Terefe et al. (2024) assessed determinants of water access in 12 East African countries using multilevel logistic regression. Results indicated that the age and gender of the household head, education, wealth index, and media exposure at community level significantly influenced access to safe water sources.

Finally, Xu (2025) analysed trends in inequality of water access in Nigeria between 2008 and 2018. The study highlighted that rural–urban disparities were largely explained by differences in the household wealth index, underscoring the strong role of economic capacity in determining access. Taken together, these studies highlight that socioeconomic factors such as education, wealth, location, gender, and household size are consistently important determinants of household access to safe drinking water.

3. Data and Methods

This study used a quantitative cross-sectional design with data from the 2021 Nigeria Demographic and Health Survey (NDHS), implemented by the National Population Commission (NPC) in collaboration with International Classification of Functioning, Disability and Health (ICF) – a World Health Organization's standard for measuring health and disability. The focus was on households in Northeastern Nigeria – Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe and totalling a sample of 2,173 households. The dependent variable was access to safe drinking water, coded 1 if the household's main source was improved (piped water, public taps, tube wells, protected well, protected spring, bottled water, water tanker trucks or rainwater) and 0 if otherwise. Explanatory variables included the educational attainment of the household head, gender and age of household head, wealth index, urban or rural residence, household size, source location (on- or off-premise), and time required to fetch water.

Binomial logistic regression was employed to estimate the probability that a household had access to safe drinking water as a function of these socioeconomic characteristics. The model is specified as:

$$\Pr(DWS = 1/0) = \alpha + \beta_1 WI + \beta_2 EDU + \beta_3 LOCA + \beta_4 GEND + \beta_5 AGE + \beta_6 SIZE + \beta_7 TIME + \beta_8 DISTANCE + \mu_i \quad (3.1)$$

3.1 Variables Description and Measurement

The variables presented in model 3.1 were described and measured as shown in Table 3.1.

Table 3.1: Variables Description and Measurement

Variables	Description	Measurement
Access to safe drinking water (DWS)	Safe drinking water sources and unsafe drinking water sources	**Binary: 1 = safe drinking water sources, 0 = if otherwise**
Wealth index (WI)	Ranked into five: poorest, poor, middle, rich, richest	**Ordinal scale**
Educational level of household head (EDU)	Ranked into four: no education/informal education, primary, secondary, higher education	**Ordinal scale**
Location (LOCA)	Place of residency: Urban and Rural	**Binary: 1 = urban, 0 = rural**
Gender (GEND)	Gender of household head: male and female	**Binary: 1 = male, 2 = female**
AGE	Age of household head	**Continuous count variable**
SIZE	Household size	**Continuous count variable**
TIME	Time taken to get to water sources	**Ordinal scale**
DISTANCE	**Location of water source**	**Binary: 1 = in premises, 0 = elsewhere**

Source: Author's computation

4. Results and Discussions

The sample comprises 2,173 households across the six states of Northeastern Nigeria. Of these households, 65% have access to safe drinking water, defined as improved sources such as piped water, boreholes, protected wells, protected springs, or rainwater collection. The majority of households (68%) are located in rural areas, with only 32% residing in urban areas. The mean household size is 6 persons, and the majority of household heads are male (91%), with females accounting for 9%.

In terms of socioeconomic status, 40% of households fall within the poorest wealth quintile, while 5% are in the richest. Educational attainment of household heads varies, with 83% having no formal education, 7% having completed primary education, and 10% attaining secondary or higher education. Regarding physical access, 16% of households have their main water source located on-premises, while 84% must travel off-premise, often more than 236 minutes each way to collect water. These statistics already reveal disparities that suggest socioeconomic and locational factors strongly influence access to safe drinking water in the region.

The results of the binomial logistic regression model are presented in Table 4.1. The dependent variable is access to safe drinking water (1 = improved source, 0 = unimproved source).

Table 4.1: Results of Binomial Logistic Regression

DWS	Odds Ratio	P-value	Significance Level
WI	1.6274	0.000	**1%**
EDU	1.2110	0.044	**5%**
LOCA	9.4363	0.000	**1%**
AGE	1.0491	0.008	**1%**
AGE²	0.9925	0.019	**5%**
SIZE	0.9925	0.617	**Not significant**
GENDER	0.5784	0.013	**1%**
TIME	1.0010	0.003	**1%**
DISTANCE	0.3445	0.002	**1%**
N=2173, log likelihood=-1117.6597, pseudo-R²=0.2, LR chi² =566.48, prob>chi square =0.0000 **Significance levels: 1%, 5% and 10%**			

Source: Author's computation (2025).

The results indicate that household wealth index is one of the strongest predictors of access to safe drinking water. Compared to households in the poorest quintile, those in the richest quintile have significantly higher odds of accessing improved sources, reflecting the role of financial resources in affording water infrastructure, fees, or maintenance.

Educational attainment of the household head is also significant, with households headed by individuals with secondary or higher education being more likely to use improved water sources. Education likely improves awareness of waterborne disease risks and the benefits of safe water, encouraging adoption of improved sources.

Urban households are significantly more likely to have access than rural ones, reflecting the uneven distribution of water infrastructure and public investment. Urban areas typically have piped networks and regulated boreholes, whereas rural areas often depend on unprotected wells, streams, or seasonal sources.

Gender was another important factor. Female-headed households were found to have better access to safe drinking water than male-headed ones. This is consistent with Adams et al. (2016), Mulenga et al. (2017), and Abubakar (2019), who observed that female heads, being more directly involved in caregiving and household water use, are often more proactive in securing safe water.

The regression results revealed a statistically significant nonlinear relationship between age and household access to safe drinking water. Specifically, the positive coefficient of age and the negative coefficient of age-squared indicated an inverted U-shaped relationship. This suggests that that middle-aged household heads are more likely to prioritize safe water sources due to higher economic stability, better decision-making power, and awareness of health risks.

However, older heads may face mobility challenges, reduced income, or dependency, which could hinder their ability to maintain consistent access.

With respect to the distance of water source, the results showed a negative and statistically significant association with safe drinking water access. Households that obtain water from sources located outside their dwelling or compound are significantly less likely to use improved sources.

Interestingly, the time taken to get water was also statistically significant but positively associated with safe water access. Although this appears counterintuitive at first, it aligns with findings from Cole et al. (2017) and Mulenga et al. (2017), who explained that some households willingly travel longer distances to access better-quality or protected water sources rather than using contaminated sources closer to home. In this context, time reflects not only physical burden but also household water sourcing preferences and effort. Therefore, households that prioritize health and water safety may spend more time accessing improved sources, especially in urban slums or informal settlements where piped networks are absent.

Overall, these results are consistent with prior studies (Adjei et al., 2015; Abubakar, 2019; Mulenga et al., 2017; Tuyet-Hanh et al., 2016) and reinforce the importance of targeted interventions to improve rural infrastructure, promote education, and address affordability barriers in Northeastern Nigeria.

5. Conclusion and Recommendations

This study examined the socioeconomic determinants of household access to safe drinking water in Northeastern Nigeria using data from the 2021 Nigeria Demographic and Health Survey (NDHS) and a binomial logistic regression model. Based on the empirical findings, this study concludes that higher wealth index, education, urban residence, middle-age, water on-premises and female household leadership are associated with better access to safe drinking water, while lower-income and rural households continue to face significant challenges. In alignment with the research objectives, these results confirm that economic, educational, and geographic factors play pivotal roles in determining water access. The finding that middle age and female-headed households have modestly higher access also underscores the nuanced ways in which gender and age dynamics influence household priorities.

It is against this backdrop that the following policies have been recommended. Firstly, to address financial barriers limiting access to safe drinking water, economic support for low-income households should be prioritized. This can be achieved through government-funded subsidies, such as vouchers for water purification systems or reduced water tariffs,

aimed at making clean water more affordable for struggling families.

Secondly, addressing geographic disparities in water access requires focused investment in rural infrastructure, including the development of new boreholes, repair of existing water sources, and expansion of piped systems.

Thirdly, the positive association between educational attainment and safe water access confirms the role of knowledge and awareness in health-promoting behaviour. Thus, there is a need to scale up Water, Sanitation and Hygiene (WASH) education initiatives, particularly in communities with low literacy rates. Public health agencies should design culturally appropriate programs that focus on the importance of using improved water sources, safe water storage, and hygiene practices. Lastly, the findings that female-headed households were more likely to use improved water sources than male-headed ones suggests that women may prioritize water quality due to their caregiving and domestic responsibilities. To harness their potential, it is essential that water access strategies adopt gender-sensitive planning approaches. Women should be actively involved in water committees, project planning, and monitoring, as their insights often lead to more responsive and sustainable solutions. The integration of gender in water governance is not only equitable but also improves the efficiency and relevance of interventions (UN Women, 2020).

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