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What defines rural water security? Identifying the contributing factors to household water security in Ghana

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Abstract: Notwithstanding its rise in use in the policy and academic literature, the term water security lacks a comprehensive understanding of how it is conceptualized, measured, and applied at the household level. This paper contributes to water security debates by assessing the factors contributing to rural water security in Ghana. Drawing the analysis from six-dimension indicators, including availability, access, safety, management, preferences, and sustainability, the study examines how the absence or dysfunction of any of these dimensions constitutes water insecurity. Using cross-sectional data from 158 households, the study's analysis provides a deeper understanding of these dimensions' importance in defining rural water security. The paper recommends the need to consider context-specific issues in defining water security in policy decisions.

Key words: Households; rural Ghana; water management; water policy; water security

1. INTRODUCTION

This paper assesses the water security experiences of three rural communities in Ghana. Focusing on rural communities with dispersed agricultural populations fewer than 1000 members, limited access to infrastructure, services, and external support, this study recognizes that despite significant development in recent decades, rural communities are faced with several technical, economic, and institutional challenges that impede access to improved water supply and sanitation services (Dickson et al. 2016; Dosu and Hanrahan 2021; Dosu et al. 2021). Thus, the study communities are faced with water insecurity characterized by poor water access, the unreliability of water supply, limited capacity, and poor water quality motoring.

In assessing rural experiences, I note that the current literature has been flooded with several indicators and indices developed for measuring rural water security. Recently, the works of Dickson et al. (2016), Jepson et al. (2017), Octavianti et al. (2021), and Thomas et al. (2020) have provided some of the indicators that are valid for measuring water security from across levels and disciplines; however, these have been largely focused on reviews without the inclusion of community or household experiences. Again, while conceding that indicators and indices are useful assessment tools as they simplify the modeling process and provide results in an accessible format (Dickson et al. 2016), I agree with Dickson et al. (2016) and Jepson et al. (2017) that the current research is yet to offer a gold-standard metrics for measuring water security. Indeed, the available indicators and standards are largely context-based and lack clarity in terms of but not limited to the precision of descriptors, the absence of normalizing evaluation standards, and rationale.

In addition, despite multiple definitions of water security, there is a blurring of focus on how the concept is conceptualized and applied in different contexts, particularly in rural areas (Aboelnga et al. 2020; Bakker 2012; Cook and Bakker 2012; Gerlak et al. 2018; Hoekstra et al. 2018). This lacuna of a standardized definition of rural water security and universal assessment metrics significantly limits policy research to provide empirically sounded models on how households experience water (in)security (Jepson et al. 2017). This paper contributes to the literature on water security by assessing how the concept is considered, articulated, and operationalized within the context of rural areas. The study focuses on water security at the rural level in Ghana by using

household experiences. These experiences were assessed based on several elements that are specifically valid for water security, specifically at the community level. Thus, I contend that from the household's perspective, water security can vary within six-dimensional indicators that map water availability, water access, water safety, water management, community preferences, and sustainability of water resources and systems.

Drawing the analysis from the indicators for the human rights to water and Target 6.1 of the sustainable development goals, this paper argues that context matters when assessing and operationalizing water security. Focusing on experiential rather than the resource-based approach to water security (Octavianti et al. 2021), I further argue that these six-dimensional indicators are valid for enhancing a sustainable supply of water that allows all persons to lead healthy, dignified, and productive lives. While acknowledging that most of these dimensions can be valid for urban water security, I argue that the inclusion of cultural preferences makes this assessment unique for rural water security, considering that indigenous connections with nature are much observed in rural Ghana.

First, I delved into the concept of water security in general by reflecting on the different interpretations of water security and this study's scope. I argue that water security is a multifaceted challenge that hangs on a plethora of dimensions, making it difficult for policymakers to deal with it at different levels (Aboelnga et al. 2019; Grey et al. 2013; GWP 2000). Next, I proceed with the methodological approach for the study. Subsequently, I analyze rural water security based on the six dimensions using cross-sectional survey data from rural Ghana. Based on this analysis, I predict how these six dimensions impact rural water security in Ghana. Finally, I conclude with some recommendations to be kept in mind towards assessing and operationalizing rural water security.

1.1 Defining water security within the study context

Water security takes a central position in changing terminologies of approaches to water management, including integrated water (resources) management, sustainable water (resources), adaptive water management, water risk, water resilience, and the water-food-energy nexus (Dickson et al. 2017; Hoekstra et al. 2018). Despite the multiple definitions of water security, the analytical tools for measurement at the various levels are either absent or are in their infancy (Jepson et al., 2017). In addition, water security assessments are mostly based on scale, discipline, and contexts (Cook and Bakker 2012).

From the 1980s through the 2000s, water security assessment has been evolving (Srinivasan et al. 2017). The earliest definitions have highlighted water security as encompassing seven themes: access, quality, quantity, health, economy, time, and preference (Gerlak et al. 2018). This was, however, criticized as being anthropocentric with no consideration for the sustainability of water resources (Lankford et al. 2013). To address this shortcoming, the Global Water Partnership (GWP) (2000) defines water security, which underscores the need for water not just for human life but also to protect water resources. The addition of water sustainability has helped articulate the inseparability of societal welfare and ecosystems and the need to pay attention to each of these variables in policy decisions (Cook and Bakker 2012; Hassan et al. 2005).

In recent studies (e.g., Aboelnga et al. 2020; UNESCO and UNESCO i-WSSM 2019), water security is defined based on one's perspectives and different contexts, scales, and disciplines. As Dickson et al. (2016) and Gerlak et al. (2018) noted, multiple definitions exist, each reflecting the perspective and purpose of their different applications. In Cook and Bakker's (2012) observation, for instance, whereas some framers assess water security based on the scale of operationalization, others focused on either a narrow or a broader dimension. While Jepson et al. (2017) suggest that narrowing the scope of water security supports the use of precise analytics necessary to untangle the pathways and processes to outcomes, I agree with Bigas (2013) and Cook and Bakker (2012) that while a narrowed focus could do the magic, it may miss out on certain important aspects.

Given this, I adopted a problem- and goal-oriented perspective to conceptualize rural water security by using household experiences to identify valid and relevant factors for sustainable water

supply in rural Ghana. This does not seek to establish a generalized concept of water security but to identify dimensions of the concept that are connected and can serve as indicators for measuring rural water security in Ghana. This context-specific focus can identify specific issues of concern towards the operationalization of rural water security (Cook and Bakker 2012). For instance, as Octavianti et al. (2021) reveal, while challenges related to the quantity of available water may be considered water insecurity in some locations, water insecurity may be associated with water quality challenges in other locations. Furthermore, the type of water insecurity may change temporally or vary by sociodemographic group, emphasizing the need for context-specific assessments.

While there are many framings for water security, this study incorporates the core idea underpinning water security defined by the human right to water and sanitation and the United Nations Sustainable Development Goals (SDG 6). The end goal of this global attention to water is the need to balance human and environmental water needs (Dickson et al. 2016; Srinivasan, al., 2017). Thus, most literature (e.g., Bigas 2013; Disckson et al. 2017; Jepson et al. 2017; Grey and Sadof 2007; GWP 2000; Rijsberman 2006) suggests that experiential approaches to water security at the community, household, and individual levels take into account the variability of water availability, access, affordability, quantity, quality, human needs, and environmental considerations. These variables of water security are also in line with the United Nations' indicators for assessing the human right to water, which include the following dimensions: availability, quality, safety, accessibility, affordability, and protection of ecosystems, among others (Bigas, 2013; United Nations General Assembly Human Rights Council 2010).

However, some of these dimensions of water security overlap, implying that the achievement of one or two can result in other(s) achievement. For example, access and affordability overlap since water acquisition does depend on not only distance and time but also the users' ability to pay for it (WHO/UNICEF, 2017). Water accessibility, therefore, is a proxy for distance, time, and affordability. Similarly, drinking water safety depends on its quality measured by appropriate standards (WHO, 2011). Given this, it is safe to include quality as part of water safety. The study, therefore, summarized four dimensions from the literature definitions of water security, including availability, accessibility, safety, and sustainability of water resources and systems.

Although management is central to water security (Octavianti et al. 2021), it is conspicuously missing from most literature assessments at the community levels (Cook and Bakker 2012). In support of such omission, van Beek and Arrriens (2014) argue that management can best be seen as a means to an end and not as an end in itself. Accordingly, since water security is defined as a goal, conditions and processes should not be included in outcome statements. However, the current crisis associated with water is associated with management failures (GWP, 2000), hence the need to pay attention to management issues in the conceptualization of water security (Cook and Bakker 2012; Octaviani et al. 2021). Since communities vary in their capacity for management, this should be assessed as part of rural water security (Harvey and Reed 2006). This brings management to the fore in addition to the four key dimensions already identified.

Again, the study considers the inclusion of community preferences in assessing rural water security (Goldhar et al., 2013). The current paradigm of developments requires making provisions for the communities' preferences where such developments will take place. Such considerations will help identify religious and cultural beliefs that can affect the impact and usage of water facilities (United Nations General Assembly Human Rights Council 2010). Therefore, community preferences, including perceptions, acceptability, and desirability, remain an essential dimension to consider in assessing household water security (Goldhar et al. 2013). Considering that rural Ghanaians are more connected to nature, including water resources, this dimension is necessary for assessing rural water security. Based on this analysis, this study identified and assessed six main themes as the factors that determine rural water security in Ghana, namely, access, availability, quality, preferences, sustainability, and management.

Finally, the water security debate involves the existence of appropriate universal metrics for measuring the various indicators of household water security (Dickson et al. 2016; Jepson et al.

2017; Thomas et al. 2020). According to Jepson et al. (2017), the development of indicators for household water security has been recent and done mainly by social scientists and public health researchers using a combination of objective and experiential information. Though context matters in terms of indicators for measuring household water security, each study has been based on different assumptions, procedures, and applications. While some studies rely on perceptions to measure indicators, others included objective (albeit limited) proxies for household or individual water security (Jepson et al. 2017). Since this study involves an experiential approach to household water security, the indicator metrics for measurements based on a capabilities approach that recognizes the need of both the households and their local communities to ensure the sustainability of water supply that meet not only environmental but social and economic conditions (Octavianti et al. 2021).

2. MATERIALS AND METHODS

2.1 Study communities

This cross-sectional survey study was conducted over a period of six weeks in three small rural communities in Ghana. The study communities include Esereso and Wabrease, located in the Sunyani West District, and Wioso, found in Sekyere Kumawu district. These two districts are located in the Bono and Ashanti regions, respectively. Following consultations with government officials at the national and local levels, I honed the study districts and rural communities (Dosu, 2021).

Located in the Sunyani West District, Esereso and Wabrease have populations of 420 and 457 people, respectively (Sunyani West District Assembly 2016). Esereso has two handpump boreholes, but only one serves as a primary water source for the community even though it is considered unreliable due to frequent breakdowns. Wabrease, on the other hand, has a handpump borehole, which is over-utilized due to pressures from both community members and non-residents. Wioso is also a rural community with a population of 551 people. Like Esereso, only one of Wioso's two boreholes serves as a primary source of drinking water for the community. The study found that all the study communities have populations beyond the minimum threshold for a borehole. In Ghana, a handpump borehole is to support a maximum of 300 people.

2.2 Sampling, data collection, and analysis

A census approach was employed due to only 276 households in the three communities. Even though the study could not capture all the households, about 57% of participation was achieved. The inclusion criteria for selecting the household study participants included the status as a permanent resident of the study communities within the past 12 months and those with the age of majority (18 years and above) in Ghana (Dosu 2021; Dosu and Hanrahan 2021). The data collection excluded those who declined participation. To overcome the challenge of relying only on household heads as the unit of analysis at the expense of accurate reports on other household members (Jepson et al. 2017), I made an effort to have every household member contribute to the interview process.

Household data were collected cross-sectionally by deploying a common survey instrument to collect information from 158 households, accounting for 847 individuals in total. The survey instrument contained closed and open-ended questions and focused on demographic and socio-economic household characteristics and experiences of water insecurity. The survey questions consisted primarily of binary questions (presence/absence of indicator), water-use assessment questions, and Likert-based responses (Jepson et al. 2017). These dimensions were based on a set of benchmarks (Table 1) that were based on a minimum level of service (rudimentary service) as

prescribed by both national (e.g., Community Water Sanitation Agency [CWSA]) and international standards (e.g., SDG 6.1 indicators), including existing guidelines and technical literature.

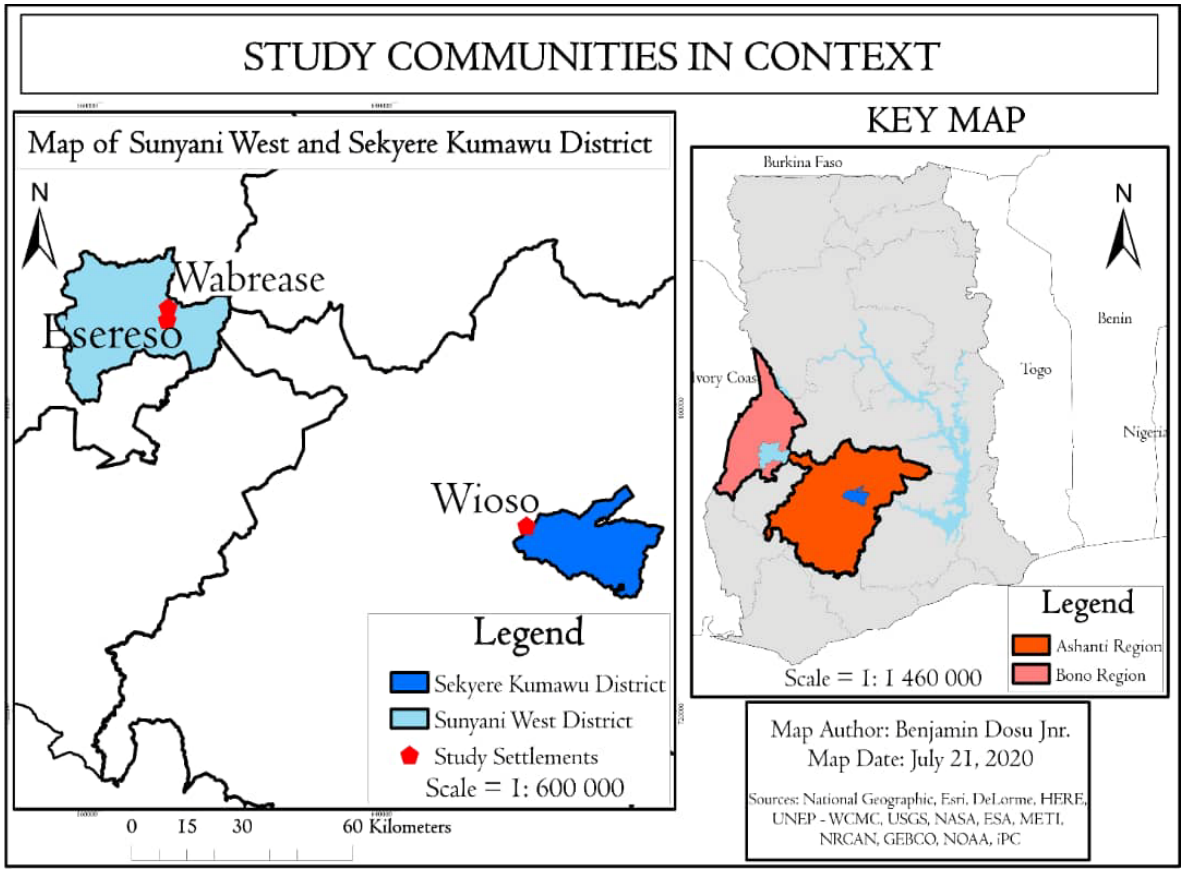

Figure 1. Locations of the study communities.

Table 1. Benchmarks for measuring water security.

Dimension	Indicators	Benchmark
Availability	Daily collection (in liters)	50 ≥ per person per day
Access	Distance (in meters)	≤ 500
	Time (in minutes)	≤ 30
	Affordability	≤ 3% of Household Income
Safety/Quality	Water testing	Twice a year
	Source water protection	Availability of water safety plans
	Water collection	Covered
	Water storage	Protected
	Users' perceptions of color, taste, and smell	Ranked from excellent to very poor
Preference/Desirability	Cultural preferences	Considered/not considered
	Social values	
Management	Participation	Effective/ineffective
	Capacity	
	Accountability/transparency	
	Responsiveness	
Sustainability	Protection of source water	Protected/unprotected
	Protection of water systems	

Source: Modified from National and International Standards

The data were collected in the study participants' preferred language – all members of the research team are fluent in several of the local languages – but the information collected was translated into English for subsequent analysis.

The data were analyzed statistically using IMB SPSS (Version 25) software. Using descriptive statistics, I presented data on the respondents' socio-economic characteristics and water security experiences based on the six dimensions. To overcome the challenges associated with integrating

quantitative and qualitative data to determine the appropriate unit of analysis, I quantified (Zhu and Li 2014) the information using binary questions (presence/absence of indicator) and Likert-based responses.

Using a multiple regression model, I tested the predictability of these six dimensions on households' water security in rural Ghana. To enhance this analysis, I framed each of the nominal variables as dichotomous. Due to fewer cases to measure all the variables, I combined some variables as a single composite unit (Tabachnick and Fidell 2013).

The outcome variable (water insecurity index) was obtained by rating (in percentages) how the six dimensions of water security can contribute to water security. The participants' ratings were in percentages (0-100%) where 0% and 100% represent highly water-secure and highly water insecure, respectively.

The multiple regression model linking the set of regressors (dimensions of water security) to the outcome variable (water insecurity) is obtained by the regression equation:

$$\hat{Y} = B_0 + B_1X_1 + B_2X_2 + ... + B_p X_p \quad (1)$$

where $\hat{Y}$ is the observed value of the outcome variable (water insecurity), B_0 is the intercept, B_1 is the regression coefficient, and X_1 to X_p represents the independent variables (IVs). Using the survey data, I model water insecurity (WI) (outcome variable) as a linear function of access, availability, safety, preferences, sustainability, and management (six regressors). The multiple regression equation that models water insecurity for this analysis is:

$$\text{Water Insecurity} = B_0 + B_{1\,\text{access}} + B_{2\,\text{availability}} + B_{3\,\text{safety}} + B_{4\,\text{preferences}} + B_{5\,\text{sustainability}} + B_{6\,\text{management}} \quad (2)$$

3. RESULTS

In this section, I present the results of households' water security experience in the study communities. These results are presented based on six main water security themes: access, availability, quality, preferences, sustainability, and effective management (Table 2).

3.1 Water availability

For a resource-based approach to water security, water available takes accounts of different forms, including water stress indicators, assessment of ecological or environmental factors, and evaluating "blue-green water" availability (Octavianti et al. 2021). However, the assessment of water availability for this study was based on three indicators, namely the temporal physical presence of water at a water point (reliability), the flow rate of water into the container, and quantity in litres per capita per day (LCD) collected from the water point (Majuru et al. 2012) to meet the required domestic water need. This assessment involves the difference between the quantity of water required per day based on the stipulated standards and the quantity collected by households (WHO 2011). This constitutes sufficient water for personal and domestic uses, which ordinarily include drinking, personal sanitation, washing of clothes, food preparation, personal and household hygiene. Overall, 50 litres of water per person per day is required to meet the most basic and domestic needs, and few health concerns may arise (WHO 2011). This means that the water requirements for every household involve the required litres multiplied by the number of persons in the households.

The study reveals that less than half (35%) of the population can meet the required 50 litres per capita per day for at least 95% of the time throughout the year. Factors such as dried boreholes and streams and frequent water facilities breakdown account for households' water unavailability to meet their basic consumption requirements, food preparation, cleaning, and laundry.

Table 2. Characteristics of water security experience of the study households using the assessment indicators (N=158)

Dimension		Measurement	Percentage	
Availability and Reliability	**Availability**	< 50 litres	64.6	
		50 litres	17.7	
		> 50 litres	17.7	**100**
	Reliability	Very Poor	12.0	
		Poor	38.6	
		Good	26.6	
		Very good	14.6	
		Excellent	8.2	**100**
Access	**Distance in Meters**	< 1000	53.8	
		1000	16.5	
		>1000	29.7	**100**
	Time in Minutes	0-30 mins	24.1	
		> 30 mins	75.9	**100**
	Percentage of expenditure on income per month	< 3%	54.4	
		3%	6.3	
		> 3%	39.2	
Safety	**Perceptions based on organoleptic properties**	Excellent	23.4	
		Very good	34.2	
		Good	20.3	
		Poor	15.2	
		Very Poor	7.0	**100**
	Overall perceptions of water safety	Safe	28.5	
		Unsafe	71.5	**100**
Management	**Capacity**	Existence of rural capacity	19.6	
		Lack of rural capacity	80.4	**100**
		Effective	16.2	
		Not Effective	83.8	**100**
	Participation	Participate		
		No participation		**100**
	Accountability	Accountable	18.4	
		Not accountable	81.6	**100**
	Responsiveness	Responsive	29.7	
		Not responsive	70.3	**100**

As part of water availability, the study assessed the perceptions of drinking water reliability based on the ability of the drinking water source to provide water for at least 95% of the year, which is interpreted as 347 days without interruption (Adank et al. 2013). Based on this assessment, more than half (60%) of the households rated their current water supply as poor and very poor. The water supply is usually interrupted during the dry seasons, where both the borehole and the alternative streams dry up. Some of the household coping strategies during water scarcity include relying on unmonitored water sources, collecting water from nearby communities or towns (usually tedious and expensive), and reducing water usage. Water from unmonitored sources is usually not treated before consumption.

3.2 Water access

Access is defined as the distance and time covered to collect drinking water from the source (physical access/coverage) and means of acquiring it (affordability) (WHO/UNICEF 2017; WHO 2011). Even though Dickson et al. (2016) identified additional factors such as ease of operating water facilities and the physical ability of water collectors, the assessment of water accessibility in this study considers the users' ability to pay for water, the distance covered for water collection, and the time traveled to retrieve water, including waiting time. According to the WHO/UNICEF Joint Monitoring Program (2017), drinking water can be considered basic to households when such water is from an improved source. The collection time should not also exceed 30 minutes for a round trip, including queuing. However, limited water service exists when the average collection time exceeds 30 minutes, including waiting time. In addition, the CWSA guidelines recommend a maximum of

500 meters, which is translated as a 1000 meters roundtrip to access a handpump borehole in rural Ghana.

Even though none of the households has optimum access (when the facility is within the yard), the study reveals that not all households (30%) are about to meet the basic distance required for water collection from improved sources. Despite meeting the basic distance requirements for water collection, only about a quarter (24%) of the households can collect water within 30 minutes, including commuting and queuing time (Table 2).

Most of the study households (61%) prefer to collect water at dawn and in the evenings to prepare for the day, and meal preparations and washing, respectively. Households spend an average of 108 minutes, covering 975 meters per round trip on the average for water collection. With an average of five trips per day to meet the water requirements of five people per household on average, about 7 hours are spent on water collection activities each day. This could be more, considering that almost half (46%) of the households spend more than five trips for water collection daily, covering about 4 kilometers on average.

The study assessed the percentage of households' water expenditure on monthly income in addition to distance and time. The WHO/UNICEF Joint Monitoring Program (2017) recommends that water costs should not exceed 3% of household income. The study reveals that about 40% of the households spend more than 3% of their monthly income on drinking water. This includes the cost of transporting water, particularly for households who use motor vehicles. The cost of water acquisition discourages people from using water from improved sources.

3.3 Water safety

The water required for personal and domestic use must be safe. Even though the WHO guidelines recommend assessing physical, biological, chemical, and radiological contaminants that pose risks to human health as proxies of water safety, only the physical component and the capacity to protect the other components were assessed in this study. Given this, the study adopted three main approaches (Dickson et al. 2016; WHO 2011). First, the study assessed local water managers' ability to protect water sources from contamination and conduct water quality testing twice a year (during the dry and rainy seasons) as stipulated by the CWSA guidelines. This also includes the existence of water safety plans, such as source water protection (SWP) and the application of a disinfectant, such as chlorine (Dickson, 2016). Due to the limited or lack of local capacity, there are no commitments to water quality testing. Besides, there are no water safety plans to protect water sources; hence, this has been left at the mercy of community bylaws without proper enforcement mechanisms.

Second, the study assessed users' perceptions of water quality based on organoleptic properties, including appearance, taste, and smell. The study participants rated their perceptions of drinking water sources based on these properties. The study reveals that less than a quarter (23%) rated the drinking quality as either poor or very poor (Table 2). The household interviews reveal that water quality perception is based on these three components, with no considerations for chemical or biological compositions. Further, community water users complain about water quality only when the water's appearance, taste, and smell are compromised. The users' poor perceptions about these physical properties can affect the water consumption.

Finally, since water can be contaminated through haulage and storage, the study identifies how water is collected and stored. These include whether water is covered during collection or storage, how long water is stored, and the safety of water collection containers. Apart from those who use *Kuffour gallons* (usually required to be covered before transport) to collect water, none of the participants cover water containers during water haulage. Besides, only about a quarter of the study participants cover water containers during storage. Since all the participants do not have an on-

premises water facility, it is difficult to collect more than enough water than required; hence, water is not stored for long. The maximum number of days for water storage before refilling in most households is three days.

Based on these three factors, the study participants ranked their perceptions of the overall water quality using a dichotomous response. More than two-thirds (72%) of the study participants rate their drinking water as unsafe to use (Table 2).

3.4 Community preferences and desirability

Understanding the preferences and perceptions of rural water users is another consideration that should be factored in when assessing a household's water security in rural areas. Aside from the cultural considerations, community preferences and perceptions can include recognizing traditionally marginalized groups, mutual respect, common goals, and legitimacy of authority. However, this study responded to the cultural appropriateness involving the use of rural water resources and the provision of rural water infrastructure (Dickson et al. 2016; UNDESA 2014). This was informed by rural indigenous relationships with natural resources, which require consideration to such indigenous cultural values and beliefs when providing water facilities and services (Jiménez et al. 2014). Therefore, factors such as taboos, myths, and customs and how these are incorporated into water management decisions were considered indicators for cultural preferences and desirability.

The assessment reveals that all the study communities have cultural practices that are connected to water, particularly from surfaces. For instance, water users are banned from going near water bodies on certain days. These include Tuesdays in Esereso and Wabrease and Fridays in Wioso. The study communities also consider farming activities near water bodies as taboo. In addition, visitors in Esereso require the assistance of a community member to seek permission of the stream before they can go near it.

Given this, the study also assessed the consideration of water users' cultural preferences community-based water management practices. The participants were asked to indicate whether existing cultural norms and values are considered during water management, particularly on projects implemented by external water managers. The study reveals that for most participants (68%), their preferences are considered in drinking water management (Table 2).

3.5 Sustainability of water resources and systems

Sustainability in rural water security involves whether water resources and infrastructure continue to meet the users' requirements over time. Given this, two proxies were used for sustainability, including system and resource sustainability. For water resources, the assessment was based on how both ground and surface water sources are sustained and prevented from depletion and pollution. Proxies used for water resource sustainability include the existence and enforcement of pollution control measures. The study reveals that the only measures that protect water resources are the poorly enforced community bylaws. Even where a community can put enforcement mechanisms to protect surface water sources, the respondents pointed out that difficulties still exist regarding enforcing such bylaws in neighboring communities that share the water sources. Accordingly, more than half (56%) of the study participants rate their water resources as either unsustainable or highly unsustainable (Table 2).

For water infrastructure, the study measured sustainability based on a borehole's ability to provide an indefinite water service with certain agreed characteristics over time. Even though no internationally agreed indicators exist for measuring the sustainability of rural water supply systems, Adank et al. (2013) note that this is usually affected by a range of factors that contribute to

the service's likelihood to be provided over time. The study reveals that factors such as limited financial, institutional, and managerial capacities affect the extent to which the water facilities can provide users' water needs over time. This was reflected in the participants' responses, where only 9% perceived their water facilities as highly sustainable.

3.6 Water management

The current challenges of household water security have been associated with management failures. Accordingly, the study assessed how rural water management affects water security. To assess water management, this study employed proxies such as community engagement, responsiveness, accountability, and rural capacity, including institutional (e.g., legislation, policies, institutional framework, administrative structures), financial (e.g., community resources, household income, proper financial management, water payment), human resource (e.g., skilled personnel, training operators), social (e.g., external support), and technical (e.g., water monitoring plans) (Dickson et al. 2016; Harvey and Reed 2006).

These proxies were assessed based on their existence and effectiveness in operation. Based on this assessment, over 80% of the study participants rated these dimensions are either limited or unavailable for effective rural water management. Given this, only a quarter (25%) of the study participants believe that the community-based water management approach is effective.

3.7 Predicting water insecurity using Multiple Linear Regressions

By pooling reported experiences of water security/insecurity derived from the six defined dimensions, the data collection gathered a set of 18 experiences of water security/insecurity. To establish how these dimensions are associated with rural water insecurity, this section uses a multiple regression model to predict the influence of these dimensions on rural insecurity.

I conducted a simultaneous multiple regression analysis with the frequency of water insecurity as the dependent variable and water access (Acc), water availability (Av), water quality (Qty), consideration of preferences (Pre), sustainability (Sus), and effective management (Mtg) as the independent variables. The means, standard deviations, and intercorrelations can be found in Table 3. No univariate or multivariate outliers were observed.

Table 3 also displays the unstandardized regression coefficients (*B*); the standardized regression coefficients (β)*;* the semi-partial correlations (sri^2)*;* and adjusted R^2. *R* was significantly different from zero, F (6, 157) = 37.5, $p < .001$. All the variables contributed significantly to prediction of rural water insecurity, access (sri^2 = .08), availability (sri^2 = .08), quality (sri^2 = .04), preferences (sri^2 = .06), sustainability (sri^2 = .04), and management (sri^2 = .09). Overall, 58% of the variance in rural water security is explained by the six dimensions of water security (independent variables). According to Cohen (1988), this is a large effect. This means that there are smaller differences between the observed data and the fitted values.

Table 3. Simultaneous multiple regression of water security dimensions on rural water insecurity

Variable	WIN (DV)	Acc	AV	Qty	Pre	Sus	Mgt	URCs (B)	SRCs (β)	sri^2
Acc	-.22							-12.9**	-.281	.08
Av	-.35			.16*				-14.1**	-286	.08
Qty	-.55						.70**	-16.7**	-.334	.04
Pre	.20							9.4**	.195	.06
Sus	-.22			-14*				-13.5**	-298	.04
Mgt	-.51							-15.3**	-.298	.09
Means	58.58	.58	.30	.28	1.32	.47	.24			
SD	22.71	.50	.46	.45	.47	.50	.44			

*Constant 72.56; R = .77; Adjusted R^2 = .58; F (6, 157) = 37.5, *p < .05; **p < .001*

4. DISCUSSION

Achieving rural water security constitutes a major challenge for policymakers, if there is no basis for defining and operationalizing the concept. This study shows that, for rural water security to be achieved, it is important to consider context-specific factors, which according to the results, include availability, access, quality, preferences, sustainability, and management.

Water management is a significant bottleneck to achieving drinking water security in most developing and even some developed countries (de Boer et al. 2013). According to UNESCO (2006), water management constitutes the main challenge to the current water crisis and not water supply or technology. Therefore, good management is necessary and is one of the highest priorities of practice for achieving drinking water security at the community level (Cook and Bakker 2012; Rogers and Hall 2003). It provides the vehicle for other variables to operate towards achieving rural water security. For example, accessibility, availability, and water quality will not have a bearing on the individual's water security experience if they lack the means to manage the water resources and infrastructure, signifying the importance of management in water security analysis.

Interestingly, the study results show that effective management is the dimension with the highest unique contribution to water (in)security. The study reveals that a change in effective management could potentially result in a significant decrease in rural water insecurity. Lankford et al. (2013) noted that effective management focuses not only on the presence of policies and institutions in enhancing people's access to safe water, but also on building the capacities of the beneficiaries to ensure effective contributions to the provision and management of drinking water. However, this study reveals that factors such as limited rural capacity, poor participation, unresponsive and unaccountable water managements constrain the effectiveness of community-based water management in rural Ghana.

Aside from water management, water resources and systems' sustainability is another dimension with the highest coefficient contribution to rural water security. The contribution of sustainability is high because it is the only dimension that pays attention to water resources and water infrastructure. Neither of them means that it is impossible to achieve each rural water security dimension. Sustainability in rural water security involves whether water resources and infrastructure continue to meet the users' requirements over time (Lockwood and Smits 2011). While sustainability is considered vital to achieving rural water security, the results of other researchers suggested poor attention is paid to such an indicator. Lockwood and Smits (2011), for instance, estimate that just a little over one-third of handpump boreholes function in most rural communities in sub-Saharan Africa. Similarly, Harvey (2004) found that depletion of groundwater levels in weathered aquifers coupled with an insufficient recharge of fractured aquifers have resulted in dry boreholes in most rural communities in Ghana. Unsurprisingly, most of this study's participants rated their water resources and systems as either unsustainable or highly unsustainable.

The study results established that limited rural capacity affects the extent to which water resources and infrastructure are sustained in rural Ghana. The sustainability of water resources always ensures its availability to meet users' demands and supplies. As the results reveal, water security achievement depends on the availability of water flow to meet households' needs. However, this is not the case in the study communities as almost two-thirds (65%) of the households cannot meet the minimum required water of 50 litres per person per day, necessary for personal and domestic uses. The study reveals that water flow is unreliable due to the frequent breakdown of water facilities as well as insufficient recharge of aquifers during the dry season.

Even though unmonitored water sources can supplement the unavailability of improved water, this study found a positive correlation between water quality and availability. This finding suggested that water users are not only interested in quantity but also in the quality of drinking water available for use. The study results also show that water quality has the highest coefficient contribution to water security, implying that improvement in water quality will result in a significant decrease in water insecurity. According to the WHO (2011), for water to be considered safe, it must be free from micro-organisms, chemical substances, and radiological hazards that can

pose threats to a person's health. Safe water should be of acceptable color, odor, and taste and must strictly follow national and/or local standards for recommended either personal or domestic use. However, this study found that households in the study communities rely on unsafe water to meet their daily needs. Even though no chemical test was conducted, the study found that water quality is compromised due to poor water monitoring, unsafe water haulage, and poor water storage. Besides, this study found that most households (72%) have bad perceptions about their drinking water quality.

Water access constitutes another critical consideration for defining rural water security. The availability of the right quantity of drinking water is meaningless if households do not have access. Access is defined as the distance and time covered to collect drinking from the source (physical access/coverage) and means of acquiring it (affordability) (WHO/UNICEF 2017; WHO 2011). As in other studies, this study found that rural households cannot boast having access to water considering these three factors. Although most households (70%) meet the prescribed basic distance required for water collection, there are those (30%) who travel more than a kilometer per trip for water collection. Surprisingly, only 24% meet the basic requirement of 30 minutes for water collection. This figure extends to about 844 million people worldwide who cannot meet prescribed basic water services (WHO/UNICEF 2017).

Aside from distance and time, communities' ability to afford water influences their uses of water and the choice of water sources. This study found that the households' inability to pay for water has two main effects: relying on unmonitored water sources and reducing the quantity of water consumed. Either way has implications on good sanitation or poses a significant health risk (WHO/UNICEF 2017).

Finally, it is necessary to factor in rural water users' preferences in operationalizing community water security (Daemane 2015). In this regard, most households contended that their cultural preferences are considered in the provision and management of rural water. The study found that this is attributed to the community-based water management that allows their people to be in charge of water management. This is one significant benefit of community-based water management since the water managers are from the community and understand their communities' social and cultural contexts. Generally, all respondents in the study communities deemed these practices and beliefs as efficient and effective in regulating the use of available water sources; hence, the need for their integration into formal interventions and policies.

In addition, the United Nations posits that all drinking water facilities and services must be culturally appropriate and sensitive to gender, lifecycle, and privacy requirements, without which beneficiaries may not participate (UNDESA 2014). Incorporating societal values into the provision of water facilities and services not only contributes to the use of such services but also solicits community support and participation in planning, implementing, and managing such facilities. In cases users' preferences are not considered in providing water services, consumers tend to rely on alternative sources for their water needs, including unmonitored sources or purchasing from expensive sources (Goldhar et al. 2013). In order to meet the preference of communities in providing drinking water services, the location of water facilities, the color, and taste of water should be factored into the design and implementation of such water facilities and services.

5. CONCLUSION

This paper has shown that rural water security encompasses contextual and multifaceted dimensions that not only constitute meeting the needs of water users, but also the sustainability of water resources and infrastructure. This means that operationalizing household water security should go beyond the anthropocentric focus to include water resources and infrastructure protection.

The study has also shown that water users require their water sources to meet the conditions of acceptable quality, accessibility, and domestic requirements for drinking, food preparation, basic sanitation, and hygiene. In addition, they expect not just effective water management that involves active participation, capacity building, accountability, and responsiveness, but also the management

approaches that respond to their preferences and enhance water resources and infrastructure sustainability. Failing to achieve this can result in a community's or a household's reliance on other alternative water sources that are usually unmonitored.

Even though this study's findings have shown that these six dimensions matter when defining rural water security, context matters when determining how water security is defined, articulated, and operationalized. The context consideration goes beyond just considering a particular community's political, socio-cultural, economic, and environmental factors to include water users' actual experiences. Given this, policy decisions and policy implementation should consider the context-specific information of community members. This can result in two potential outcomes. First, context-specific consideration can assess the actual, rather than the assumed, experiences of a particular community to enhance their water security. This represents a move away from the generalized decentralized water management approach for rural water management in Ghana. In addition, context considerations can identify certain socio-cultural variables that can serve as potentials to maximize opportunities for rural water management. For instance, the application of cultural considerations may depend on a particular context. Even though cultural considerations are vital to water management decisions in the study communities, this may not work in different communities.

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