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Gender and Other Vulnerabilities to Water–Energy Accessibility in Rural Households of Katsina State, Northern Nigeria

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Abstract: Water and energy are essential resources for all people. However, despite the availability of sufficient water and energy resources, men and women continue to be subject to unequal rights to both water and energy in terms of access, allocation, gathering, and quality of resources. Socio-economic parameters, which include gender, income, and location, are determinant factors of water and cooking energy accessibility in this study. The research aims to assess the accessibility of water and cooking fuels across female-headed households, and evaluate particular vulnerabilities and challenges faced by women and children in rural areas of Katsina State in circumstances of water and energy insecurities. A study involving a questionnaire covering 550 rural households across 11 areas in Katsina State, north-western Nigeria, was conducted. A Pearson product correlation analysis was performed to measure the strength of association between the respondents educational level and income. A chi-square test of independence was carried out to measure the degree of dependence of the households' resources accessibility. The authors assessed the disproportionate threats and health risks linked to fetching water and gathering of fuel resources. The research findings indicate that water and energy uncertainty among women in rural households is due to unequal responsibilities associated with water- and energy-related household duties that are potentially linked to disadvantages for females, including violence, security threats, diseases, and disempowerment. To address these challenges, water and energy interventions, and important pathways for beneficial change, are proposed for rural regions in sub-Saharan Africa. This should lead to more gender equity associated with water and energy.

Keywords: water resources access; cooking energy access; gender-based resource access; socio-economic sustainability; sustainable development goals; traditional rural practices; vulnerability; water; energy; food nexus

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1. Introduction

A significant fraction of rural households in low- and middle-income countries, particularly of sub-Saharan Africa, have no access to piped water in their neighbourhood [1,2]. There are long walking distances to collect water, as well as cooking fuel, especially from an "improved" source of water for potable use and other household activities. The collection of water and cooking fuels can be a considerable physical and economic load that particularly impacts on women and mainly female children [3–5]. Households linked to water collection journey times of greater than 30 min commonly collect progressively less water [6,7]. Restricted water and energy availabilities often lead to a reduction in the amount of water and energy that are used for drinking, hygiene, and cooking in the household.

Residents' access to clean potable water and cooking fuels is imperative for appropriate development, and addressed in the Sustainable Development Goals (SDGs) [8]. The Joint Monitoring Program of the World Health Organization on water highlights that "Access to drinking water means that the source is less than 1 km away from its place of use and that it is possible to reliably obtain at least 20 L per member of a household per day." [1]. For the post-2015 SDGs, access to basic drinking water is defined as "using an improved source with a total fetching time of 30 min or less for a round trip including queuing" [9].

Access to good-quality water and a clean energy supply is an essential requirement for the reduction of poverty, and sustainable human development [10–12]. Despite impressive accomplishments towards sustainable access to safe water and clean energy sources, billions of people still lack access to sustainable resources nowadays. The Joint Monitoring Program (JMP) states that 26% of the global population (2.6 billion people) safely manages potable water, and that 2.3 billion people reside in water-stressed regions of the world [13]. Furthermore, at least 20% of the global population (about 1.4 billion people) are still denied access to electricity sources, and around 40% of the global population (roughly 2.7 billion people) depend on traditional biomass as their major source of energy for cooking [14]. Universal sustainable access to both clean water and energy are key priorities of the global development agenda, which is the foundation for the SDGs. Without sustainable water and energy provisions, large proportions of the world's population are denied access to essential amenities. As a consequence, the poor are forced to live and work in unhealthy circumstances.

Two-thirds of the world's poor people are female. They typically reside in water-scarce regions, with limited access to a secure and permanent supply of water for productive and household uses [15]. The majority of these poor people rely on agriculture for their livelihood, and reside in regions of south Asia and sub-Saharan Africa. These areas are linked to the world's water-poorest communities [16].

The SDGs were unanimously accepted by the member states of the United Nations in September 2015, providing a comprehensive framework for global cooperation to achieve a sustainable prospect for the planet. The 17 SDGs and their 169 targets define a path to fight long-standing inequality and injustice, end extreme poverty, and protect the planet's environment. Sustainable access to clean water and energy, as well as gender equality, are central to the success of the SDGs. The global goal on water (SDG6) consists of key elements such as ensuring availability to clean water and safe sanitation for all, as well as safe and affordable drinking water. The global goal on energy (SDG7) comprises three key targets: affordable, reliable, and common access to contemporary energy services; a substantial share of renewable energy in the overall energy mix; and doubling up the rate of improvement in global energy productivity [17]. It is imperative to highlight that inequality in accessing water and energy resources is intensified among some communities. For instance, women in rural communities often represent a marginalized group, which is unjustifiably burdened with inaccessibility to good-quality water and clean energy sources [13]. Females excessively serve as water and energy suppliers, collecting water and cooking fuels across many households. Frequently, women and girls need to walk long distances to fetch water and energy supplies [18].

Consequently, in low- and medium-income countries, water and energy inaccessibility is typically characterized by insufficient household access to both good-quality water and energy sources. This is particularly the case for electricity, leading to a reliance on unimproved water sources and unclean fuels for heating, cooking, and lighting, which can be harmful for human health and welfare [13,19–22].

Concerning the gender dimension, the understanding of 'gender' by the authors needs to be defined in the context of this article. The authors agree with Risman [23], and view gender as a social structure that identifies and legitimatizes certain behaviours, roles, and responsibilities as masculine or feminine, which is subsequently linked to social actions. As people usually act in accordance with their predefined gender roles, the social structure is remodelled [24]. Gender is typically associated with differences in what people can actually

perform, the services and resources they may access, and their potentials and prospects for their own development [25]. Concerning the study region in rural Nigeria, gender is traditionally seen as binary. However, the authors are aware of, and accept, a more modern view of gender as not being binary.

There are considerable inter-linkages between water, energy, gender, and health-worsening imbalances among females, which cause health challenges. Amid other challenges, inaccessibility to safe and sufficient water, as well as clean energy, increases the risk for related waterborne and respiratory illnesses including, for example, cholera, which is a bacterial infection transmitted by polluted water, and cardiovascular illnesses, due to indoor air pollution [26–30]. Considering the position of females in providing water and energy for their households, women and girls are particularly exposed to the contraction and transmission of several diseases [26,30].

A number of conceptual frameworks of vulnerability are significant for directing multiple disciplines [31–35]. To evaluate the various vulnerabilities experienced, the study used the vulnerability concept, based on resource accessibility. This refers to a state of being exposed to the possibility of being assaulted, or otherwise harmed, either emotionally or/and physically, due to an incapacity to protect affected individuals' personal interests in the course of resource accessibility [36–38].

Since 2015, gender equality and the empowerment of women are seen as crucial in attaining the SDGs. Adhering to these development obligations, a considerable number of studies focus on the impacts of inequality experienced by females, with women and girls regularly experiencing a greater proportion of the detrimental effects of water and energy inaccessibility. However, limited work has been undertaken on the interaction between gender, water, and energy at the household level, particularly in rural areas. Remarkably, the Sustainable development Goals (SDGs) highlight the significance of equal rights to resource accessibility across gender in target 5.a. Thus, water and energy are crucial resources, which women should have the same right to as their male counterparts. Moreover, the importance of ending all forms of gender-based discrimination against women is enshrined in target 5.1 of the Sustainable Development Goals (SDGs) [39]. The series of connections between gender, water, and energy arise from the conventional roles played by women and girls on a household scale, which includes the collection of water and cooking fuel, as well as cooking [40].

Across several nations, women are prohibited from working, for social and cultural reasons. According to the World Bank, there are over 100 economies with labour regulations that limit the types of employment women can embark on, as well as where and when they are allowed to work [41]. It further assesses that this has an effect on the employment options of about three billion women. Furthermore, the report points out that 18 countries give husbands legitimate rights to prevent their spouses from working. Correspondingly, International Labour Organization (ILO) reports disclose that 14% of the women in Africa are household workers, and women represent an estimated 83% of household workers globally [42]. In 2018, the work force involvement rate of women was 48%, in contrast with that of men, which was 75% in the matching year [43]. This situation is more common in rural areas of Nigeria, where more than 50% of Nigerian women reside [44]. Despite the gender-based employment marginalisation faced by women in many regions of the world, studies show that women contribute immensely to households' resources accessibility. Studies [45,46] reveal that women in many rural Nigerian households contribute significantly from what they earn towards running daily activities, and securing households' food security [45,46].

Individual constituents (either water or energy) are examined in some research projects. For instance, other studies [26–30] assess individual elements, such as water or energy, as a separate entity. Pouramin et al. [26] find that females experience barriers towards accessing basic water provisions. They discover that women, due to their responsibilities as water providers, are at risk of exposure to polluted water, thereby suffering from various negative health effects. Wu [29] investigates the influence of the choice of household cooking

energy source on female's health from various dimensions, including health and common activities. The study intends to assess energy transition and health enhancement concerning developing countries. Findings for individual households indicate that cooking energy selection switches from solid fuel to clean energy sources, which improves female health.

Regardless of these gender-related inequalities, research evaluating the intersection between gender on one side, and water and energy on the other, is still in progress. Successfully addressing gendered water–energy inequities requires considerable focused resources. Thus, this study aims to examine women's accessibility to households' water and energy; it also explores the various vulnerabilities experienced due to water and energy collection in rural areas of Katsina State, northern Nigeria.

This research article is structured in the following way: after a concise overview and a critical review of the scientific literature related to water–energy accessibility in Section 1, Section 2 summarises the methodology covering a description of the materials and methods applied to conduct the work, which involves the description of the study area, conceptual framework, a selection of the rural surveyed communities, as well as statistical analysis of the data. Section 3 is devoted to the results, highlighting socio-economic characteristics of the female household heads, access to water and energy across the identified income groups, physical distances covered, and time taken to collect water and cooking fuel. Moreover, key findings are discussed in Section 4. Section 5 concludes on the main results, and emphasizes the wider importance of this work. Finally, Section 6 summarises limitations and recommends future studies.

2. Materials and Methods

2.1. Study Area Description

The project was carried out in Katsina State, located within latitude 11°08′ N and 13°22′, and longitude 6°52′ E and 9°20′ E, with an area of about 24,000 km^2 (Figure 1). The state consists of 34 local government areas. The average literacy proportions are 59% for males, and 29% for females. In 2019, 56.42% of people in the state were below the poverty threshold [47]. The state population estimated census data released by the National Population Commission states that the total population for the year 2021 was 9,145,600, of which 4,664,256 (51%) and 4,481,344 (49%) were males and females, respectively.

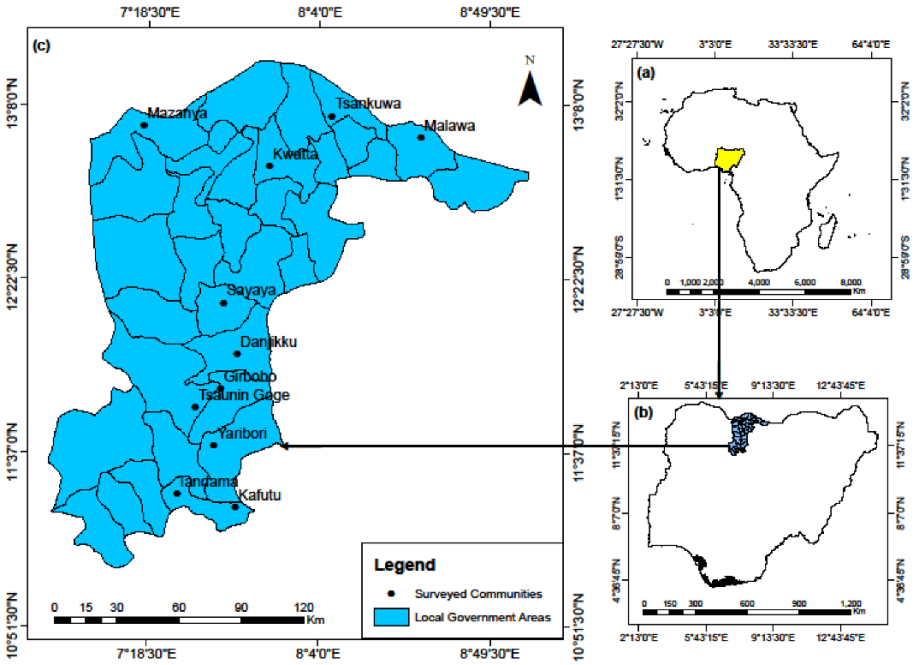

Figure 1. (**a**) Map of Africa indicating Nigeria; (**b**) map of Nigeria highlighting Katsina State; and (**c**) map of Katsina State outlining the surveyed rural communities.

The map of the study region highlighting the surveyed communities was created using a geographical information system application and subsequent cartographical analysis. Global positioning system coordinates of the sampled communities were noted during the field study, and integrated into the existing digital map database, accessible at the Geographical Information System and Remote Sensing Unit (Department of Geography, Umaru Musa Yarádua University).

2.2. Conceptual Framework

To investigate the inter-linkages between gender and accessibility to households' resources (water and energy), and to understand the different intensities of vulnerabilities as a result of water and cooking energy accessibility among rural, women-headed households, a conceptual framework for the study was designed. In rural, women-headed households of low- and medium-income countries, water and energy insecurities typically manifest themselves as a deficiency in household access to both safe drinking water and cooking fuels, leading to a reliance on unclean water and cooking fuels (biomass), which can be detrimental for health and well-being.

Fetching water and gathering biomass is commonly the responsibility of females. They can be asked by their husbands to perform this task for many hours per day, resulting in less productive time and energy for formal employment, education, as well as social and political interactions in public. Water and cooking fuel (biomass) collections may also be unsafe, due to grievances from carrying heavy loads and other health impacts (see above). In some contexts, women also face an increased exposure to both physical and sexual attacks. Consequently, old-fashioned gender divisions of household labour mean that females commonly spend considerable time at home, and prepare almost all household meals. This leaves females more vulnerable to the negative impacts of indoor air contamination and accidents. The associated impacts are felt disproportionately between males and females, with women experiencing a higher percentage of the harmful effects of water and energy insecurity.

2.3. Research Design

The study was designed based on the conceptual framework, illustrated in Figure 2, to explore women's access to households' water and cooking fuels, as well as the associated vulnerabilities experienced by accessing these resources. A semi-structured questionnaire was specifically designed for this study, including a socio-economic section, and questions about the physical and economic access to water and energy sources, as well as the considerable vulnerabilities and burdens experienced by females in rural communities. The focus was on conditions linked to water and cooking fuel accessibility, considering particularly the unequal dangers, physical security threats, and health risks, as well as time and energy losses, linked with water and energy access.

In order to explore the characteristics of socio-economic classification, the collected information included household heads' educational level, monthly income, and occupation. To understand the accessibility to water and energy sources, respondents were first questioned about the leading sources of drinking water and cooking energy in the surveyed area. Sources specified were grouped into enhanced and unimproved water sources [48]. The improved sources are piped water into dwelling, piped water to yard, public tap/standpipe, borehole/tube well, protected dug well, protected spring, and rainwater; original water sources are unprotected spring, unprotected dug well, cart with tank or drum (water vending), tanker truck, and surface water.

The cooking energy sources were also categorised, based on the World Health Organization (WHO) [49], into clean and unclean fuels. The clean fuel sources are electricity, natural gas, liquefied petroleum gas, ethanol/methanol, and kerosene; the unclean sources are coal, charcoal, sawdust, fuelwood, agricultural residue, and animal dung. To measure the distance covered to access various water sources, and the time taken to collect the corresponding water, WHO and the United Nations Children's Fund (UNICEF) recommend

thresholds of 1000 m and 30 min, respectively [18]. The authors adopted these values in this study for categorisation purposes.

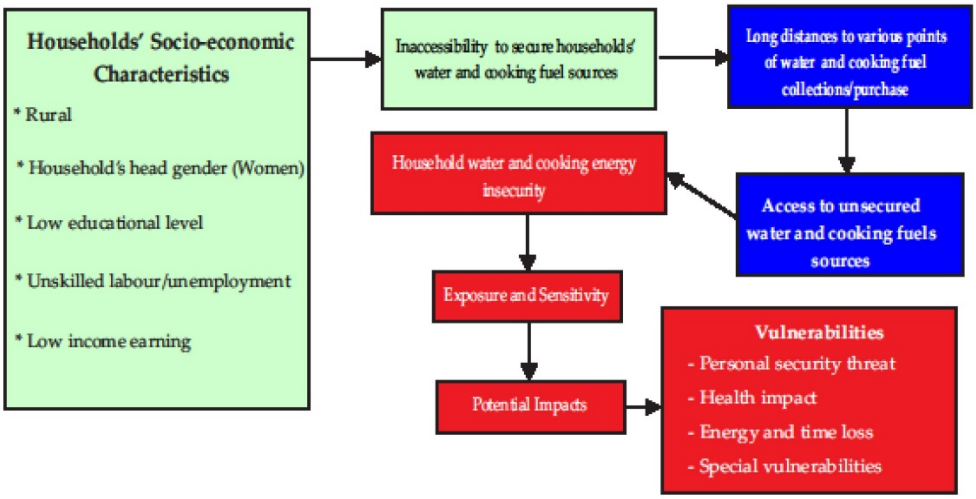

Figure 2. A conceptual framework connecting households' socio-economic characteristics, water and energy insecurity, and various associated vulnerabilities.

2.4. Selection of the Surveyed Households

A qualitative study design was carried out in Katsina State. The state has been stratified into urban and rural areas. Hence, this format was adopted in selecting ten surveyed communities that were chosen considering rural norms [50]. The selected surveyed rural communities are Mazanya, Tsankuwa, Kwalla, Malawa, Sayaya, Danjanku, Girbobo, Tsaunin Goge, Tandama, Yari bori, and Kafutu, as indicated in Figure 1.

Only households that are headed by a female were considered for the study. Respondents were questioned on the estimation of distance and time taken for a round trip to fetch water, quantity of water collected from the various sources, availability of cooking fuels at the point of purchase or collection, and who is responsible for water and energy collections. Information on vulnerabilities such as personal security threats, health impact of the water and energy collection trip, and energy and time loss, as well as special vulnerabilities, were also gathered and analysed.

2.5. Data Collection

Primary and secondary sources of data were applied for this study. The primary data were generated through the structured questionnaire administration. The survey was conducted in person by ten field assistants, who are conversant with the surveyed rural communities.

Data were collected over a period of one month (between mid-March to mid-April 2022). Due to unavailable data on the number of female-headed households in the study area, the number of households surveyed is a reflection of the available female-headed households across the surveyed communities. Mazanya has 11.8% of the surveyed households (65 households), Sayaya has 12.7% (70 households), Kwalla and Malawa each have 10.2% (56 households each), Danjanku has 9.1% (50 households), Tsankuwa has 7.3% (40 households), Girbobo has 7.6% (42 households), Tsaunin Goge has 9.5% (52 households), Tandama has 8.4% (46 households), and Kafutu has 6.7% (37 households). Finally, Yari bori, which represents 6.5% of the surveyed households, has 36 households. At the end of the exercise, 550 copies of questionnaires were served to the female-headed households across the selected rural communities.

2.6. Statistical Data Analysis

IBM SPSS version 24 was applied for data entry and analysis. Descriptive statistics were used to assess the household heads' socio-economic and demographic variables, as well as their access to various water and energy sources. Summary statistics in terms of proportions, expressed in percentages, were calculated. To determine the association and direction of the water and energy crisis, the Pearson product-moment correlation (PPMC) was employed to determine the relationships between the socio-economic variables of the female household heads. The corresponding key variables are educational status and monthly income. Simple bivariate correlations were adopted. Chi-square tests of independence were undertaken, to determine whether there is relationship between access to households' water and energy and the households' income groups. The authors only considered a minimum degree of significance at 95% confidence level ($p = 0.05$).

3. Results

3.1. Framework and Household Characteristics

The empirical study context, through the administration of a well-constructed questionnaire, generates dependable results, which authenticates the study's theoretical framework, which discloses the consequences of water and energy insecurity across the income groups of women-headed households within the rural context, and the various vulnerabilities associated with insecurities.

In total, 550 households were assessed among the ten surveyed rural communities of Katsina State. The study data are based on the responses of the female household heads across the investigated communities. Results indicate that most of the household heads are widows (61%), 20% are divorcees, and 18% are married. Overall, 56% of the female household heads are housewives, 33% are farmers, and 5% of them are traders. Regarding household income, the majority, representing 51%, earn less than NGN 30,000 (USD 72.8)/month, while 27% receive between NGN 30,000 and NGN 50,000 (USD 78.2–121.3)/month.

Three income groups are classified, based on the household monthly income, as follows:

- Group 1 (low-income-earning) includes illiterate people and those who have a monthly income of less than NGN 30,000. This group is classified as low by the socio-economic categorisation, because it comprises 51% of household heads characterised by no formal education level, and low monthly income;
- Group 2 (medium-income-earning) is formed by 27% of respondents with a low educational level (mostly below secondary school certificate), and a medium monthly income between NGN 30,000 and 50,000;
- Group 3 (high-income-earning) corresponds to the household heads with an income above NGN 50,000. This group represents 21% of the respondents with a high educational level (mostly secondary school certificate).

To determine the strength and direction of association between educational status of the women household heads and various income groups, the Pearson product-moment correlation (PPMC) r was calculated. The Pearson's r analysis indicates that there is a strong association ($r = 0.82$). The p value is less than 0.05, which implies the significance of the measure of association.

3.2. Accessibility to Water Sources

The sources of water accessible for household applications, and in the studied communities, are presented in Table 1. The overall result reveals that public borehole and public dug wells are the major sources of water across the surveyed households, representing 44% and 23%, respectively. It is observed that 3% of the households rely on privately owned boreholes and tanker trucks.

Table 1. Sources of water related to household income groups.

Main HH Water Source	Monthly Income of the Household Heads							
	<NGN 30,000 (USD 78.2)		NGN 30,000–50,000 (USD 78.2–121.3)		Above NGN 50,000 (USD 121.3)		Total	
	n	%	n	%	n	%	n	%
Public tap	-	-	31	21.1	-	-	31	5.6
Private borehole	-	-	-	-	15	12.6	15	2.7
Public borehole	102	36.4	72	48.6	65	54.6	239	43.5
Protected dug well	55	19.4	-	-	13	10.9	68	12.4
Unprotected dug well	126	44.5	-	-			126	22.9
Water vending	-	-	26	17.5	26	21.8	52	9.5
Tanker truck	-	-	19	12.8	-	-	19	3.4
Total	283	100	148	100	119	100	550	100

Across the income groups, there are not too many main water sources for household purposes. Most of the households from low-income groups access unprotected dug wells (45%), protected dug wells (19%), and a remaining 36% access public boreholes. In the medium-income group, access to various water sources are public borehole (48%), public tap (21%), tanker truck (13%), and water vending (18%). In the case of high-income groups, 12% access private boreholes, 55% public boreholes, and 11% protected dug wells. Finally, 22% of household water is provided through water vending. The chi-square analyses for income groups and access to water indicate a high statistical significance ($p < 0.01$).

After analysing the physical access to the water sources, Table 2 describes the distance to various water sources. Households that access privately owned (located in dwellings) boreholes have easy physical access to water sources, which also represent a total proportion (100%) of households that access private boreholes, and 21% of households that have their various water sources located in their respective dwellings. Households that access protected and unprotected boreholes represent 18% and 61%, respectively. These frequencies also represent 19% and 34% of the households accessing both protected and unprotected dug wells, respectively. Furthermore, these households have an average distance to the nearest water source of less than 1000 m (1 km).

Table 2. Household physical accessibility to various water sources.

Main Water Source	Average Distance to Water Source							
	In Dwelling		<1000 m		1000 m and above		Total	
	n	%	n	%	n	%	n	%
Public tap			24	10.6	7	2.8	31	5.6
Private borehole	15	21.1	-	-	-	-	15	2.7
Public borehole	-	-	112	49.6	127	50.2	239	43.5
Protected dug well	13	18.3	25	11.0	30	11.9	68	12.4
Unprotected dug well	43	60.6	54	23.9	29	11.4	126	22.9
Water vendor	-	-	11	4.9	41	16.2	52	9.5
Tanker truck	-	-	-	-	19	7.5	19	3.4
Totals	71	100	226	100	253	100	550	100

Table 2 reveals that households that access water through public boreholes represent the highest proportion (50%) of households that access it within less than 1000 m, while the lowest proportion (5%) of households within the same distance range access their household water supply through water vending. Various water sources are identified with a physical access with average distance of more than 1000 m across the surveyed households. The highest record is for public boreholes (50%). Public taps have the lowest proportion (3%) linked to the same average physical distance. The chi-square analyses

for average distance covered to access various water sources indicates statistically highly significant ($p < 0.01$) findings.

3.3. Time Required to Collect Water from Various Sources

Table 3 indicates the time taken to fetch household water sources from various points of collection. Findings show that 13% of the total households surveyed have their various sources located in their respective dwellings. Hence, they spend no time on water collection. Findings further reveal that 14% of households spend less than 30 min collecting household water. The study further reveals that 90% of households collect water from a distance of at least 1000 m, and spend more than 30 min collecting water from various sources. Moreover, Table 3 reveals that 76% of the households have various water sources located within less than 1000 m, and spend more than 30 min on water collection, including queuing.

Table 3. Time required to fetch water from various sources.

Time Taken for a Round Trip Including Queuing	Location of Water Source							
	Within the Dwelling		<1000 m		1000 m and above		Total	
	N	%	n	%	n	%	n	%
No time spent	71	100	-	-	-	-	71	12.9
Less than 30 min	-	-	54	23.9	23	9.1	77	14.0
30 min and above	-	-	172	76.1	230	90.1	402	73.1
Total	71	100	226	100	253	100	550	100

3.4. Responsibility for Water Collections

Table 4 shows the division of responsibility for water fetching among the family members related to the distance to various points of water sources. Findings indicate that 80% of the total surveyed households collect water from different sources, across various distances. Furthermore, for 47% of the households, water collection is only the responsibility of women (household heads). For 27% of households, collection is a shared responsibility among women and children, while 22% of households only involve children.

Table 4. Responsibility of water collection across the availability.

Various Distances of Water Sources	Responsibility for Water Collection							
	Household Head (Women)		Women and Children		Children		Total	
	n	%	n	%	n	%	n	%
Less than 1000 m	80	32.8	71	55.5	75	70.1	226	47.2
1000 m and above	164	67.2	57	44.5	32	29.9	253	52.8
Total	244	100	128	100	107	100	479	100

3.5. Household Cooking Energy Sources across Income Groups

The overall portfolio of cooking fuel across the households is overshadowed by conventional solid biomass fuels, and the majority (59%) access fuelwood as the main fuel for cooking, as indicated in Table 5. This is followed by agricultural residues (28%) and charcoal (6%). This contrasts with 5% of the surveyed households accessing non-solid fuels (cooking gas and kerosene) as their core fuels for cooking. Furthermore, the usage of animal dung-cakes and sawdust for cooking is normally insignificant at 2% and 1%, respectively.

Across the income groups, most of the surveyed households from low-income groups access fuelwood (58%) and agricultural residue (38%). The remaining 4% access dung-cakes as their main cooking fuel source. In the medium-income group, access to various cooking fuel sources are fuelwood (64%), agricultural residue (31%), and charcoal (5%). In the case of the high-income group, 11% of households access liquefied petroleum gas, 18% kerosene, 21% charcoal, 3% sawdust, and 54% use fuelwood. Furthermore, the chi-square analyses for

income groups and access to cooking fuel consumption indicate high statistical significance ($p < 0.01$).

Table 5. Sources of cooking energy related to household income groups.

Energy Sources	Monthly Income of the Household Heads							
	<NGN 30,000 (USD 78.2)		NGN 30,000–50,000 (USD 78.2–121.3)		Above NGN 50,000 (USD 121.3)		Total	
	n	%	n	%	n	%	n	%
Cooking gas (liquefied petroleum gas)	-	-	-	-	6	10.9	6	1.1
Kerosene	-	-	-	-	21	17.6	21	3.8
Charcoal	-	-	7	4.7	25	21.0	32	5.8
Sawdust	-	-	-	-	4	3.3	4	0.7
Fuelwood	165	58.3	95	64.2	64	53.7	324	58.9
Agricultural residue	107	37.8	46	31.1	-	-	152	27.6
Dung	11	3.7	-	-	-	-	11	2.0
Totals	283	100	148	100	119	100	550	100

3.6. Household Physical Accessibility and Availability to Cooking Fuel Sources

Table 6 reveals that only 8% of households cannot access their various cooking fuel sources locally. Findings further show that most of the cooking fuels that are readily available when needed are biomass, which constitutes fuelwood (61%), agricultural residue (37%), and dung cakes (3%). Household cooking fuel that is readily available on market days within the access location include kerosene (14%), charcoal (8%), and fuelwood (79%). Additionally, cooking fuel sources that are not locally available consist of non-solid fuel sources, which include cooking gas (14%) and kerosene (19%). The solid fuel sources within the physical access location involve sawdust (4%) and charcoal (58%). The chi-square analyses for cooking energy availability at various points of collection is also highly statistically significant ($p < 0.01$).

Table 6. Availability of various cooking energy sources.

Energy Source	Availability of Cooking Fuels at the Point of Purchase or Collection							
	Always Available When Needed		Available at the Local Periodic Market		Not Locally Available		Total	
	n	%	n	%	N	%	n	%
Cooking gas (liquefied petroleum gas)	-	-	-	-	6	13.9	6	1.1
Kerosene	-	-	13	14.0	8	18.6	21	3.8
Charcoal	-	-	7	7.5	25	58.1	32	5.8
Sawdust	-	-	-	-	4	9.3	4	0.7
Fuelwood	251	60.6	73	78.5	-	-	324	58.9
Agricultural residue	152	36.7	-	-	-	-	152	27.6
Dung	11	2.7	-	-	-	-	11	2.0
Total	414	100	93	100	43	100	550	100

3.7. Time Taken to Collect Cooking Energy Sources from Various Sources

Table 7 provides an overview of the time taken to collect various available cooking energy sources from different points of purchase or collection. Results indicate that 40% of households surveyed spend less than 30 min on cooking energy collection. Moreover, 33% of households spend between 30 min and 1 h on collecting cooking fuels, while 27% of households spend more than 1 h on similar tasks. Table 7 also reveals that 49% of the households have various sources of cooking fuel, and spend less than 30 min on the cooking energy source collection, while 47% of households that use cooking energy sources spend 30 min on their collection.

Table 7. Time taken to collect cooking energy sources from various points of purchase or collection.

Average Time Taken for Cooking Energy Collection Round Trip	Location of Cooking Energy Sources							
	Always Available When Needed		Available at the Local Periodic Market		Not Locally Available		Total	
	N	%	n	%	N	%	n	%
Less than 30 min	201	48.5	15	16.2	4	9.3	220	40.0
30 min to 1 h	121	29.3	41	44.0	19	44.2	181	32.9
Above 1 h	92	22.2	37	39.8	20	46.5	149	27.0
Total	414	100	93	100	43	100	550	100

3.8. Responsibility for Cooking Fuel Collections

Table 8 shows that the responsibility of cooking fuel collection is distributed among the household members related to the fuel availability at the various points of purchase or collection. Findings indicate that across 129 households, which represent 23.4% of the households surveyed, it is exclusively the role of women to collect or buy cooking fuels from various points. The table further shows that for 145 households, which represent 26.3% of the total households surveyed, it is a shared responsibility among women and children to either buy or collect the fuel sources from various locations, while for the remaining half of the surveyed households, only children take on this responsibility of energy collection. Moreover, Table 8 further shows that for 88% of households, it is an exclusive role of children to collect fuel when it is always available when needed. For only 5% of households, there is a shared responsibility among women and children to collect fuels that are not locally available.

Table 8. Responsibility for cooking fuel collection.

Availability of Cooking Fuels at the Point of Purchase or Collection	Responsibility for Cooking Fuel Collection							
	Household Head (Women)		Women and Children		Children		Total	
	N	%	n	%	N	%	n	%
Always available when needed	76	58.9	95	65.5	243	88.1	414	75.3
Available at the local periodic market	22	17.1	43	29.7	28	10.1	93	16.9
Not locally available	31	24.0	7	4.8	5	1.8	43	7.8
Total	129	100	145	100	276	100	550	100

3.9. Vulnerabilities Associated with Water and Cooking Energy Collection

Table 9 shows various vulnerabilities that are mostly experienced during water and energy collection across the surveyed households. Findings indicate that 35% and 34% of the responsible people experience energy and time loss (e.g., physical exhaustion) during water and energy collections, respectively. Furthermore, 30% and 31% of the respective people experience personal security threats during the collection round trips, while 9% and 21% suffer from various vulnerabilities linked to adverse health impacts during the water and energy collection trips, correspondingly. Small proportions of the respective energy (14%) and water (16%) access challenges are linked to various special vulnerabilities, due to disabilities, old age, and pregnancy.

Table 9. Various vulnerabilities linked to water collection.

Vulnerabilities Experienced	Various Vulnerabilities Related to Water Collection									
	Security Challenge and Threat		Health Impact		Energy and Time Loss		Special Vulnerabilities		Total	
	n	%	N	%	n	%	n	%	n	%
Due to water collection	166	30.1	105	9.1	194	35.3	85	15.5	550	100
Due to energy collection	169	30.7	117	21.3	188	34.2	76	13.8	550	100

4. Discussion

This investigative study adds hard data evidence to the ongoing discussion towards achieving sustainable equitable access to clean water and energy, regardless of gender, socio-economic status, or location in sub-Saharan, rural African settings. Ending all forms of discrimination against women is not only a fundamental human right, but is central for the sustainable future of these regions. Empowering women and girls helps economic growth and development. Thus, ensuring equitable rights to economic resources and accessibility to household resources, which include water and energy, is key to empowering women.

The study observes that physical and economic inaccessibility to good-quality water and clean energy is prevalent in many of the surveyed rural households. Poor water and energy access is more widespread in low-income households, whereas poor accessibility to these essential household resources is associated with various vulnerabilities experienced across the affected households.

The investigation, across 550 households headed by females, reveals a low level of household head education, which implies that women are denied access to the same education as men. The study also reveals that the relationship between the educational status of female household heads with their various income groups is strong. In addition, high-income households with a household head with a relatively higher educational level tend to have easy access to enhanced water and clean energy sources. This finding reveals the water access situation where low-income households have access to various unimproved water sources. Consequently, the study shows the prevalence of access to different sources of unclean (solid) cooking fuels across the surveyed households. This is directly associated with a low-income level and location. Previous articles indicate that income is important for rural household water and energy preferences in developing states [51–60].

The results show that the accessibility to various water sources, availability of fuels, and the various distances to either points of collections or purchases varies across the investigated households. Several households (52.8% of the surveyed households) obtain water by walking more than 1000 m from their households, which coincides with some studies conducted in other sub-Saharan African countries [61,62]. The distances are above the maximum threshold recommended by WHO and UNICEF [18].

The study further reveals the frequent unavailability of many high-value fuel sources from local supplies, which include cooking gas, kerosene, charcoal, and saw dust, across the surveyed rural communities. This can be explained by poorly developed markets and distribution problems [63]. Conversely, households that access low-value energy sources made of biomass, which include dung, agricultural residue (post-harvest waste), and fuelwood, find these readily available either at the point of collection or via purchase.

The findings support international investigations by Rahut et al. [54] and Zhou et al. [64] in rural households of Pakistan and northern China, respectively. They find that the availability of biomass energy sources in the respective rural households are a major factor in energy choice. Furthermore, Gaur [57] finds that in rural areas of India, closeness to the market is one of the reasons that positively affects domestic use of modern fuel sources.

The study reveals the average distance travelled and time taken to collect water from various sources remains high for most households, which indicates that a large proportion of women and children live in families where the burden of collection is both over 1000 m and 30 min, which means that the distance covered and time taken are higher than the respective WHO and UNICEF thresholds for a safe journey [18]. Consequently, the study finds that rural women and children spend unreasonable time periods collecting cooking energy sources. This finding is supported by Heltberg [65], who finds that household responses to fuel scarcity leads to increased fuel collection times in rural India.

Moreover, the findings reveal that the majority of the surveyed households travel long distances to collect water and cooking fuels. On their daily trips to collect water and cooking fuel, rural women across the investigated households are vulnerable to dangers threatening their personal security. As the water and cooking fuel collection sources are located at

various different places away from their households, women and children commonly walk very long distances, and have to trek via unsecured paths, often on their own and defenceless. Women and girls fetching water and cooking fuel everyday often became the target of threats to their personal security, sexual violence, and physical attacks.

Pommells et al. [66] report that travelling long distances, intensified by the regularity of community women's water-fetching habits, gives attackers the chance to target women who are alone, isolated, and defenceless. In addition, other studies [66–68] reveal that beyond the physical threats, which include sexual assaults, women are also subjected to psychological stress linked to panic attacks and general anxiety, intensified by the lack of confidence among females. On the same paths to water and fuel collection locations, physical violence linked to animal attacks is also reported [66,67,69]. Sharing the same water resource and foot paths with dangerous hungry animals also contributes to physical insecurity.

The study reveals that women and children collecting large quantities of water and cooking fuel multiple times per day report considerable physiological health impacts attributed to their trips. These health impacts are outside of those linked to water quality or safe cooking fuel. Women are often executing collection activities from an early age when good physical development is critical. Other studies [69,70] state that adverse health impacts linked to collecting water and cooking fuels include lasting back injuries, fatigue, micronutrient shortages due to a high number of calories being burned, body parts scratched and wounded by shrubs, attacks by wild dogs, and bites by venomous snakes.

Combining health effects with security fears, a broader scope of health risks appear. As an example, sexual attacks may not only damage the attacked person physically and psychologically, but may also result in long-term sexually transmitted diseases, such as the human immunodeficiency virus, potentially leading to the acquired immunodeficiency syndrome. Animal strikes are also a considerable health threat. Inflicted injuries are either hard to cure in remote rural locations and/or are liable to infection, potentially leading to mortality. The consequential health effects as a result of these experiences not only damage the physical advancement of women and children, but also obstruct their capability to take part in or achieve other daily activities and tasks, which include school education and professional work. As a consequence, some women remain uneducated, and without qualified jobs.

While collecting water and fuels for various household activities including cooking, hygiene, drinking, cleaning, and other fundamental actions is not a waste of time, the way in which most women and children across the investigated households fetch the resources often pose a great loss of time for them. In most of the surveyed households, access to water and cooking fuel sources is remote. It follows that women spend many hours making their daily collection round trips. The time spent could be used differently, for other productive or recreational activities.

The challenges highlighted in this study are also common to other rural settings, for example in Somalia, where women devote an average of 11.3 h weekly to the fetching of water [68]. The time spent on water and cooking fuel collection is accompanied by an opportunity cost [5], linked to 'trade-offs' [68]. Fetching water, collecting fuelwood, and other household responsibilities performed by women cause trade-offs including reduced security, nourishment deficiencies, and insufficient schooling [68].

In addition to time loss, the intensity of energy required to carry out water and fuel collections leaves little energy to accomplish other productive pursuits in the remaining daytime hours. Therefore, enhancing access to water, as well as cooking fuel, and reducing the distant trips to collect water and fuel allows women to participate in other productive activities, such as education and professional work.

This study reveals the influence of various income groups on access to household resources. For instance, high-income groups are linked to a lower average distance to the water sources than the other groups. However, this is not the case for collecting water from improved sources. The insecurity is related to the time taken and distance covered, which show the vulnerability of all respondents, regardless of their income group. There is a very

high level of health concern common to all individuals who need to walk more than 1000 m to a water source, or require more than 30 min for total collection time.

The research reveals that across all investigated households, rural women and children are exclusively accountable for the collection of water and cooking fuels. Geere and Cortobius [68] also highlight that the women and children are principally in charge of fetching water. Moreover, women with special vulnerabilities are at an even greater disadvantage in accessing water. The study indicates that older adults, pregnant women, orphans, individuals with long-term illnesses, disabled females, and women coping with social stigma are in a more difficult position to access, and subsequently carry, water. It follows that these people are especially vulnerable, and their households face severe water insecurity [66,68]. Respondents report that pregnant women are extremely exposed to water uncertainty because of their physical constraints in undertaking the water collection activities. These groups have diverse physical or incidental constraints, and their incapability to perform the trip of water collection effectively broadens the challenge of inequitable access to water sources. This may either force them to take more dangerous journeys to other water resources, reduce their opportunity to successfully meet their basic needs for water, or force them to make other more costly arrangements.

The study findings reveal that it is a major role of women to collect cooking fuel across the investigated households; this coincides with the findings of the African Development Bank [69], which indicate that the typical rural energy predicament is linked to traditional gender role separation, with women spending considerably more time than men addressing energy supply needs for family survival [71]. This renders them vulnerable to wounds, including attacks by feral animals [70]. Moreover, addressing the challenges of women's access to water and energy is critical towards achieving SDGs 5, 6, and 7. Females are disadvantaged concerning water and energy governance in rural societies in sub-Saharan Africa, because they are not participating in the decisions concerning water and energy access, control, and utilisation. In order to proceed positively on SDG 6.B ("stakeholders participation") and SDG 7.1.2 ("proportion of population with primary reliance on clean fuels and technology"), a clear focus on addressing SDGs 5.1 ("end all forms of discrimination against all women and girls everywhere"), 5.2 ("eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation"), and 5.5 ("ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life") is required [17]. Therefore, it is necessary to include women in local water and energy management decision-making, in order to lessen discrimination and violent behaviour linked to water and energy collection.

The struggles faced by rural women can be addressed if there is improved ownership by women, and a reduction in power held by men who traditionally manage key components of the household income, which also concerns water and energy management. Safeguarding women, so they have the same opportunities as men, would encourage them, and add invaluable understanding to basic processes that they are personally connected to, such as water and energy organisation.

5. Conclusions

The study examined gender accessibility to household water and energy supply in varied income households in rural communities in the Sahel Savannah region of Katsina State. There is a strong relationship between water and energy access and household income (r = 0.67 and r = 0.74 for water and energy, respectively). The results show that access to unimproved water and unclean energy sources for cooking are dominant across the surveyed households. Based on the distance to various water sources and the time taken to fetch water, findings reveal high levels of water insecurity. The majority of the families obtain water outside the specified WHO maximum standard in terms of time spent on collection. The study suggests that households are susceptible to water-borne diseases based on closeness to unimproved resources. Households depend on unclean cooking

fuels with inefficient technologies (stoves), together with less healthy kitchen arrangements including the lack of a chimney, exhaust fan, or general ventilation. Access to solid cooking fuel sources, alongside inefficient cooking arrangements, further reveals that households are also prone to lethal diseases, as a result of indoor air pollution.

6. Limitations and Future Research

A vast majority of the rural inhabitants in Katsina State are confronting the growing risk of banditry, which is organised crime including murder, rape, kidnapping, and cattle rustling. Hence, due to these circumstances, the researchers had limited access to more rural households, as the security of the survey team could not be guaranteed at all times.

The data collected on the household water and energy accessibility and availability only relate to female-headed households. Other elements of water and cooking energy securities, which include affordability, safety, and stability should also be assessed in future studies. Moreover, the research should be extended to other rural households of low- and middle-income regions, and could evaluate the progress towards achieving sustainable gender equality for the most vulnerable social classes.

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