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Assessment of Household Water Security in Makurdi Town, Benue State, Nigeria

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ABSTRACT

Makurdi town is contending with many water related issues that impede efforts targeted at achieving water security for the growing population. Water security is a multidimensional concept that seeks to address the array of issues related to water. Previous studies in Nigeria and Makurdi in particular, employ a methodology for water security assessment that merely accounts for water access or water scarcity, thereby limiting the scope of the concept. This study employed a modified framework to holistically determine the water security status of households in Makurdi town. Data was gathered via the questionnaire administered to 404 respondents mainly household heads (both male and female), using the systematic random sampling technique. The water security index was calculated using an adopted formula. The results show that Makurdi town has a water security index of 3.15, indicating that the town is moderately water-secure, although certain areas require improvement. While water supply, hygiene, and resilience to water-related disasters generally perform well, sanitation emerges as the weakest dimension. The results also showed evidence of spatial variation between and within income groups. Following these findings, the paper recommends among other things that government should foster stronger collaborations with non-state actors to mobilize technical expertise and financial resources to support the provision of critical infrastructure needed to close the gap in water security across neighborhoods in Makurdi town.

INTRODUCTION

'*Water has power to enhance life; it also has the power to destroy it.* Ellen Johnson Sirleaf, Former President of Liberia and Goodwill Ambassador for Water, Sanitation and Hygiene for Africa. Excerpts of the speech presented at the World Water Day, 2003. The epigraph above highlights the importance of water to life and its role in promoting socio-economic development and diversity of ecosystems. To underscore the importance of water, the United Nations Conference on Sustainable Development in 2012 included a water specific target in the Sustainable Development Goals (SDGs); to promote access to clean and sustainable management of water and sanitation for all by the year 2030. To further buttress the importance of this resource, the United Nations also declared access to water a basic human right. The denial of this right erodes human dignity, signifies water scarcity and the absence of water security. Water security is the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability (UN-Water, 2013). Failure to achieve water security can have a wide range of societal set-backs including (but not limited to) negative effects on human health, exacerbation of energy and food security and the potential for the occurrence of armed conflicts especially in already water scarce regions (Taka *et al.*, 2021). Achieving water security for all should therefore be a top priority and aspiration of every nation. Unfortunately, meeting this aspiration has become a critical global challenge, particularly for countries in the developing parts of the world. In Nigeria, there is increasing concern over the state of water insecurity; millions of people do not have regular and equitable access to clean drinking water, there is a rise in water borne diseases, and unpredicted and devastating floods, as well as other natural disasters related to water (World Bank, 2021; WHO-UNICEF/JMP, 2017). Water security embodies a set of issues which are complex, multidimensional and interdependent (Mishra *et al.*, 2021). A first step towards enhancing water security will therefore be to measure it. This gives us a numeric idea of the extent to which water security has or has not been achieved across different locations (Mishra *et al.*, 2021). Furthermore, measuring water security will determine how well we can manage the situation (Gain *et al.*, 2016). A number of studies have assessed water security at different scales; from global (Gain *et al.*, 2016), national (Marttunen *et al.*, 2019), basin (Truong *et al.*, 2023) and city level (Mukharjee *et al.*, 2022). Each of these studies adopts a number of dimensions/indicators that are specifically valid for the different scales under consideration. These studies have however been criticized particularly for concealing the spatial disparity within regions, in addition to losing valuable insights across different countries and regions (Nkiaka, 2022). In Nigeria, many water security assessment studies have used one or at most two components/dimensions (Kairo *et al.*, 2022; Adejumo, 2020; Ayodeji *et al.*, 2018; Amao &

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Omonona, 2010); mostly limiting water security merely to promoting access to water. These indicators give a gleam picture of the water security challenge. Against the backdrop of a looming water crisis in Nigeria (Ahile & Mailumo, 2017), it is imperative to develop a robust and comprehensive framework for measuring water security particularly at the household level. This will aid planning, better administration and management of water. It is on this premise that this research was conceived.

Statement of the Research Problem

The pursuit of water security remains a major challenge in many urban centers in developing countries, where rapid population growth, inadequate infrastructure, and climate-related risks continue to strain water systems (Marttunen *et al.*, 2019). Makurdi, a rapidly growing urban center in Benue State, Nigeria, exemplifies these challenges. 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 (Women Environmental Program, 2024). Although these challenges are well documented, existing studies in Nigeria, including those focused on Makurdi, have largely examined water issues in isolation; primarily emphasizing access to water. Such approaches fail to capture the multidimensional nature of water security and therefore provide an incomplete basis for policy formulation and interventions. There is currently no comprehensive framework that integrates the various dimensions of water security at the household level within the context of Makurdi. This study addresses this gap by applying a multidimensional framework to assess household water security in Makurdi. By integrating issues of access, quality, reliability, sanitation, hygiene and water-related risks, the study aims to provide a more holistic understanding of water insecurity and generate insights that can inform effective planning and management strategies

Objectives of the Study

This study seeks to the address the following objectives

- Determine the status of households' water security in Makurdi town.
- Determine the spatial variation in water security across neighborhoods in Makurdi town.

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 70 43'50"N of the equator and longitude 80 32'10"E of the Greenwich meridian (Figure 1). Makurdi town has a mean elevation of 92 meters above sea level, a circular radius of 16km2, 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 330C and a mean minimum of 22.50 C with annual range of 10.50 C. Temperatures may occasionally climb to 370 C in some days in March and April (Iorkua, 2006).

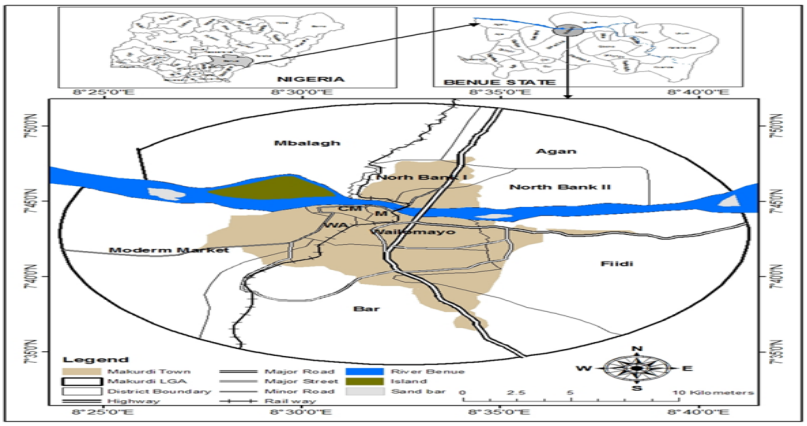

Figure 1: Districts in makurdi L.G.A

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 (Kogbo 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).

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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 reflect the distribution of the population.

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 will equally consist of nine (9) high, middle and low income neighborhoods as 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	Ankpa Wadata	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: Authors field work, 2026

Data Needs, Sources and Analytical Techniques

Data was collected mainly through the Questionnaire. The study employed 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. It is important to note that out of the 405 questionnaires distributed, only 404 were returned and analyzed.

To determine the level of household water security, data employed covered the four components (water supply, sanitation, hygiene, and water-related disasters), 16 indicators and 20 variables that constitute the framework for the study. The computation of the water security index involves five key step

- Selection of dimensions, indicators and variables
- Normalization of variables
- Assigning weights to dimensions, indicators and variables
- Computing the water security index by aggregating variables, indicators and dimensions
- Interpretation of the water security index score

Selection of Dimensions, Indicators and Variables

The selection of dimensions, indicators and variables is guided by the water security definition (UN-Water, 2013) adopted by the study. More importantly, the selection was also done based on measurability and availability of data. Dimensions are the broad components of water security; indicators represent the dimensions, while variables quantify the indicators as shown in Table 2.

Table 2: Dimensions Indicators and of Variables for Water Security Assessment for the Study Area.

Dimension (i)	Indicator (j)	Variable (k)	Measurement Unit
Water Supply	Water usability	Household quantity of daily water requirement for drinking	Liters/day
		Household quantity of daily water requirement for other purposes	Liters/day
	Water accessibility	Proportion with access to pipe water supply	% of households
		Water supply service duration	Hours/day
		Average distance covered to get water from other hygienic sources	Kilometers
		Time taken to collect water from other sources	Mins/hour
	Water quality	Proportion of households using potable drinking water	% of households

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Sanitation	Access to improved sanitation facilities	Proportion of households with hygienic latrines	% of households
	Waste water recycling	Amount of waste water recycled by households	Liters/day
	Investment in sanitation facilities	Percentage of income spent on sanitation	% annual income
Hygiene	Water borne disease factor	Proportion of households with cases of diarrhea, typhoid or dysentery	% of households
	Awareness	Educational level of household head	5 Point rating scale
	Adequacy of water for hygienic purposes	Water consumption for households' daily hygiene	Liters/day
	Affordability of hygiene services	Proportion of households that can afford hygiene services	% of households
Water-related disasters	Flood preparedness	Level of flood preparedness	5 Point rating scale
	Frequency of floods	No. of flood events in the last ten years.	
	Flood factor	Proportion of town prone to flooding	% area
	Flood damage	Estimated economic damage caused by floods	In Naira
	Temperature	Mean annual temperature	0C
	Precipitation	Mean annual rainfall	mm/year

Source: Adopted from Assefa et al. (2018) with modifications by authors

Normalization of Variables

Since variables and indicators are captured at different measurements units, developing a numerical value to represent the indicators on a common and comparable scale becomes very necessary. Table 3 gives details of the representation of each variable and indicator used in the study, classifying the obtained values into a dimensionless 1–5 scale, where 1 is considered poor and 5 excellent.

Assigning Weights to Dimensions, Variables and Indicators

Weighing elements that have unrelated issues with different units can be complicated and may lead to misinterpretation. To overcome this challenge, this study assigned equal weights to all dimensions, indicators and variables (see table 4), implying that all dimensions are equally important. The sum of weights given to dimensions equates to 1.

Calculation of the Water Security Index

Having computed the weights of each indicator, the household water security index is then calculated by multiplying the weight and the score values of the indicators. This is done for each of the dimensions. Thereafter, the dimension's score or index are aggregated and averaged to get the overall water security index for the town. The procedure in calculating water security index is shown below via the following formulas (Assefa *et al.*, 2018):

$$I_{ij} = \sum_{j=1}^{n} \sum_{k=1}^{m} w_{ij} \times V_{ij}k \quad (1)$$

Where:

I_{ij} = value of indicator j for dimension i;

n =no. of indicators in dimension i

m = no. of variables in indicator j;

$w_{ij}k$ = weight given to variable k of indicator j of dimension i

$V_{ij}k$ = score of variable k of indicator j of dimension i

$$Di = \sum_{j=1}^{n} w_{ij} \times I_{ij} \quad (2)$$

Where:

D_i = value of dimension I;

w_{ij} =weight given to indicator of indicator j of dimension i

Where:

$$WSI = \sum_{i=1}^{p} w_i \times D_{ij} \quad (3)$$

WSI = Water security index

p = number of dimensions

w_i = weight assigned to dimension i

Note: total weights given to dimensions, indicators and variables equals 1.

Interpretation of the Water Security Index Score

The interpretability criterion of the water security index for this study was based on a 1-5 scale as shown in table 3. A score closer to 1 indicates a poor level of water security, while a score closer to 5 indicates an excellent level of water security representing an ideal example of a water-

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Table 3: Interpretation of the water security index scores for Makurdi town.

Index	Level of water security	Interpretation
(<1.5)	Poor	The town is incapable of meeting the basic water requirements for its households/population. Water is poorly managed creating a serious point of concern for all dimensions of water security.
(1.5 – 2.5)	Fair	There are no sound policies or measures in place to ensure water security for the town. Consequently, there are major gaps and serious concerns in almost all dimensions of water security.
(2.5 – 3.5)	Good	The town has a fairly satisfactory environment for facilitating water security. However, some dimensions of water security are still a cause of concern.
(3.5 – 4.5)	Very good	The town is well-placed with most of the dimensions of water security. Their security against the dimensions may not be at par with the others, but the overall situation is still nonetheless very satisfactory.
(>4.5)	Excellent	The town is an ideal example of a water-secure society. It shows exemplary levels of security against every dimension of water security.

Source: Adopted from Assefa et al. (2018) with modifications by authors

secure town or city.

To determine the spatial variation in water security across neighborhoods in Makurdi town, the computed sub-index scores of the dimensions was employed.

Table 4: Reference values used to normalize the variables.

Dimension	Indicators	Variables	Unit	Representation (Normalization)					Reference
				1	2	3	4	5	
Water Supply	1	Household quantity of daily water requirement for drinking	Liters/ day	<60	61-70	71-80	81-90	>90	Waldron, 2005
	2	Household quantity of daily water requirement for other purposes	Liters /day	<60	61-70	71-80	81-90	>90	Waldron, 2005
	3	Proportion with access to pipe water supply	% of households	0-60	61-70	71-80	81-90	9 1 - 100	Proposed by Author
	4	Water supply service duration	Hours /day	<8	8-16	17-20	21-23	24	Assefa et al., 2018
	5	Average distance covered to get water from other hygienic sources	Meters	>1000	7 5 1 - 1000	501-750	250 -500	<250	WHO-UNICEF /JMP, 2017

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	6	Time taken to collect water from other sources	Minutes	41-50	31-40	21-30	10-20	<10	Howard & Bartram, 2003
	7	Proportion of households using drinking water	% of households	0-60	61-70	71-80	81-90	9 1 - 100	Aboelnga *et al.*, 2020
Sanitation	8	Proportion of households using hygienic atrines	% of household	0-60	61-70	71-80	81-90	9 1 - 100	Assefa *et al.*, 2018
	9	Amount of waste water recycled by households	Liters/day	<10	10-30	30-50	50-70	>70	Howar & Bartram, 2003
	10	Proportion of income spent on sanitation	% annual income	0-60	61-70	71-80	81-90	9 1 - 100	Proposed by Author
Hygiene	11	Proportion of households withcase of diarrhea, typhoid or dysentery	% of households	81-100	61-80	41-60	21-40	0-20	WHO-UNICEF /JMP , 2017
	12	Educational level of household head	5 point scale	Primary	Sec	Diploma	Degree	PG	Proposed by Author
	13	Water consumption for household daily hygiene	Liters/day	<60	61-70	71-80	81 -90	91 -100	Waldron, 2005
	14	Proportion of households that can afford hygiene services	% of households	0-20	21-40	41-60	61 -80	81 -100	Assefa et al., 2018
	15	Level of flood preparedness	5-point scale	UNPRE	SLI	NS	SW	ALW	Proposed by Author

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	16	No. of flood events in the last 10 years	Count	>7	6-7	4-5	2-3	1	Park *et al.*, 2022
	17	Proportion of town prone to flooding	% area	>40	40 – 21	20 – 11	10 – 5	<5	Trough *et al.*, 2023
	18	Estimated economic damage caused by floods	In Naira (billions)	>40	31-40	21-30	11-20	<10	Proposed by Author
	19	Mean annual temperature	oC	>40	35 - 40	30-35	25-30	<25	Proposed by Author
	20	Mean annual rainfall	mm/year	<70	70-80	81-90	91-100	>100	Proposed by Author

Authors compilation, 2026

RESULTS AND DISCUSSION

Water Security Index

The overall water security index (WSI) for Makurdi town is derived by computing the index of all four dimensions, aggregating and taking the average. The procedure and results are presented below.

Water Supply Dimension

This dimension was assessed using three indicators: water usability, water accessibility and water quality, with the view to check if people used water of acceptable quality and that the water is in adequate and sustainable quantity to ensure that they meet their water demand at all times. The water security sub-index for the water supply dimension for Makurdi town is 3.56 (indicating a very good level) as shown below. Further inference into the results of the values, scores and weights of the indicators (table 5) show that water quality and water usability were in good standing. For instance, the results show that 87.5% of the sampled population used drinking water that was of high quality.

Table 5: Values, scores, and weights of the water supply indicators

Indicator	Variable	Unit	Value	Score	Weight
Water usability	Household quantity of daily water requirement for drinking	Litres/day	87.4	4	0.33
	Household quantity of daily water requirement for other purposes	Liters/day	341.7	4	
Water accessibility	Proportion with access to pipe water supply	%	1.3	1	
	Water supply service duration	Hours/day	0.7	1	
	Average distance covered to get water from other hygienic sources	Kms	189.2	5	
	Time taken to collect water from other sources	Hours/day	4	4.3	
Water quality	Proportion of households using drinking water that meets water quality standards	%	87.5	4	

$$\text{Water Supply Dimension Sub-Index} = \sum_{j=1}^{n} w_{ij} \times I_{ij}$$

= (0.33 x 4) + (0.33 x 2.8) + (0.33 x 4)
= 1.32 + 0.92 + 1.32
= 3.56

Sanitation Dimension

This dimension was also assessed using three indicators: access to improved sanitation facilities, wastewater recycling and investment in sanitation facilities. The calculated values, scores and weights of these indicators are shown in table 6. The results as computed and presented below show that the index score for the sanitation dimension is 2.31, indicating a fair level of water security. Further inference into the results show that 80% of the sampled population used hygienic latrines, while only 49.6 liters of the wastewater that was generated in a day by households was reused for other purposes such as flushing of toilets, car washing, and watering of vegetables.

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Table 6: Values, scores and weights of the sanitation indicators.

Indicator	Variable	Unit	Value	Score	Weight
Access to improved sanitation facilities	Proportion of households using hygienic latrines	%	80	3	0.33
Waste water recycling	Amount of waste water recycled by household	Liter/day	49.6	3	
Maintenance of sanitation facilities	Proportion of income spent on sanitation	%	10.71	1	

$$\text{Sanitation Dimension Sub-Index} = \sum_{j=1}^{n} w_{ij} \times I_{ij}$$

= (0.33 x 3) + (0.33 x 3) + (0.33 x 1)
= 0.99 + 0.99 + 0.33

= 2.31

Hygiene Dimension

This dimension was assessed using four indicators: water borne disease factor, awareness, adequacy of water for hygiene purpose and affordability of hygiene services. The calculated values, scores and weights are shown in table 7. The sub-index for the hygiene dimension is calculated to be 3.4 as shown below, indicating a good water security standing. The results also show that households used an average of 83.6 liters of water daily for hygiene purposes.

Table 7: Values, scores and weights of the hygiene indicators.

Indicator	Variable	Unit	Value	Score	Weight
Water borne disease factor	Proportion of households with cases of diarrhea, typhoid or dysentery	%	49.5	3	0.25
Awareness	Educational level of household head	Likert scale	3.6	3.6	
Adequacy of water for hygiene purpose	Daily water consumption for household hygiene	Liters/day	83.6	4	
Affordability of hygiene services	Proportion of households that can afford hygiene services	%	59	3	

$$\text{Hygiene Dimension Sub-Index} = \sum_{j=1}^{n} w_{ij} \times I_{ij}$$

= (0.25 x 3) + (0.25 x 3.6) + (0.25 x 4) + (0.25 x 3)
= 0.75 + 0.9 + 1 + 0.75
= 3.4

Resilience to Water Related Disasters Dimension

Six indicators were employed to assess this dimension: flood preparedness, frequency of floods, flood factor, flood damage, temperature and rainfall. Table 8 depicts the calculated values, scores and weights for these indicators. The sub-index for the resilience to water-related disasters dimension is calculated to be 3.34, indicating a good water security level.

Table 8: Values, scores and weights of the resilience to water related disaster indicators.

Indicator	Variable	Unit	Value	Score	Weight
Flood preparedness	Level of flood preparedness	5 point scale	3.5	4	0.167
Frequency of floods	No. of flood events in the last 10 years	count	5	3	
Flood factor	Proportion of town prone to flooding	%	48.8	1	
Flood damage	Estimated economic damage caused by floods	Billions of naira	5	5	
Temperature	Mean annual temperature	oC	32.77	3	
Rainfall	Mean annual rainfall	Mm/year	96.54	4	

$$\text{Water Related Disasters Sub-Index} = \sum_{j=1}^{n} w_{ij} \times I_{ij}$$

= (0.167 x 4) + (0.167 x 3) + (0.167 x 1) + (0.167 x 5) + (0.167 x 3) + (0.167 x 4)
= 0.668 + 0.501 + 0.167 + 0.835 + 0.501 + 0.668
= 3.34

Overall Water Security Index for Makurdi Town.

The overall household water security index is calculated based on the analysis of the results of all dimensions' sub-indexes (water supply, sanitation, hygiene, and resilience to water related disasters) as shown below.

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WSI= Dimension (1)+Dimension (2)+Dimension (3)+Dimension (4)

4

= 3.56 + 2.31 + 3.40 + 3.34

4

= 3.15

The water security index for Makurdi town is 3.15, indicating a good water security level. This is interpreted to mean that Makurdi town has a fairly satisfactory environment for facilitating water security, with some dimensions however having some concerns.

Spatial variation in water security across neighborhoods in Makurdi town.

This section assesses spatial variation in water security across high-income, middle-income and low-income neighborhoods across Makurdi town based on the computed sub-index scores of the dimensions used to assess water security for the town: water supply, sanitation, hygiene and resilience to water related disasters.

Spatial Variation in Water Security across High-Income Neighborhoods.

The result of the assessment of spatial variation in water security across high-income neighborhoods is presented in table 9 and figure 2. The mean water security index score of 3.18 shows that high-income neighborhoods generally fall within the "good" category. An assessment across individual neighborhoods shows that Old GRA has the highest water security index of 3.64, indicating a "very good" water security status for this neighborhood. The results further show water supply (4.29), hygiene (3.75) and resilience to water related disasters (3.54) emerge as high performing dimensions, with the sanitation dimension (2.97) showing some concerns. Conversely, the results show that the other neighborhoods: Ankpa Quarters, Welfare Quarters, Kwararafa Quarters, Judges Quarters, Modern market road, Mission ward, Court 5 and Nyiman fall under the "good" water security level. Nyiman however has the lowest overall water security index of 2.78, showing good performance in water supply (3.05) and hygiene dimensions (3.25). Court 5 also shows strong performance in water supply (3.46), resilience to

Table 9: Water Security across High-Income Neighborhoods.

	Dimensions					
Neighborhood	**Water Supply**	**Sanitation**	**Hygiene**	**Resilience to water related disasters**	**Water Security Index**	**Mean Water Security Index**
Ankpa Quarters	3.46	2.31	3.5	3.34	3.15	3.18
Welfare Quarters	3.46	2.31	3.25	3.51	3.13	
Old GRA	4.29	2.97	3.75	3.54	3.64	
Kwararafa Quarters	3.79	1.98	3.5	3.34	3.15	
Judges Quarters	3.87	2.97	3.75	3.17	3.44	
Modern Market	3.14	2.31	3.25	3	2.93	
Mission Ward	2.97	1.98	3.5	3.67	3.03	
Court 5	3.46	2.64	3.75	3.67	3.38	
Nyiman	3.05	1.98	3.25	2.84	2.78	

Source: Author's fieldwork, 2026.

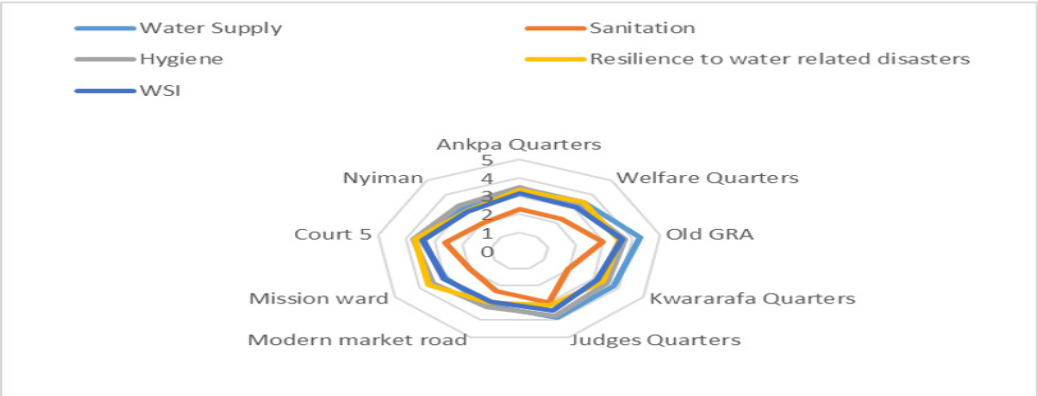

Figure 2: Water security index for each of the dimensions across high-income neighborhoods.

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water related disasters (3.67) and hygiene (3.75).

Spatial Variation in Water Security across Middle-Income Neighborhoods.

The results of the assessment of the spatial variation in water security across middle-income neighborhoods is presented in table 10, and shown in figure 3. The results show that middle-income neighborhoods have a mean water security index score of 3.17, indicating that these neighborhoods also fall within the "good" water security category. The results also show some variance in water security within the neighborhoods. Lobi Quarters has the highest overall water security index of 3.67, indicative of a "very good" water security condition. The neighborhood performs very well across all dimensions, with high sub-index scores: water supply (4.13), hygiene (3.75), resilience to water related disasters (3.51), and sanitation (3.3). Closely following Lobi Quarters is Federal Housing with a water security index of 3.44, categorized as having "good" water security condition. Federal Housing shows a strong performance with respect to hygiene dimension (3.75) and resilience to water related disasters (3.51) that is similar to what is obtained in Lobi Quarters, while the sub-indexes for water supply (3.54) and sanitation (2.97) dimensions are comparatively lower than what is recorded in Lobi Quarters. Gbonko and Katungu are the least neighborhoods, having a water security index of 2.76 and 2.84 respectively, but both can be categorized as having "good" water security condition.

Table 10: Water Security across Middle-Income Neighborhoods.

	Dimensions					
Neighborhood	**Water Supply**	**Sanitation**	**Hygiene**	**Resilience to water related disasters**	**Water Security Index**	**Mean Water Security Index**
Ankpa Ward	3.54	2.31	3.25	3.34	3.11	3.17
Achusa	3.3	1.98	3.5	3.51	3.07	
Lobi Quarters	4.13	3.3	3.75	3.51	3.67	
Clark Quarters	3.96	2.31	3.5	3.34	3.28	
Terwase Agbadu	3.46	1.98	3.5	3.51	3.11	
Gbonko	2.97	1.65	3.25	3.2	2.76	
Katungu	3.46	1.32	3.25	3.34	2.84	
Federal Housing	3.54	2.97	3.75	3.51	3.44	
High Level	3.87	2.31	3.75	3.34	3.31	

Source: Author's fieldwork, 2026

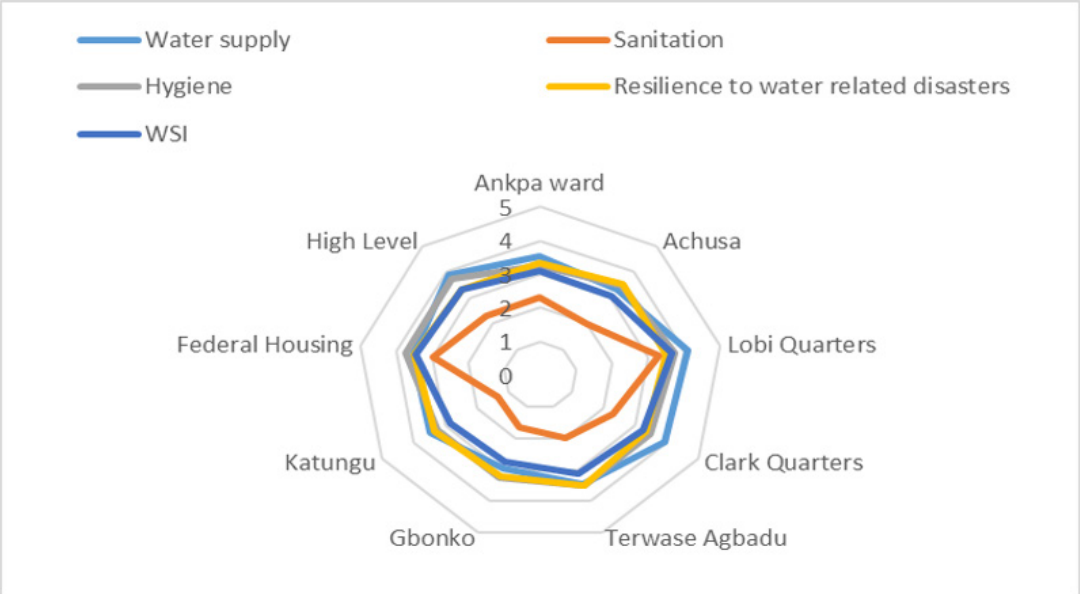

Figure 3: Water security index for each of the dimensions across middle-income neighborhoods.

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Spatial Variation in Water Security across Low-Income Neighborhoods

The result of the findings on spatial difference in water security across low-income neighborhoods is presented in table 11 and also illustrated visually in figure 4. The results show that low-income neighborhoods generally fall within the "good" water security category, with an average water security score of 2.98. This suggests that these neighborhoods possess a moderately satisfactory environment for water security, but there are gaps across some dimensions. A cursory look at individual neighborhoods shows that Fiidi has the highest sub-index score (3.13), while Wadata has the lowest sub-index score.

Table 11: Water Security across Low-Income Neighborhoods.

	Dimensions					
Neighborhood	**Water Supply**	**Sanitation**	**Hygiene**	**Resilience to water related disasters**	**Water Security Index**	**Mean Water Security Index**
Wadata	3.29	0.99	3.0	2.84	2.53	2.98
Mobile Barracks	3.55	1.65	3.25	3.67	3.03	
Madikpo	3.21	1.98	3.0	3.17	2.84	
New Garage	3.62	1.65	3.25	3.51	3.01	
Fiidi	3.38	2.64	3.25	3.51	3.13	
Agbough	3.3	1.65	3.5	3.0	2.86	
Yogbo Road	3.46	2.64	3.0	3.2	3.08	
Asase	2.97	2.14	2.75	3.34	2.8	
Wurukum	3.87	1.65	3.5	3.0	3.0	

Source: Author's fieldwork, 2026

Water supply emerges as the best performing dimension in these neighborhoods, with Wurukum having the highest score of 3.87, closely followed by New Garage (3.62). The hygiene dimension also performs well in these neighborhoods with Wurukum having the highest score of 3.5, followed by Fiidi, Mobile Barracks, and New Garage, all sharing an index score of 3.25. This suggests that households adopt good hygiene practices. The disaster resilience dimension also performs well in these neighborhoods. In contrast, the sanitation dimension shows deficiencies and represents an obstacle to the overall water security in these neighborhoods.

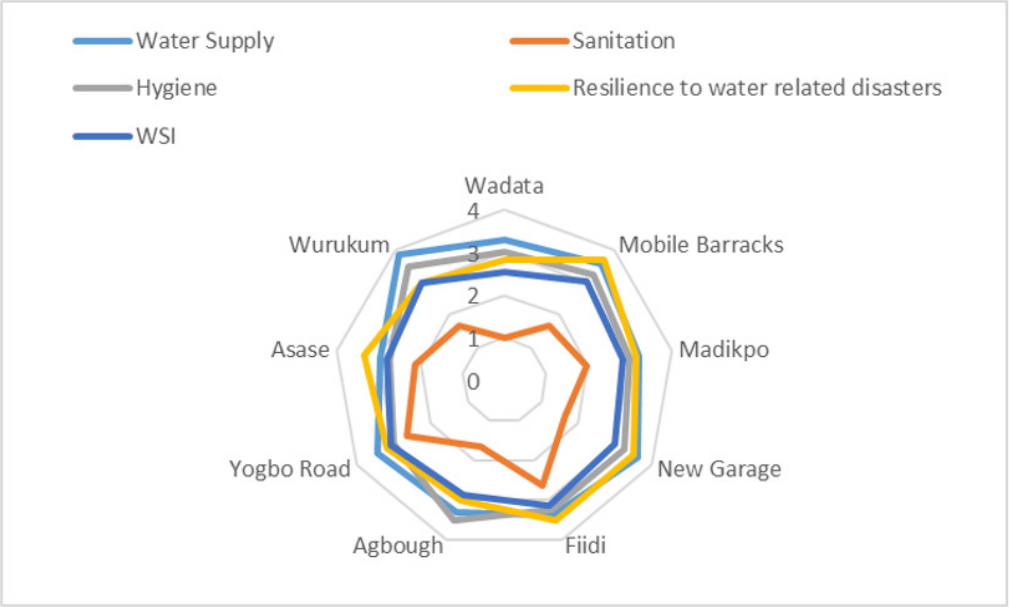

Figure 4: Water security index for each of the dimensions across low-income neighborhoods.

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Discussion

This study applied a modified framework for the assessment of household water security accounting for water supply, sanitation, hygiene and resilience to water related disasters. This framework takes care of the gaps created by city-level, national or regional frameworks of water security. This is a framework that can be easily applied to other urban areas where data is available. The water security index for Makurdi town is 3.15, indicating a good water security level. This is interpreted to mean that Makurdi town has a fairly satisfactory environment for facilitating water security, with some dimensions however having some concerns. Hailu *et al.* (2020) also arrived at a water security index of 3.25 for Awash Basin in Ethiopia, which falls in the same category as Makurdi town. Going by dimensions, the water supply dimension sub-index of 3.56 is very good. This suggests that investments in water infrastructure particularly boreholes by individuals and Non-Profit Organizations, has improved access and reliability of water supply in Makurdi town (Ahile *et al.*, 2018). Efforts by the government to sustain public water supply to some parts of the town have also helped to boost the water supply situation of the town, hence the dimension's sub-index score. However, there are challenges of seasonal water shortages that still need to be addressed. Findings by Assefa *et al.* (2018) align with this study; water supply in Addis Ababa is adjudged to be good, but there is a challenge in satisfactorily reaching the whole city with sufficient amount of water. The hygiene dimension has a sub-index of 3.40, which is interpreted as good, indicating encouraging progress, possibly reflecting high level of awareness of public health issues among the resident of Makurdi town. This also suggests that residents have fair access to hygiene facilities, although this may not be consistent across all neighborhoods, a situation that could limit long-term gains. Resilience to water-related disasters is fundamental for assessing the people's ability to respond to water-related disasters such as floods and droughts (Park *et al.*, 2022). This dimension has a sub-index of 3.34, also categorized and interpreted as good. This indicates that residents of Makurdi town take flood preparedness seriously. This is particularly true for residents living in neighborhoods close to the banks of the river Benue. Previous studies have however shown that Makurdi is vulnerable to climate variability and flooding (Onuh *et al.*, 2025; Unum *et al.*, 2025; Oyatayo *et al.*, 2018; Muhammad & Atu, 2018), indicating that the findings may not completely mirror the overall resilience condition of the town. As climate change persists, more countries and communities are becoming vulnerable to the associated impacts. For instance, findings by Park *et al.* (2022) show that most countries in Asia particularly Indonesia and Bangladesh are highly vulnerability to water related disasters, particularly floods. These findings suggest that strengthening flood management systems particularly in vulnerable neighborhoods will be crucial in preventing recurring damages and economic losses from floods. The sanitation dimension has a sub-index of 2.31 (the lowest of all the water security dimensions employed for this study), which is considered a fair water security level. This score is however interpreted to mean that this dimension is still a concern; implying that despite the gains made in improving access to sanitation facilities, there are still likely gaps in access to safe toilets, poor

CONCLUSION

Achieving water security is a major challenge in cities, particularly in developing countries. Previous studies in Nigeria and Makurdi in particular, employ a methodology for water security assessment that merely accounts for water access or water scarcity, thereby limiting the scope of the concept. This study employed a modified framework to determine the water security status of households in Makurdi town using indicators that holistically assesses water supply, sanitation, hygiene, and resilience to water related disasters. The study has shown that Makurdi town is moderately water secure. This status however masks considerable disparities in some dimensions and indicators across the town; the water supply, hygiene, and resilience to water related disasters dimensions are better placed, while the sanitation dimension generally shows poor results, indicating a gap and highlighting an opportunity for development. The study also shows considerable disparity in water security across high, middle, and low income neighborhoods in Makurdi town. All category of neighborhoods shows good results for the water supply and hygiene dimensions. High and middle income neighborhoods show strong resilience to water related disasters, with low income neighborhoods showing some level of vulnerability. The sanitation dimension shows poor results generally. However, low income neighborhoods report the worst results.

Based on the findings above, the study makes the following recommendations

- To improve the poor sanitation of households across most neighborhoods, individuals should also invest more in provision of sanitation facilities to improve neighborhood access to sanitation.
- The government should foster stronger collaborations with NGOs, private sector actors, and international development partners to mobilize technical expertise and financial resources to support the provision of critical infrastructure needed to close the gap in water security across neighborhoods in Makurdi town.
- Researchers should periodically carry out water security assessments to judge the progress made over time. This will also reveal areas that require critical interventions.

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