

Limiting Factors and Coping Strategies with Water Security Challenges in Makurdi Town, Nigeria

Ahiile, Stephen Iorlumun ¹; Ocheri, Maxwell Idoko (Phd) ²; Kwanga, Godwin, A (Phd) ²; Uyeh, Miranda Afa ³; and Philip, Asula Iveren ⁴

¹Department of Environmental Sciences and Technology, Akawe Torkula Polytechnic, Makurdi, Nigeria.

²Department of Geography, Moses Orshio Adasu University, Makurdi, Nigeria. ³Department Of Geological Technology, Akawe Torkula Polytechnic, Makurdi, Nigeria. ⁴Department Of Science Laboratory Technology, Akawe Torkula Polytechnic Makurdi, Nigeria.

Corresponding author: steveahile@gmail.com

DOI: <https://doi.org/10.62154/ajesre.2026.022.01018>

Abstract

The overall aim of water resource management is to ensure water security for all. Unfortunately, meeting this aspiration has become a critical global challenge particularly in the developing countries due to an array of problems. Makurdi town for instance is contending with many issues that impede efforts targeted at achieving water security for the growing population. This study assessed the limiting factors and coping strategies adopted by residents to deal with water security challenges. Data was gathered via the questionnaire administered to 404 respondents mainly household heads (both male and female), using the systematic random sampling technique. The Principal Component Analysis identified four underlying factors (which together explain 93.4% of the total variance in the data set) affecting water security. The results also showed that households employ multiple coping strategies, most of which are perceived to be effective. The Fisher's Exact statistic was employed to test for association between neighbor class and the adoption of coping strategies. The results revealed that neighborhood class significantly influence reliance on certain coping strategies, including the use of multiple water sources ($p=0.012$), purchasing water from vendors ($p = 0.016$), and storing water in big containers ($p = 0.030$). The study concludes that addressing water security challenges in Makurdi town will involve adopting innovative and cost-effective strategies. The study recommends among other things that Government should invest more resources into water supply projects to ensure people have unhindered access to portable water.

Keywords: Water Security, Coping Strategies, Water Security Limiting Factors, Water Management, Makurdi.

Introduction

Water is important to life and is at the heart of sustainable development. The significance of water for human survival, socio-economic development, and healthy ecosystems is widely highlighted in the literature (Babel et al., 2020). Water and many other related resources are tightly drawn together such that decisions regarding the management of water directly affects the others resources (Food Agriculture Organization, 2014).

Water security is a multi-dimensional concept that involves ensuring reliable access to sufficient, safe, and affordable water for all purposes; it also extends to issues of water management, infrastructure, sanitation, hygiene and resilience to water related challenges (Chapagain et al., 2022). Water security has emerged as critical development challenge, with the situation escalating in complexity in recent decades. Many countries, particularly those in Africa, exemplify this challenge, with the aspiration of building water secure communities increasingly looking like a mirage.

The attainment of water security is constrained by a range of factors that vary across regions. For instance, Kujinga et al. (2014), identified limited surface water sources and poor policy formulation as key factors affecting water security in Botswana, while Nkiaka (2020) identified GDP per capita, female primary school completion rate, and poor governance as key determinants of water security. Similarly, Anang et al. (2024), found that household income significantly influences water conservation attitudes in Johir Bahru, Malaysia. These variations underscore the importance of investigating context-specific determinants of water security.

Beyond identifying limiting factors, existing studies have also examined how households cope with water insecurity. Coping strategies often reflect local environmental conditions and the availability of resources (Pereira et al., 2009), and may be short-term or long-term depending on the severity of water challenges (Majuru et al., 2016). At the household level, commonly reported strategies include drilling boreholes, storing water, and resisting disconnections from public supply systems in Gweru, Zimbabwe (Kusena et al., 2017); fetching water from streams, reducing consumption, harvesting rainwater, and purchasing water from vendors in the Nzoia River Basin, Kenya (Odwor, 2021); and asset sales, water sharing, improved water management practices, and dietary adjustments in Enugu, Nigeria (Igweh et al., 2025). Similar strategies such as reliance on vendors, rainwater harvesting, and stream water use have also been observed in Nanka, Enugu State (Ezeudu et al., 2022) and Damaturu (Gana and Sa'id, 2025). While these studies provide valuable insights, they largely focus on coping mechanisms related to water supply and access. However, water security extends beyond availability to include issues of water quality, governance, infrastructure, and exposure to water-related hazards. As noted by Bakker (2012), water security reflects the broader challenges of 21st-century water management. Therefore, an investigation of the limiting factors of water security as well as the coping strategies employed to mitigate these challenges should adopt a more comprehensive approach; one that integrates both the limiting factors and coping strategies associated with the multi-dimensions of water security.

Statement of the Problem

The pursuit of water security remains a major challenge in many urban centers in Nigeria. Makurdi, a rapidly growing urban center in Benue State, Nigeria, is contending with many

water related issues that impede efforts targeted at achieving water security for the growing population. Despite its proximity to the River Benue, the town experiences persistent water insecurity characterized by limited access to potable water, poor water quality, and recurrent water-related disasters, particularly flooding. An investigation of the factors and coping mechanisms employed by residents should incorporate all these water related issues.

Previous studies conducted in different parts of Benue State have mainly assessed water supply situation. Agbehi (2007), assessed domestic water supply in Ugbokolo Community. Similarly, Ifan (2002) examined the challenges of water supply in Mbatlav district in Gboko LGA, while Aper and Agbehi (2011) examined the determining factors of water supply pattern in Ugbokolo. Furthermore, Ocheri (2006) analysed water consumption patterns in Makurdi. Ahile et al. (2015) also examined the residents coping strategies with water scarcity in Makurdi town. These studies have only investigated the challenges of water supply and water scarcity. No attempt has been made in the literature to extensively examine factors and coping strategies that holistically incorporate other water related challenges in Makurdi town. The study therefore attempts to provide answers to the following questions:

- i. What are the factors limiting households in Makurdi town from achieving water security?
- ii. What is the perception of residents about the effectiveness of the strategies they adopt to cope with water security challenges in Makurdi town?
- iii. Is there any relationship between neighbourhood class and the strategies adopted to cope with water security challenges? To answer this question, a hypothesis was formulated as follows:

Ho: There is no significant relationship between neighbourhood class and the coping strategies adopted by residents to deal with their water security challenges.

Objectives of the Study

The objectives for this study are to:

- i. determine the limit factors for household water security attainment in Makurdi town
- ii. determine residents' perception of the effectiveness of the strategies adopted to cope with water insecurity in Makurdi town.
- iii. Examine the relationship between neighbourhood class and the strategies adopted by residents to cope with water insecurity.

Conceptual Framework/Literature Review Sustainable Livelihood Framework

This study is built on the foundation of the Sustainable Livelihood Framework (Figure 1). The framework which considers the household as the basic building block of livelihood

analysis (Pond and Pedley, 2011), provides a comprehensive approach to understanding the relationship between water security and household coping behavior. The framework posits that household access to water is shaped by a vulnerability context characterized by climate, environmental, and socio-economic factors, which can directly affect water access, quantity, and reliability (Bharwani et al., 2008).

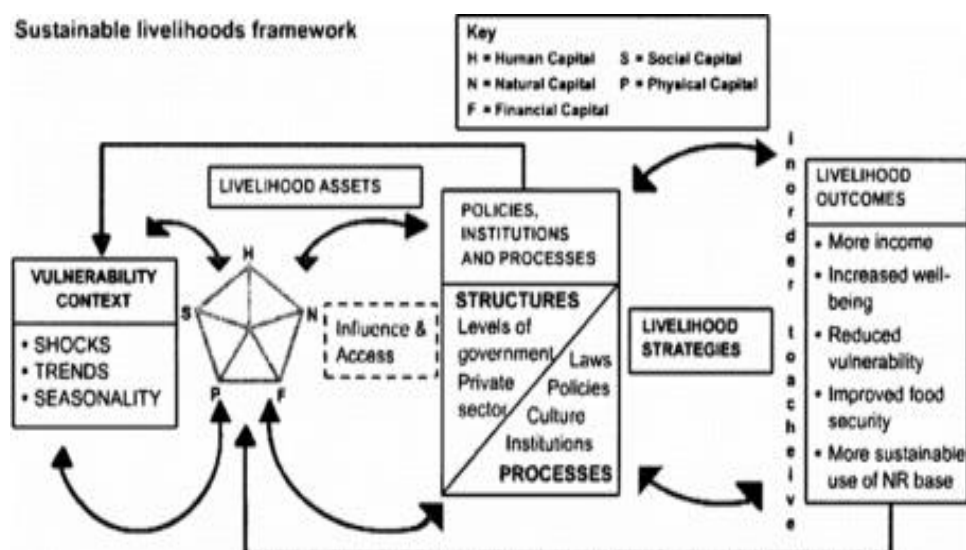


Figure 1: Sustainable Livelihood Framework (DFID, 1999).

Central to the framework is the understanding that the relative availability of various “capital assets” shape the livelihood options of households particularly in developing countries. These assets include social (family or social networks), financial (savings or supplies of credit), human (knowledge or physical ability), physical (water infrastructure), and natural (availability of water or land resources) capital (Carney, 1999). Households draw on these assets to secure water and respond to scarcity. Specifically, water availability is affected by natural water availability (natural capital) and water infrastructure (physical capital), as well as social capital (Kemp-Benedict et al., 2009). It is also important to note that the interactions between these assets are mediated by institutional structures and policies that influence access and distribution.

In response to water related challenges, households adopt diverse coping strategies which could be short-term or long term, depending on the magnitude of the water challenges faced (Majuru et al., 2016). These strategies ultimately determine water security outcomes and overall livelihood sustainability.

Water Security Limiting Factors and Households Coping Strategies.

Water is an essential resource, not only for public health, the environment and its ecosystems, but also for energy production, agriculture and food security. Unfortunately,

complex water challenges affect millions of people across the globe. In Nigeria, studies relating to the underlying factors that contribute to the water security challenges remain scanty. Abubakar (2019) examined factors influencing water security at the household level. This study however limited its scope to investigation only factors relating to access to drinking water. Using the Logistic regression analysis, the study indentified place of residence, education, wealth index, access to electricity, and gender as the major factors affecting access to drinking water. Olujuigbe (2011), employed descriptive statistics to evaluate domestic water security in Ado-Ekiti, focusing on factors affecting access to water and water quality. The study revealed similar factors to those highlighted above. Water security in Nigerian urban centers is critically compromised by rapid urbanization, deteriorating infrastructure, and inadequate water governance (Adejumo, 2020). The multidimensionality of this challenge underscores the importance of employing a methodology such as the Principal Component Analysis to investigate water security limiting factor; this tool identifies key underlying factors that enhance policy relevance, aiding policymakers to prioritize interventions.

It is widely expected that Government at all levels should prioritize and ensure the achievement of water security for the growing population. But while people wait for this to happen, they will have to device strategies to cope with their water related challenges. Analyzing water coping strategies provides insight into policy and interventions needs of communities, while also clarifying the roles of institutions and stakeholders in developing solutions (Vidya et al., 2020). This analysis also deepens our understanding of how individuals and households respond to water insecurity, enabling the design of context-specific interventions that build on existing coping mechanisms (Zug and Graefe, 2014).

The general consensus in the literature is that water insecurity in Nigeria is triggered mainly by the lack of investment in water provision. To this end, most studies investigate coping strategies that solely promote access to water. This study extends the literature by introducing mechanisms that will help address not just the limitation in water supply but other water related challenges.

Materials and Methods

Description of the study area

Makurdi town situated in the plains of Benue trough in the middle belt region of Nigeria, lies within the geographical coordinates of latitude 7°43'50"N of the equator and longitude 8°32'10"E of the Greenwich meridian (Figure 2). Makurdi town has a mean elevation of 92 meters above sea level, a circular radius of 16 km², and a total landmass of about 700 km² (Ali, 2018). The town is traversed by the river Benue, dividing it into the north and south banks, the latter forming the most significant part of the town.

The climate of Makurdi is the hot and humid type which corresponds with the Koppen's (Aw) climate classification. Generally, the climatic condition in Makurdi town is influenced by the

south-westerly and the north-easterly winds. Temperatures are generally high throughout the year due to the constancy of insolation, with the maximum of 33°C and a mean minimum of 22.5°C with annual range of 10.5°C. Temperatures may occasionally climb to 37°C in some days in March and April (Iorkua, 2006).

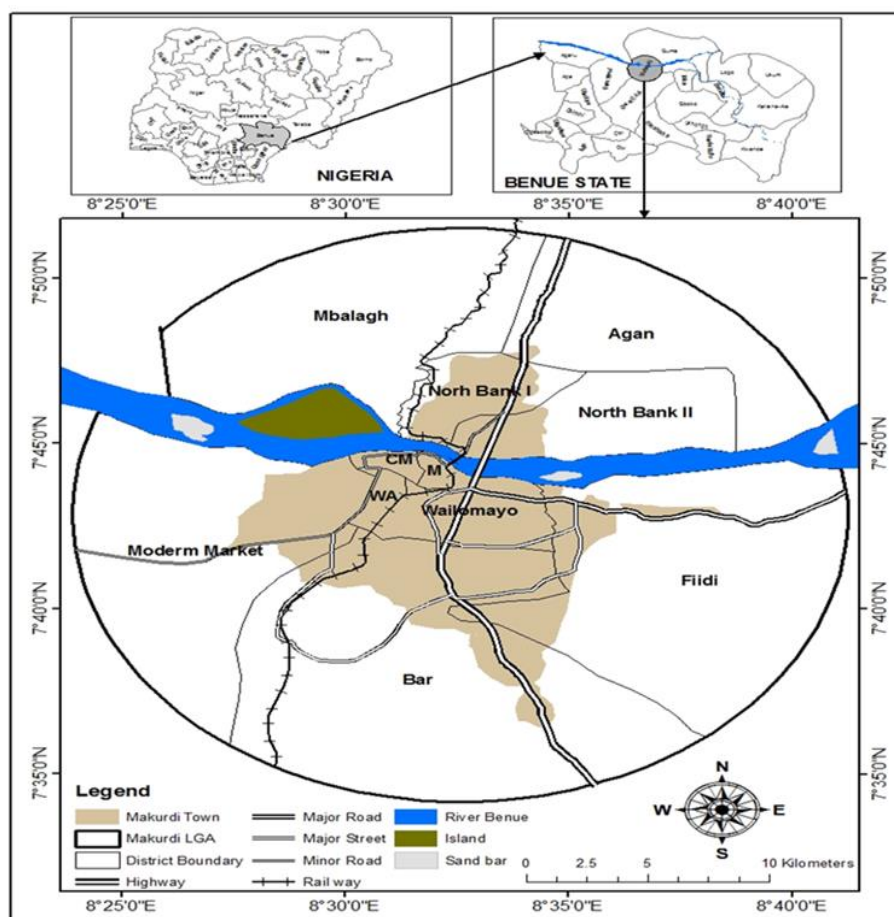


Figure 2: Districts in Makurdi L.G.A

The rainfall of the area is highly seasonal, coming in form of intense, violent, convectional showers of short duration. The annual rainfall ranges between 1500mm to 2000mm, with a peak rainfall in the months of July and September. The geology of Makurdi town is of cretaceous and consists of fluvio deltaic sediments with well-bedded sandstones which are of hydrogeological significance in terms of groundwater yield and exploitation (Kogbe et al, 1978).

The vegetation of Makurdi is that of Guinea Savannah, consisting of tall scattered trees and short grasses. It is observed that the vegetation is largely influenced by local climatic

conditions and the distribution of rivers/streams in the area, geology, as well as human influence (Muhammed, 2018).

Sample Size Determination

Makurdi town has a population of 539,757 consisting of 146,774 households (National Population Census figures of 1991 projected to 2025 at 2.8% annual growth rate). Using Yamane (1967), a sample size of 399 was determined. However, this sample size was adjusted to 405 to ensure a fair reflection of the population distribution across the study area during data collection. Out of this number, 404 questionnaires were returned and analyzed.

Sampling Procedure

The study selected twenty-seven (27) neighborhoods, three (3) each from the nine (9) council wards that make up Makurdi town. This selecting was done on the basis of the income level of neighborhoods, classified as high, middle and low income. Consequently, the twenty- seven neighborhoods equally consisting of nine (9) high, middle and low income neighborhoods are shown in table 1. The criteria for this segregation was based on the quality of housing, cost of rent, land and property value, and the presence of infrastructure (e.g good road networks) and social amenities.

Table 1: Sampled Council Wards and Neighborhoods

S/No	Council Ward	Sampled Neighborhoods		
		High Income	Middle Income	Low Income
1	AnkpaWadata	Ankpa Quarters	Ankpa ward	Wadata
2	Bar	Welfare Quarters	Achusa	Mobile Barracks
3	Central South Mission	Old GRA	Lobi Quarters	Madikpo
4	Clark	Kwararafa Quarters	Clark Quarters	New Garage
5	Fiidi	Judges Quarters	TerwaseAgbadu	Fiidi
6	Modern Market	Modern market road	Gbonko	Agbough
7	North Bank I	Mission ward	Katungu	Yogbo road
8	North Bank II	Court 5	Federal Housing	Asase
9	Wailomayo	Nyiman	High level	Wurukum

Source: Compiled by Author, 2026

Data Collection and Analytical Techniques

Data for this study was collected mainly through the Questionnaire. The study employed the systematic random sampling to collect information from 399 household heads in the study area; to do this, one in every three hundred and sixty-eight (1 in 368; derived by dividing the 146,774 households by the sample size of 399) house within the sampled

neighborhoods was selected and a questionnaire administered to the head of the household.

The Principal Component Analysis was used to analyze the perceived factors affecting water security in the study area using data collected on a 5-point Likert scale. Descriptive statistics such as frequency counts and percentages were used to analyze the strategies adopted by respondents to cope with water security challenges. To evaluate the perceived effectiveness of the coping mechanisms adopted by the respondents, a 5-point Likert Scale: Strongly Agree (5), Agree (4), Not Sure (3), Disagree (2), and Strongly Disagree (1), was employed. For each strategy, frequencies of responses were multiplied by weights (5-1) to compute the cumulative points. The Weighted Mean Scores (WMS) and Rank were derived to measure perceived effectiveness. The WMS of 3.0 was used as the benchmark to gauge the perceived level of effectiveness of the coping strategies adopted in the study area. Therefore, a score of 3 and above indicates that the coping strategy adopted is effective, while a score below 3 indicates it is not effective. For further interpretation, a score of 4 and above is considered highly effective, 3.5-3.99 is considered effective, 3.0-3.49 is moderately effective, while a score less than 3 is considered not effective (Agbi, 2022). The WMS were then ranked to see their level of effectiveness.

The Fisher's exact statistics was used to test the association between neighborhood class and the type of coping mechanisms adopted by respondents. The essence was to determine the influence of neighborhood class on their choice of coping mechanisms. The rule is that where the Fisher's Exact test produce a p-value greater than 0.05 then there is no statistically significant evidence that a coping strategy adoption differs between neighborhood class (high, middle and low-income). Conversely, where the p-value is less than 0.05, then there is significant association.

Presentation of Results

Socio-demographic Characteristics of Respondents

Data on the socio-demographic characteristics of the respondents was collected via the questionnaire and is presented in table 2 below. For gender, the results show that 75% of the respondents are male, while 25% are female. This indicates that majority of the households were headed by the men. The findings also show that majority of the respondents (49.8%) are aged between 46-60 years, indicating that they likely to have many dependents with a lot of water needs. Findings also reveal that about 32.8% of the households have between 2-4 residents, 46.4% have between 5-10 residents, 17.3% have between 11-15 residents, while 3.6% have more than 16 residents. The results also show that Makurdi town has an average household size of 6 persons. This is also indicative of a population with high water needs.

For the educational level, findings show that 53.2% are graduates, while 12.1% have further obtained postgraduate education, culminating to 65.3% of the respondents considered to

be well educated. It is therefore expected that this population will have a high level of awareness of water conservation, hygiene practices, and the importance of safe water use. For the income level, findings show that 52.2% of the respondents earn between 1-2 million naira annually, while 18.6% earn income above 2 million. Given the economic status of Makurdi town, 70.8% of the sampled population can be said to be relatively living comfortable lives. These people will be more likely to afford water infrastructure like boreholes and storage tanks to boost their water access.

Table 2: Socio-demographic Characteristics of Respondents

Gender	Frequency	Percentage	Marital Status	Frequency	Percentage
Female	101	25	Single	21	5.2
Male	303	75	Married	353	87.3
			Divorced	16	4
			Widowed	14	3.5
Total	404	100%	Total	404	100%
Age	Frequency	Percentage	Income	Frequency	Percentage
18-30	30	7.4	< 500000	63	15.6
31-45	141	34.9	501000 – 1m	55	13.6
46-60	201	49.8	1.1m – 1.5m	76	18.8
61-70	31	7.7	1.6m – 2m	135	33.4
> 70	1	0.2	> 2m	75	18.6
Total	404	100%	Total	404	100%
Education	Frequency	Percentage	Household size	Frequency	Percentage
Primary	1	0.2	2-4	133	32.8
Secondary	47	11.6	5-10	187	46.4
Diploma	92	22.8	11-15	70	17.3
Graduate	215	53.2	16 and above	14	3.5
Post Graduate	49	12.1			
Total	404	100%	Total	404	100%

Source: Author's fieldwork, 2026

Factors Affecting Household Water Security in Makurdi Town.

The study examined the factors affecting household water security in the study area. To achieve this, 20 factors (herein called variables, are defined as shown in table 3) obtained based on a review of literature and evidence from preliminary survey, were subjected to principal component analysis (PCA) in order to reduce the dimensionality of the dataset.

Table 3: Description of Factors Affecting Household Water Security in Makurdi Town

Variable code	Variable label	Variable Description
X ₁	NWSOA	Number of water sources available to a household
X ₂	PROXI	Proximity to reliable water sources
X ₃	AWIN	Age of water infrastructure
X ₄	PMWI	Poor maintenance of water infrastructure
X ₅	ISTOFA	Inadequacy of household water storage facilities
X ₆	TIME	Time spent to fetch water
X ₇	NOPRFW	Number of persons responsible for fetching water
X ₈	INEAWA	Inequality in access to water
X ₉	DSPEL	Prolonged dry spells
X ₁₀	SFIWS	Seasonal fluctuations in water supply
X ₁₁	POLLWS	Pollution of water sources
X ₁₂	OEGW	Over extraction of groundwater
X ₁₃	FLOOD	Reoccurring and frequent floods
X ₁₄	SIZE	The size of the household
X ₁₅	INCOME	Income level of household
X ₁₆	EDUC	Educational/knowledge level of household
X ₁₇	POPURB	Increased rate of population and urbanization
X ₁₈	HHWA	Low health and hygiene awareness
X ₁₉	WASH	Low investment in water and sanitation by government
X ₂₀	CONSER	Non-participation of community members in water conservation

Source: Author's fieldwork

The variables used were tested to assess their adequacy for the model using two test methods: the KMO and Bartlett's test of Sphericity. The KMO checks sample adequacy for the use of PCA; a KMO above 0.8 is considered excellent. In this case KMO = 0.978 which implies that the sample used for the analysis is excellent for the model. Bartlett's Test of Sphericity verifies if variables are sufficiently correlated in the model. Since the p-value = 0.00 is less than 0.05, (table 4) it implies that the variables are sufficiently correlated and suitable for PCA.

Table 4: Results of the KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO)		.978
Bartlett's Test of Sphericity	Approximate Chi Square	7.954E3
	Degree of freedom	190
	Significance	.000

Source: SPSS

Extraction of Components

The PCA extracted four components whose eigenvalues are greater than 1. In the interpretation of the components, only variables with loadings from +/- 0.5 were considered significant. The four components extracted jointly explaining 93.4% of the total variance in the dataset (tables 5 & 6), leaving only 6.6% to minor factors not captured in the study.

Table 5: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.942	29.710	29.710	5.942	29.710	29.710	5.548	27.739	27.739
2	5.087	25.437	55.146	5.087	25.437	55.146	4.724	23.618	51.357
3	4.118	20.592	75.739	4.118	20.592	75.739	4.673	23.366	74.723
4	3.541	17.704	93.443	3.541	17.704	93.443	3.744	18.718	93.442
5	.170	.848	94.290						
6	.146	.728	95.018						
7	.116	.580	95.598						
8	.098	.492	96.090						
9	.094	.468	96.558						
10	.088	.442	96.999						
11	.083	.414	97.413						
12	.080	.400	97.814						
13	.077	.386	98.200						
14	.068	.341	98.541						
15	.062	.309	98.849						
16	.057	.285	99.134						
17	.056	.280	99.414						
18	.047	.234	99.648						
19	.040	.202	99.850						
20	.030	.150	100.000						

Extraction Method: Principal Component Analysis

Table 6: Varimax Rotated Components Matrix

Variable	Variable code	Components			
		1	2	3	4
Number of water sources available to a household	X1	.877	.211	.265	-.230
Proximity to reliable water sources	X2	.900	.156	.204	-.245
Age of water infrastructure	X3	.879	.178	.213	-.242
Poor maintenance of water infrastructure	X4	.877	.173	.216	-.230
Inadequacy of household water storage facilities	X5	.897	.180	.225	-.231
Time spent to fetch water	X6	.889	.171	.235	-.229
Number of persons responsible for fetching water	X7	.154	-.015	.560	.781
Inequality in access to water	X8	.163	-.009	.544	.789
Prolonged dry spells	X9	.131	-.022	.543	.779
Seasonal fluctuations in water supply	X10	.153	.009	.530	.791
Pollution of water sources	X11	.488	.536	.575	-.278
Over extraction of groundwater	X12	.437	.566	.577	-.321
Reoccurring and frequent floods	X13	.476	.568	.546	-.280
The size of the household	X14	.485	.525	.591	-.267
Income level of household	X15	.458	.535	.597	-.287
Educational/knowledge level of household	X16	.067	.821	-.448	.240
Increased rate of population and urbanization	X17	.077	.831	-.427	.280
Low health and hygiene awareness	X18	.070	.831	-.448	.260
Low investment in water and sanitation by government	X19	.110	.837	-.399	.240
Non-participation of community members in water conservation	X20	.084	.804	-.460	.268
Total Eigen values		5.942	5.08	4.11	3.54
% of Variance		29.71	25.4	20.5	17.7
Cumulative %		29.71	55.1	75.7	93.4

Significant loadings i.e +/-0.5 are bolded

Interpretation of Components

Component 1: Household Water Access and Infrastructure Deficiency

This component is associated with household water access and infrastructure deficiency and its effect on water security. The component has an eigen value of 5.94 and accounts for 29.71% of the total variance in the dataset. The component shows very high loadings on variables X1–X6, including number of water sources (.877), proximity to reliable sources (.900), age of infrastructure (.879), poor maintenance (.877), inadequate storage (.897), and

time spent fetching water (.889). These consistently high loadings indicate that this component captures the fundamental physical and infrastructural limitations that households face in accessing water. The component suggests that the reliability, condition, and accessibility of water infrastructure strongly shape households' daily experiences with water supply.

Component 2: Socio-economic, Institutional, and Demographic Constraints

This component highlights the influence of socio-economic, institutional, and demographic constraints on water security. The component has an eigen value of 5.08 and accounts for 25.4% of the total variance in the data set. The component is dominated by strong positive loadings above .80 on X16–X20: educational level (.821), population growth and urbanisation (.831), low hygiene awareness (.831), low government investment (.837), and low community participation (.804). This cluster indicates the role of social capacity, demographic pressure, governance failures, and community engagement in influencing water access. The presence of consistent high loadings across these variables suggests that water challenges are deeply embedded in wider socio-economic structures and institutional limitations.

Component 3: Hydrological Stress and Socio-economic Vulnerability

This component reveals the effect of environmental and seasonal water stress on water security. The component has an eigen value of 4.11 and accounts for 20.5% of the total variance in the data set. The components include moderately high loadings on X7–X15, particularly number of persons fetching water (.560), inequality in access (.544), prolonged dry spells (.543), seasonal fluctuations in supply (.530), pollution (.536), groundwater over-extraction (.566), recurrent floods (.568), household size (.525), and income level (.535). The combination of climatic variables (X9–X10), environmental pressures (X11–X13), and household characteristics (X14–X15) reveals that this component captures the interaction between household vulnerability and environmental variability. The loadings indicate that climatic stressors significantly shape water availability while also increasing household-level exposure and burden.

Component 4: Environmental Degradation and Water Resource Pressure

This component demonstrates the impact of environmental degradation and water resource pressure on water security, and it is defined by strong positive loadings on X7 (.781), X8 (.789), X9 (.779), X10 (.791), and moderate negative cross-loadings with some pollution and flood-related variables. The high loadings on seasonal drought, seasonal fluctuation, and access inequality suggest this component reflects pressure arising from recurrent environmental stress and fluctuations in water availability. This component reinforces how climatic instability amplifies household-level inequalities in access and reliability of water sources.

Coping Strategies Adopted to Deal with Water Security Challenges

The result of respondent's perception on the effectiveness of some of the strategies adopted to cope with water security challenges in Makurdi town is presented in table 7. Based on the computed weighted mean scores (WMS), the results reveal that dredging of hand-dug wells (4.22), storing water in big containers (4.20), sending children to fetch water (4.14), rainwater harvesting (4.13), and buying water from vendors (4.03), ranked 1st, 2nd, 3rd, 4th and 5th respectively, are considered highly effective coping strategies.

The results of the analysis also reveal that relying on multiple sources of water (3.98), protecting wells from flood water intrusion (3.97), reducing water consumption (3.87), and water recycling (3.81), ranked 6th, 7th, 8th and 9th respectively are perceived to be effective coping strategies.

The results finally show that the option of getting water from places of worship (3.23), relocating to other neighborhoods with good access to water (3.13), and adopting low-water hygiene and sanitation technologies (3.02), ranked 10th, 11th, and 12th respectively, are perceived as moderately effective strategies.

Table 7: Respondents' Perception of the Effectiveness of the Adopted Coping Strategies to Water Security Challenges.

Coping Strategy		SA	A	NS	DA	SD	Total	WMS	Rank	Remark
Relying on multiple sources of water	Frequency	39	340	9	12	4	404			
	Points cumulated	195	1360	27	24	4	1610			
	Weighted mean score						3.98	3.98	6	Effective
Water recycling	Frequency	21	326	19	36	2	404			
	Points cumulated	105	1304	57	72	2	1540			
	Weighted mean score						3.81	3.81	9	Effective
Rainwater harvesting	Frequency	88	297	8	9	2	404			
	Points cumulated	440	1188	24	18	2	1672			

Coping Strategy		SA	A	NS	DA	SD A	Total	WMS	Rank	Remark
	Weighted mean score						4.13	4.13	4	Highly Effective
Get water from places of worship	Frequency	10	192	89	109	4	404			
	Points cumulated	50	768	267	218	4	1307			
	Weighted mean score						3.23	3.23	10	Moderately effective
Reducing water consumption	Frequency	41	301	35	23	4	404			
	Points cumulated	205	1204	105	46	4	1564			
	Weighted mean score						3.87	3.87	8	Effective
Buying water from vendors	Frequency	83	277	23	19	2	404			
	Points cumulated	415	1108	69	38	2	1632			
	Weighted mean score						4.03	4.03	4	Highly Effective
Relocating to other neighborhoods	Frequency	18	166	81	130	9	404			
	Points cumulated	90	664	243	260	9	1266			
	Weighted mean score						3.13	3.13	11	Moderately Effective
Store water in big containers	Frequency	100	295	3	3	3	404			
	Points cumulated	500	1180	9	6	3	1698			

Coping Strategy		SA	A	NS	DA	SD A	Total	WMS	Rank	Remark
	Weighted mean score						4.20	4.20	2	Highly Effective
Sending children to fetch water	Frequency	98	281	12	11	2	404			
	Points cumulated	490	1124	36	22	2	1674			
	Weighted mean score						4.14	4.14	3	Highly Effective
Adopting low-water hygiene and sanitation technologies	Frequency	42	134	26	198	4	404			
	Points cumulated	210	536	78	396	4	1224			
	Weighted mean score						3.02	3.02	12	Moderately Effective
Dredging hand-dug wells to get water	Frequency	134	242	13	13	2	404			
	Points cumulated	670	968	39	26	2	1705			
	Weighted mean score						4.22	4.22	1	Highly Effective
Protect wells from flood water intrusion	Frequency	221	104	19	32	28	404			
	Points cumulated	1105	416	57	64	28	1607			
	Weighted mean score						3.97	3.97	7	Effective

Test of Association Between Neighborhood Class and Coping Strategy Employed.

Evidence of association between neighborhood class and strategies employed to cope with water security challenges in Makurdi town was explored using contingency tables and tested with the Fisher's Exact statistic at 5% level of significance. Table 8 below

summarizes the results. The results revealed a statistically significant association between neighborhood class and reliance on multiple sources of water as a coping strategy ($F_{\text{exact}} = 17.478$; $p = 0.012$). This implies that neighborhood class influences household adoption of relying on multiple sources of water as a coping strategy. The results further show that despite been a widely adopted coping strategy across all neighborhoods (95% in high-income neighborhoods, 90% in middle-income neighborhoods and 97% in low-income neighborhoods), the extent of adoption still varies slightly by neighborhood class. For instance, relatively fewer households in the middle-income neighborhoods adopt this strategy, while more households in low-income neighborhoods depend most on this strategy, reflecting their challenges and unreliability of depending on a single source of water.

The association between neighborhood class and buying water from vendors was also tested and shown to be statistically significant ($F_{\text{exact}} = 17.124$; $p = 0.016$), indicating that the dependence on vendors for water is also influenced by neighborhoods class. The result also shows that despite being a widely adopted coping strategy across all neighborhoods (89% in high-income neighborhoods, 90% in middle-income neighborhoods and 89% in low-income neighborhoods), slight variations exist; households in middle-income neighborhoods seem to rely more on vendors for water.

The association between neighborhood class and storing water in big containers was also tested and equally shown to be statistically significant ($F_{\text{exact}} = 13.158$; $p = 0.030$), indicating that neighborhood class influences household reliance on storing water in big containers as a coping strategy. The results however show slight variation in the adoption of this strategy, with almost all high-income neighborhoods (99.9%) adopting the strategy relative to what is obtainable in other neighborhoods. A conclusion can be drawn that because of the economic status of households in high-income neighborhoods, they are more likely to afford the cost of buying big tanks which can be used to store water.

The results show no significant association between neighborhood class and the adoption of the other coping strategies: rainwater harvesting, water recycling, sending children to fetch water, reducing water consumption, getting water from worship centers, relocating to other neighborhoods, adopting low-water hygiene and sanitation technologies, dredging dry wells and protect wells from flood water intrusion. For all these coping strategies, the Fisher's exact test produced p -values > 0.05 , meaning there is no statistically significant evidence that coping strategy adoption was influenced by neighborhood class. The results further revealed that besides not being significant, relocating to other neighborhoods ($F_{\text{exact}} = 6.212$, $p = 0.627$) was a rare and undesirable coping option; over 70% of households across all neighborhood class disagreed with this option. In addition, getting water from worship centers was also not significant ($F_{\text{exact}} = 9.215$, $p = 0.294$) and its use as a coping strategy was limited across all neighborhoods.

Table 8: Association between Neighborhood Class and Coping Strategies Adopted.

Neighborhood Class	Relying on multiple sources of water					Total	Statistics
	SA	A	NS	DA	SDA		
High Income	11 (8.5)	112 (86.8)	2 (0.1)	3 (0.2)	1 (0.1)	129	F _{exact} = 17.478 Df = 8 (p = 0.012)
Middle Income	12 (8.4)	115 (80.9)	6 (4.2)	9 (6.3)	0 (0)	142	
Low Income	16 (12)	113 (84.9)	1 (0.7)	0 (0)	3 (2.3)	133	
Total	39	340	9	12	4	404	
Water recycling							
High Income	5 (3.8)	103 (79.8)	4 (3.1)	17 (13.2)	0 (0)	129	F _{exact} = 11.022 Df = 8 (p = 0.153)
Middle Income	9 (6.3)	116 (81.6)	5 (3.5)	12 (8.4)	0 (0)	142	
Low Income	7 (5.2)	107 (80.4)	10 (7.5)	7 (5.3)	2 (1.5)	133	
Total	21	326	19	36	2	404	
Rainwater harvesting							
High Income	33 (25.5)	92 (71.3)	2 (1.5)	2 (1.5)	0 (0)	129	F _{exact} = 7.131 Df = 8 (p = 0.491)
Middle Income	29 (20.4)	104 (73.2)	5 (3.5)	4 (2.8)	0 (0)	142	
Low Income	26 (19.5)	101 (75.9)	1 (0.7)	3 (2.2)	2 (1.5)	133	
Total	88	297	8	9	2	404	
Get water from places of worship							
High Income	2 (1.5)	92 (71.3)	25 (19.3)	10 (7.8)	0 (0)	129	F _{exact} = 9.215 Df = 8 (p = 0.294)
Middle Income	4 (2.8)	54 (73.2)	38 (6.3)	46 (17.7)	0 (0)	142	
Low Income	4 (3)	46 (75.9)	26 (0.7)	53 (2.2)	4 (3)	133	
Total	10	192	89	109	4	404	
Reducing water consumption							
High Income	15 (11.6)	93 (72.1)	11 (8.5)	10 (7.7)	0 (0)	129	F _{exact} = 12.610 Df = 8 (p = 0.100)
Middle Income	15 (10.5)	112 (78.8)	12 (8.4)	3 (2.1)	0 (0)	142	
Low Income	11 (8.2)	96 (72.1)	12 (9.0)	10 (7.5)	4 (3)	133	
Total	41	301	35	23	4	404	
Buying water from vendors							
High Income	35 (27.1)	80 (62.0)	5 (3.8)	9 (6.9)	0 (0)	129	F _{exact} = 17.124 Df = 8
Middle Income	22 (15.4)	106 (74.6)	6 (4.2)	8 (5.6)	0 (0)	142	
Low Income	26 (19.5)	91 (68.4)	12 (9.0)	2 (1.5)	2 (1.5)	133	

Neighborhood Class	Relying on multiple sources of water					Total	Statistics
	SA	A	NS	DA	SDA		
Total	83	277	23	19	2	404	(p =0.016)
	Relocating to other neighborhoods						
High Income	9 (6.9)	50 (38.7)	28 (21.7)	40 (31.0)	2 (1.5)	129	F _{exact} =6.212
Middle Income	6 (4.2)	63 (44.3)	27 (19.0)	44 (30.9)	2 (1.4)	142	Df=8
Low Income	3 (2.2)	53 (39.8)	26 (19.5)	46 (34.5)	5 (3.7)	133	(p=0.627)
Total	18	166	81	130	9	404	
	Store water in big containers						
High Income	37 (28.6)	92 (71.3)	0 (0)	0 (0)	0 (0)	129	F _{exact} =13.158
Middle Income	24 (16.9)	115(80.9)	1 (0.7)	1 (0.7)	1 (0.7)	142	Df= 8
Low Income	39 (29.3)	88 (66.1)	2 (1.5)	2 (1.5)	2 (1.5)	133	(p =0.030)
Total	100	295	3	3	3	404	
	Sending children to fetch water						
High Income	31 (24.0)	92 (71.3)	3 (2.3)	3 (2.3)	0 (0)	129	F _{exact} =7.016
Middle Income	30 (21.1)	100 70.4)	6 (4.2)	6 4.2()	0 (0)	142	Df=8
Low Income	37 (27.8)	89 (66.9)	3 (2.2)	2 (1.5)	2 (1.5)	133	(p =0.507)
Total	98	281	12	11	2	404	
	Adopting low-water hygiene and sanitation technologies						
High Income	18 (12.7)	38 (26.9)	14 (9.9)	67 (47.5)	4 (2.8)	141	F _{exact} =8.016
Middle Income	14 (9.8)	62 (43.6)	8 (5.6)	58 (40.8)	0 (0)	142	Df=8
Low Income	10 (8.3)	34 (28.1)	4 (3.3)	73 (60.3)	0 (0)	121	(p =0.217)
Total	42	134	26	198	4	404	
	Dredging hand-dug wells to get water						
High Income	43 (33.3)	77 (59.6)	2 (1.5)	6 (4.6)	1 (0.7)	129	F _{exact} =8.896
Middle Income	43 (30.2)	86 (60.5)	9 (6.3)	4 (2.8)	0 (0)	142	Df=8
Low income	48 (36.0)	79 (59.3)	2 (1.5)	3 (2.3)	1 (0.7)	133	(p =0.300)
Total	134	242	13	13	2	404	
	Protecting wells from flood water intrusion						
High Income	82 (46.1)	67 (37.6)	9 (5.06)	8 (4.49)	12 (6.75)	178	F _{exact} =5.812
Middle Income	90 (65.6)	24 (17.5)	6 (4.37)	11 (8.04)	6 (4.5)	137	Df=8
Low Income	49 (55.1)	13 (14.6)	4 (4.5)	13 (14.6)	10 (11.2)	89	(p =0.410)
Total	221	104	19	32	28	404	

Discussion of Results

Water security is a multi-faceted problem, which is affected by divergent factors. According to Khan et al. (2020), issues such as population growth, urban sprawl, changing socioeconomics, and the threat of climate change are the most common hurdles to achieving and maintaining water security. This study employed the Principal Component Analysis (PCA) to identify four factors limiting household water security in Makurdi town to include: household water access and infrastructural deficiency; socioeconomic, institutional, and demographic constraints; hydrological stress and socioeconomic vulnerability; and environmental degradation and water resource pressure.

The study has shown that water infrastructural deficiency is the major limiting factor to achieving water security in Makurdi town. Earlier studies conducted on the subject matter in Benue State align with the findings of this study, lamenting the neglect or failure of the Benue State Government to invest in the water sector (Ortserga et al., 2022). Consequently, most neighborhoods particularly those in the new layouts have continued to experience poor access to water supply. Unfortunately, the case of Makurdi is not isolated. Nayak and Samai (2025), equally attributed the growing water insecurity challenge in Odisha, India to the lack of investment in water infrastructure. In addition to the lack of investment in providing new public water sources, the World Bank (2021) reports that there is a high breakdown rate of water infrastructure across Africa, occasioned by lack of maintenance, thus threatening the sustainability of what has already been achieved.

The second component shifts the focus from infrastructure provision to poor policies and weak institutional arrangements. Poor policies often act as risk multiplier, capable of turning water scarcity into a severe water crisis for communities (Mishra et al., 2021). Previous studies carried out in Makurdi have concluded that the town lacks a well-defined public water supply policy, resulting in uncoordinated and inequitable provision of public water in many neighborhoods within the town (Ortserga et al., 2025; Chia et al., 2015). Other studies have separately attributed the lingering water related challenges in Ado-Ekiti (Sodamada et al., 2020) and Lafia town (Obadiah, 2011) to weak institutional arrangements, particularly where key staffs of water corporations are overlooked in favor of politicians in the appointment of management positions. This creates “bad blood”, resulting in managerial instability with a tendency to affect service delivery.

The next component highlights the effect of environmental and seasonal water stress on water security. Climatic stressors particularly erratic rainfall patterns, drought, flood, and increased temperatures significantly shape water availability and accessibility (Amparo-Salcedo et al., 2025), consequently increasing household-level exposure and burden. It is reported for instance that erratic rainfall manifesting in the delay in the onset of the Kiremt and Belg seasons in Kenya, as well as the reduction in volume of water in the Turkwel river in Ethiopia, have affected water availability for semi-urban households involved in small-scale vegetable farming, thus threatening their income (Murgatroyd et al., 2021). In

Lebanon, climate-related uncertainties are projected to reduce water availability for domestic use by as much as 9% by 2040, with reductions reaching up to 50% during the dry season (World Bank, 2024). These kinds of shocks can sometimes force people to abandon their traditional livelihoods, especially where they lack financial capacity to build resilience. The last component demonstrates the impact of environmental degradation and water resource pressure on water security. Environmental degradation in Makurdi town is mainly manifested through soil erosion, improper waste disposal, and pollution of rivers, streams, and other water bodies (Ochoche et al., 2025). Indiscriminately disposed solid waste and industrial effluents are often washed by rainfall into water sources, leading to their contamination. Studies have reported the dominant presence of heavy metals (Ali et al., 2020), nitrates (Ocheri et al., 2010), and coli form bacteria (Agyo et al., 2020) in selected hand-dug wells across Makurdi town, with significant implications for low-quality of life of residents. Increased population growth and urbanization places pressure on existing water resources. As demand for water increases, water sources become overstretched. A study conducted by Ahile et al. (2018a) in three housing estates in Makurdi (Aper Aku estate, BIPC estates in Nyiman and North Bank), showed an alarming 46 boreholes drilled in about 153 units that were occupied. This indicates that people are increasingly becoming dependent on ground water for their water supplies. This could lead to environmental crisis such as groundwater depletion in the near future. A similar crisis of ground water depletion and land subsidence has been reported in Baluchistan, Pakistan (van Steerbergen et al., 2014). Due to the multi-dimensionality of the challenges limiting water security in Makurdi town, residents come up with strategies to cope. In this study, coping strategies employed by respondents, generally proved to be useful, with some variations in their level of effectiveness. For instance, storing water in big containers is considered a highly effective strategy that improves household resilience during water shortages (Odwor, 2021), while rainwater harvesting is highly effective where rainfall is adequate. A key merit of rainwater harvesting is that it eliminates financial cost and drudgery of water collection. Sending children to fetch water is also considered highly effective strategy, but it carries significant social drawbacks for the children; it interferes with their schooling, negatively affects their academic achievement, causes stress, anxiety, and fatigue, and exposes them to environmental risks (Majuru et al., 2016). Due to the draw backs of this strategy, households are advised to ensure that children are protected by ensuring they don't spend too much time fetching water. The adopting of buying water from vendors is an equally highly effective strategy especially during emergencies, but can be expensive especially for households whose income is considerably low (Ahile et al., 2015). In addition, the effectiveness of this strategy depends on the ease to water access and quality of water (Abubakar, 2018). Furthermore, this strategy may also force families to spend a considerable portion of their income on water at the expense of other commodities (Collins et al., 2019).

Relying on multiple sources of water is a common diversification strategy that prevents over-dependence on one source. Achore and Bisung (2023) have shown that this strategy increased water reliability and resilience of Ghanaian households, thereby improving water security, enhancing their adaptation to environmental change, and promoting equity and access. Other households reduce their water consumption in order to cope with the challenges. This is a practical approach to managing water demand, though it is less preferred than supply-side strategies. Many other households perceive waste water recycling as an effective strategy. However, this strategy is culturally less acceptable and its use is limited. This assertion aligns with findings of studies conducted by Ahile et al. (2018b) and Abba et al. (2013), both of which concluded that the perception and use of grey water in Makurdi town and Maiduguri metropolis respectively was very low. Another coping strategy considered effective by residents is the protection of wells from flood water intrusion. It was observed during field data collection that many households haven't given a thought to the possibility of using this strategy. Considering Makurdi's vulnerability to flooding, residents should consider more innovative ways of up-scaling their resilience.

Water insecurity particularly poor water access forces some people to relocate to other neighborhoods. Studies have shown that this strategy is not a sustainable option; it can be costly and affect social ties (Gomez et al., 2019). Similarly, getting water from places of worship and adopting low-water hygiene and sanitation technologies are perceived by households in Makurdi town as moderately effective coping strategies. Since getting water from worship centers is mostly dependent on goodwill, water supply can be irregular. There can also be issues of crowding and conflicts at the water points; people queue for long hours and sometimes end up fighting over water. In the case of using low-water hygiene and sanitation technologies, it was observed that this strategy was adopted mainly in the high income neighborhood, not necessarily due to their income but health awareness. This highlights the importance of up-scaling environmental and healthy living awareness campaigns across Makurdi town.

Conclusion

This paper has shown that neighborhoods in Makurdi town face water security challenges. The study identifies four underlying factors affecting household water security (these factors collectively explain most of the variability in water security conditions), highlighting poor access to water and infrastructure deficiency as the major factor. The study has also shown that residents devise strategies to cope with water security challenges in their neighborhoods; the adopted coping strategies were largely effective. However, the significant association between neighborhood class and reliance on specific coping strategies indicates that socio-economic status of households shape their response to water insecurity. Overall, the paper has shown that the approaches employed in understanding water security limiting factor and coping strategies in most urban settings

are isolated; they do not holistically reflect the multidimensionality of the water security challenge.

Based on the findings of the study, the following recommendations are made:

- i. To address the problem of poor access and infrastructure deficit identified as the major factor limiting water security, Government should invest more resources into water supply projects; water storage tanks should be constructed and positioned strategically in all areas of the town to ensure people have unhindered access to portable water. Relatedly, households are also encouraged to engage in communal water supply projects by pooling resources together to either sink boreholes or dig wells for their common use.
- ii. Community involvement in environmental management initiatives should be encouraged. This will help residents to have a sense of belonging and responsibility and thus help reduce the vulnerability of their neighborhoods to water related disasters.
- iii. Households should increasingly adopt the use of simple and cost-effective strategies such as rainwater harvesting and wastewater recycling in addressing their water security challenges.

References

- Abba, K., Hauwa, L.B., and Jimma, M.A. (2013). Assessment of Domestic Waste Water Disposal in Some Selected Wards in Maiduguri Metropolis, Borno State, Nigeria. *Journal of Geography and Geology*, 5(4): 83-93. <http://dx.doi.org/10.5539/jgg.v5n4p83>
- Abubakar, I. R. (2018). Strategies for coping with inadequate domestic water supply in Abuja, Nigeria. *Water International*, 43(5): 570-590. DOI: 10.1080/02508060.2018.1490862
- Abubakar, I.R. (2019). Factors influencing household access to drinking water in Nigeria. *Utilities Policy*, 58: 40-51. <https://doi.org/10.1016/j.jup.2019.03.005>.
- Achore, M. and Bisung, E. (2023). Coping with water insecurity in urban Ghana: patterns, determinants, and consequences. *Journal of Water, Sanitation and Hygiene for Development*, 13(2): 150-164. Doi: 10.2166/washdev.2023.203.
- Adejumo, S.A (2020) Urban Household Water Insecurity in Ibadan. *International Journal of Research and Scientific Innovation*. 8(8): 15-27. ISSN: 2321-2705.
- Agbehi, S.I. (2007). Assessment of domestic water supply in Ugbokolo community, Okpokwu LGA, Benue State. Unpublished M.Sc Project, Department of Geography, Benue State University, Makurdi.
- Agbi, A.I. (2022). Perception of Sustainable Development Goals among Science Lecturers in Colleges of Education in South-south Nigeria. *International Journal of Research in Education and Sustainable Development*. 2 (11): 1-14. ISSN: 2782-7666.
- Agyo, R.A., Ofukwu, R.A., Okoh, A.E. and Agada, C.A (2020) Bacteriological quality of water in private wells and boreholes in Makurdi Metropolis, Benue State, Nigeria. *International Journal of One Health*, 6(1): 76-82. DOI: 10.14202/IJOH.2020
- Ahile, S.I., Tyav, T.T., and Ityavyar, E.M. (2018a). An expository review of the causes and impacts of water scarcity in Makurdi, Benue State, Nigeria. *Ife Social Sciences Review (Special issue)*: 230-236. ISSN: 03313115

- Ahile, S.I., Udoumoh, E.F., and Adzande, P. (2015) Residents Coping Strategies with Water Scarcity in Makurdi Town, Nigeria. *Mediterranean Journal of Social Sciences*, 6(4), S2: 100-108. ISSN: 2039-2117.
- Ahile, S.I., Udoumoh, E.F., Ityavyar, E.M., and Ikape, M.O. (2018b) Grey water Re-use: A Sustainable Option for Addressing Water Scarcity in Makurdi Town, Benue State, Nigeria. *The International Journal of Humanities and Social Studies*, 6(8): 90-95. ISSN: 2321- 9203.
- Ali, P. I. (2018). Assessment of Household Vulnerability and Adaptation to Flooding in Makurdi Town, Benue State, Nigeria. Unpublished Ph.D Thesis, Department of Geography, Benue State University, Makurdi, Nigeria.
- Ali, P.; Nyajo, A., Onah, M.A., Dam, P.D., Enefu, J., Shabu, T., Vangeryina, T., Adimanyi, A.O. and Udoo, V. (2022). Assessment of Surface and Groundwater Quality In and Around Benue Brewery Limited in Makurdi Town, Benue State, Nigeria. *Nigerian Annals of Pure and Applied Science*, 5(1): 85-94. DOI: 10.5281/zenodo.7130715.
- Amparo-Salcedo, M., Perez-Gimeno, A. and Navarro-Pedreno, P. (2025). Water security under climate change: challenges and solutions across 43 countries. *Water*, 17, 633: 1-25. <https://doi.org/10.3390/w17060633>.
- Anang, Z., Yusop, Z., Sharma, A.K., Panagoulia, D., Abdul-Rashid, N.K., and Nawawi, N.R. (2024). Socioeconomic Factors Affecting Water Conservation in Johir Bahru and Kuala Terengganu Districts of Malaysia. *International Journal of Sustainable Development and Planning*. 19(9): 3321-3338. DOI:10.18280/ijstdp.190905.
- Aper, J.A., and Agbehi, S.I. (2011). Pattern of Domestic Water Supply in Ugbokolo Community in Benue State, Nigeria. *Journal of Water and Soil Research*, 1(1): 72-83. <https://icidr.org.ng>
- Babel, M. S., Shinde, V. R., Sharma, D. & Dang, N. M. (2020). Measuring water security: a vital step for climate change adaptation. *Environmental Research*, 185, 109400. Doi.org/10.1016/j.envres.2020.109400.
- Bakker, K. (2012). Water Security: Research Challenges and Opportunities. *Science*, 337(6097): 914- 992. Doi:10.1126/science.1226337.
- Bharwani, S., Downing, T., Haase, D., Pahl-Wostl, C., Taylor, A., and Shale, M. (2008). Dynamic Vulnerability: Learning from NeWater Case Studies (NeWater Deliverable No. D 2.1.2). Oxford: Stockholm Environment Institute.
- Carney, D. (1999). Approaches to Sustainable Livelihoods for the Rural Poor. ODI Poverty Briefings. Available @ <http://www.odi.org.uk/publication/briefing/html>. Retrieved 19/08/2018.
- Chapagain, K., Aboelnga, H.T., Babel, M.S., Ribbe, L., Shinde, V.R., Sharma, D., and Nguyen, M.D. (2022). Urban water security: A comparative assessment and policy analysis of five cities in diverse developing countries in Asia. Available @ SSRN: <https://ssrn.com/abstract=3992955>.
- Chia, V.D., Ijir, S.T. Iwar, R., and Ndulue, E.I. (2015). The contending issues of domestic water supply in Makurdi Metropolis, Benue State, Nigeria. *Civil and Environmental Research*, 6(9): 89-96. ISSN: 2225-0514
- Collins, S. M., Mbullo Owuor, P., Miller, J. D., Boateng, G. O., Wekesa, P., Onono, M., and Young, S. L. (2019). 'I know how stressful it is to lack water!' Exploring the lived experiences of household water insecurity among pregnant and postpartum women in western Kenya. *Global Public Health*, 14(5): 649-662. <https://doi.org/10.1080/17441692>.
- DFID (1999). Sustainable Livelihood Guidance Sheet. London: UK, DFID. Available @ <http://www.livelihoods.org/info/infoguidancesheets.html>. Retrieved 4/05/2026.

- Ezendu, O.B., Ezendu, T.S., Ugochukwu, U.C., Okolo, O.J., Ani, C.D., Ajogu, A.P., Ajaero, C.C, Mbakwe, U.I., and Nduji, N.N. (2022). Coping Strategies, Cultural Practices, and Policy Implications on Domestic Water Supply in an Erosion Susceptible Rural Community, Nigeria. *Resources*, 11(77): 1-20. <https://doi.org/10.3390/resources11080077>.
- Food and Agriculture Organization (2014). The Water-Energy-Food Nexus: A new approach in support of food security and sustainable agriculture. Available [@openknowledge.fao.org/handle/20.500.14283/bi496](https://openknowledge.fao.org/handle/20.500.14283/bi496).
- Gana, A.H., and Sa'id, A.I (2025). Household Water Access and Coping Strategies in Nasarawa-Tsangaya, Damaturu, Yobe State, Nigeria. *Journal of African Innovative and Advanced Studies*.10 (2): 339-351. ISSN: 3072-1533.
- Gomez, M., Perdiguero, J. and Sanz, A. (2019). Socioeconomic Factors Affecting Water Access in Rural Areas of Low and Middle Income Countries. *Water*, 11, 202; Doi: 10.3390/w11020202.
- Ifan, A.B. (2002). The problem of water supply in Mbatav district in Gboko LGA of Benue State, Nigeria. Unpublished B.Sc Project, Benue State University, Makurdi, Nigeria.
- Igweh, A., Ugwuoke, M., Nzenwa, R., Odoh, J. and Ugwuja, G. (2025). Water Insecurity Experiences and Coping Strategies Adopted among Individual in Enugu, Nigeria: A Gender Perspective. *Journal of Rural and Community Development*, 20 (2): 56-78. ISSN 1712-8277.
- Iorkua, S.A.(2006). A Study of the Inter- Relationship among Gully Elements in North Bank Makurdi. *Journal of Geography and Development*,1(1): 32-51. ISSN: 2006-0378.
- Kemp-Benedict, E., Bharwani, S., de la Rosa, E., Krittassudthacheewa, C. and Matin, N. (2009). Assessing Water-related Poverty Using the Sustainable Livelihoods Framework. Stockholm Environment Institute, Working Paper. Stockholm, Sweden.
- Khan, S., Guan, Y., Khan, F., and Khan, Z. (2020). A comprehensive index for measuring water security in an urbanized world: The case of Pakistan's capital. *Water*, 12 (1): 166-174. <https://doi.org/10.3390/w12010166>
- Kogbe, C. A., Torkshi, A., Osijuk, D. and Wozney, D. E. (1978). Geology of Makurdi in the Middle Benue Valley Nigeria. Ocasional Publication of the Department of Geology, Ahmadu Bello University, Zaria.
- Kujinga, K., Mmopelwa, G., Vanderpost, C., and Masambe, W. (2014). Short- and Long-Term Strategies for Household Water Insecurity in Ngamiland, Botswana. *Journal of Sustainable Development*. 7 (3); 96-117. ISSN: 1913 – 9063.
- Kusena, W., Beckedahl, H., and Desai, S. (2017). Civil Society and Residents Coping Strategies with Water Shortages and Household Food Insecurity in Gwene, Zimbabwe. *Journal of Arts and Humanities*, 6 (2): 91-103. ISSN: 2167-9053.
- Majuru, B., Suhrcke, M., Hunter, P., (2016). How Do Households Respond to Unreliable Water Supplies? A Systematic Review. *International Journal of Environmental Research and Public Health*, 13(12), 1222; DOI: 10.3390/ijerph13121222.
- Mishra, B.K., Kumar, P., Saraswat, C., Chakraborty, S., Gautam, A. (2021) Water Security in a Changing Environment: Concept, Challenges and Solutions. *Water*, 13, 490. <https://doi.10.3390/w13040490>.
- Muhammed, M.Y. (2018). Assessment of Environmental Sanitation Methods in Makurdi Town, Benue State, Nigeria. A Dissertation submitted to the School of Post Graduate Studies, Nassarawa State University, Keffi, for an award of Post Graduate Diploma in Environmental Resource Management.

- Murgatroyd, A., Charles, K.J., Chautard, A., Dyer, E., Grasham, C., Hope, R., Hoque, S.F., Korzenevica, M., Munday, C., Alvarez-Sala, J., Dadson, S., Hall, J.W., Kebede, S., Nileshwar, A., Olago, D., Salehin, M., Ward, F., Washington, R., Yeo, D. and Zeleke, G. (2021). *Water Security for Climate Resilience Report: A synthesis of research from the Oxford University REACH programme*. University of Oxford, UK: REACH.
- Nayak, N. and Samai, A. (2025). An evaluation of water security in coastal urban areas: A comprehensive case study of Bhubaneswar, Odisha. *Lex-localis Journal of Local Self-Government*, 23 (4): 2740-2750. ISSN: 1855-363X.
- Nkiaka, E. (2022) Exploring the Socioeconomic determinants of water security in developing regions. *Water Policy*, 24(4): 609-615. DOI: 10.2166/wp.2022.149.
- Obadiah, B. (2011). An appraisal of public water supply system for a partnership arrangement for Lafia town, Nigeria. Unpublished MSc. Project submitted to the Post Graduate School, Amadu Bello University, Zaria.
- Ocheri, M. (2006). Analysis of Water Consumption Pattern in Makurdi Metropolis. *Journal of Geography and Development*, 1(1): 71-83. ISSN: 2006-0378.
- Ocheri, M.I., Mile, I.I. and Obeta, M.C. (2010). Seasonal variation of nitrate levels in hand dug wells in Makurdi metropolis. *Pakistan Journal of Nutrition*, 9 (6): 539- 542. DOI:10.3923/pjn.2010.539.542
- Ochoche, S., Omokaro, G.O., and Onyamoche, C. (2025). Assessment of Urbanization's Environmental Impact in Makurdi Metropolis, Benue State, Nigeria. *The International Journal of Environmental Impacts*, 8(2): 393-400. DOI: 10.18280/ijei.080218.
- Odwori, E.O. (2021). Household Coping Strategies for Unreliable Water Supplies in Nzoia River Basin, Kenya. *International Journal of Research and Scientific Innovations*, 8 (4): 7- 15. ISSN: 2321-2705.
- Olujayigbe, A. E (2011). Evaluation of Domestic Water Security in a Developing Economy: A focus on Ado-Ekiti, Nigeria. *Journal of Sustainable Technology*, 2 (1): 85-96. ISSN: 2251-0680.
- Ortserga, S., Kwaghsende, F.K., and Gyuse, T.T. (2025). Investigating the Multidimensional Drivers of Public Water Supply Inequality in Makurdi town, Nigeria. *IRE Journals*, 9(4): 1163-1174. ISSN: 2456-8880.
- Pereira, L.S., Cordery, L. and Lacovides, L. (2009). *Coping with water scarcity: Addressing the challenges*. New York: Springer. ISBN 978-1-4020-9578-8.
- Pond, K. and Pedley, S. (2011). Current situation in access to drinking-water. In: *Valuing Water, Valuing Livelihoods*; Hunter P., Jagals, P. and Pond, K (eds). IWA Publishing, London, United Kingdom. ISBN: 9781843393108.
- Sodamade, G.A., Balogun-Adeleye, R.M., Agbeye, O. and Momodu, O. (2020). Assessment of water supply challenges in Ado-Ekiti, Nigeria. *Journal of Engineering Research*, 25(2): 203-212. ISSN: 07956 – 2333.
- Van Steerbergen, F., Kaisarani, A.B., Khan, N.U., Gohar, M.S. (2014). A case of groundwater depletion in Balochistan, Pakistan: Enter into the void. *Journal of Hydrology Regional Studies*, 4: 36-47. DOI:10.1016/j.ejrh.2014.11.003
- Vidya, V., Shalean, M.C., Clark, K.A., Yeam, J., Nowakowski, V.G., and Young, S.L. (2020). Coping Strategies for Individual and Household-level Water Insecurity: A Systematic Review. *Wiley Interdisciplinary Reviews: Water*, 7(5): 1-18. DOI: 10.1002/wat2.1477.
- World Bank (2021) *Nigeria: Ensuring Water, Sanitation and Hygiene for all*. Available @ worldbank.org, accessed on 9/04/2026.

- World Bank (2024). Water Security and Climate change: Insights from Country Climate and Development Reports. Available @ www.worldbank.org/water.
- Yamane, T. (1967). Elementary Sampling Theory. Englewood Cliffs, NJ: Prentice-Hall. Available @ <https://books.google.com>
- Zug, S., and Graefe, O. (2014). The Gift of Water. Social Redistribution of Water among Neighbors in Khartoum. Water Alternative, 7 (1): 140-159. Available @ www.water-alternatives.org.