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Social Aspects of Groundwater Use and Management in the Wa West District

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abstract

Despite the relevance of groundwater to the rural safe drinking water needs, inadequate description of its distinctive social aspects in the policy documents and empirical literature makes it difficult to assess its specific contribution towards the achievement of policy targets. This paper used a mixed research design to assess the social aspects of groundwater use and management in the Wa West District of the Upper West Region of Ghana. Findings indicated that boreholes and dug wells constituted the major forms of water infrastructure in the study communities. There is an implicit stakeholder framework for the governance and management of groundwater but hardly noticed, as they do not deliberately separate groundwater from surface water governance. Accessibility and affordability were close to meeting policy and standard expectations on average, but quantity of groundwater use fell below the acceptable level attributable to factors such as household size and water storage container size among others. Socio-cultural factors such as the use of open dump sites and unregulated construction of graves and pit latrines negatively impact on groundwater security. This study recommended the education of communities and promotion of community participation as strategies of addressing any identified challenges of groundwater use and management.
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Background of the Study

Over 95% of people in developing countries depend on groundwater as a source of safe water (Denis, 2014), which is used together with other sources of water in domestic, industrial, commercial, and agricultural activities, and contributes to poverty reduction through the livelihood opportunities associated with these activities (Bukari, 2017). This explains why the social aspects or characterisations of groundwater use and management are essential for ascertaining the typical socially functional requirements. In a study on social aspects of small water systems, Flora (2004) and Grigg (2016) cited accessibility, cost, paying for the services, safety, reliability, social justice, empowering women and flexibility aspects, and the relationship between these and the social, political, and economic settings in which those who manage and use the water systems operate as determinants of the effectiveness of the social aspects. According to Grigg (2016), although social aspects of water are not well defined, they represent the conditions that create connections between people and water.

Thus, with a focus on the social aspects of groundwater use and management, this study aims at recognising groundwater as part of life in society, developing structures in terms of social classes for its management, and how these mould adaptive behaviours to meet expectations in groundwater accessibility and use (Jensen, 2017). It also includes the effects on supporting human life, their influence through social feedback on human well-being and the development of human social organisations for the management of groundwater resources and use (Zening, Danvang, Cuimei & Huiliang, 2019). This study focused on groundwater related policies and institutional frameworks for performing various management roles, infrastructure, accessibility, affordability, and contribution to the well-being of rural households.

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According to Beeferman and Wain (2019), cited in Miller (2021), infrastructure is about facilities, structure, equipment, or similar physical assets, and the enterprises that employ them to people having the capabilities to thrive as individuals and participants in social, economic, political, and other roles in ways critical to their own well-being and that of their society. Thus, in the social aspects of groundwater as a premise of this study, attention is on the basic groundwater infrastructure in the study communities, specifically boreholes with hand pumps for the abstraction of groundwater to satisfy the socio-economic wellbeing of rural households.

Accessibility to water refers to the existence of sufficient water to meet domestic needs, when it is available and close to households, and does not require more than 30 minutes of walking time to get to the drinking water source (Garriga, 2012; WHO & UNICEF, 2015). Access to water is described as reasonable when it is within 1km of walking distance and 20 litres of it is available to each person per day in a defined spatial unit (World Health Organisation [WHO], 2023). About 74% of global population has access to safely managed water, while two billion people still lack access to safe water (Kashiwasi & Fujs, 2023). In 2014, groundwater provided 49% of the domestic water needs of the global population and around 43% of all water used in irrigation (Rodella, Zaveri & Bertone, 2014). Of the 41% of Ghanaians who depend on groundwater, 59% is rural and 16% is urban (Business and Financial Times, 2022).

Also, affordability of metered water with rigorous tariff payment (groundwater or surface water sources) through piped water systems favours urban households in terms of ability to pay (60%), compared to rural households' ability to pay (32%) in northern Ghana (Bukari, 2017). However, in groundwater resource management, not enough is known about payment and affordability of water from rural groundwater point sources such as boreholes with hand pumps, as these are mostly unmetered, provided by various stakeholders as donor funded, and so no rigorous tariff payment (Bukari & Aabeyir, 2022).

Several studies have been conducted on the characterisation of water services, but there are still empirical gaps. For instance, Flora (2004) studied the social aspect of small water systems and emerged with a pyramid of social control. However, apart from a lack of focus on groundwater, an elaboration on the socio-cultural practices that negatively impact on water and the associated standard regulations and managerial gaps remain a niche. Grigg (2016), also examined the social aspects of water management, but his focus was on collective action in water service management rather than groundwater issues. In Ghana, Bukari et al. (2023) investigated water technologies in the Lawra Municipal and Nandom Districts of the Upper West Region of Ghana, but their study was not focused on groundwater, but rather general water, sanitation and hygiene technologies and the activities of the non-governmental sector in the provision of such infrastructure, which satisfies the 'enterprise' component of the definition of infrastructure provided by Beeferman and Wain (2019). Adank et al. (2013) also investigated the status of rural water services in Ghana, and identified mechanised boreholes, hand pumps and dug wells as rural groundwater point source infrastructure. But this was in a broader context of rural water infrastructure and lacks focus on detailed characterisation of groundwater use, management and livelihood outcomes to inform groundwater policy specifics, requiring further research in that aspect.

In general, whereas mainstream literature is replete with information on the spatial, geological, and physico-chemical aspects of groundwater, not enough has been covered on the social aspects, creating a research niche in that regard.

Objectives of the Study

The objectives of this study were to describe:

a. The nature of groundwater infrastructure in the rural communities
b. Groundwater governance and management in the rural communities
c. Accessibility of groundwater
d. Affordability of groundwater
e. Livelihood outcomes of groundwater use

The paper is structured to achieve these objectives by a background statement, conceptual framework, research methods, discussion of results and conclusions.

Conceptual Framework

Figure 1 elaborates the social characterisations of groundwater in terms of independent factors such as the institutional frameworks for groundwater management and governance, infrastructure, and policy contexts, which collectively account for the outcomes, as the dependent factors.

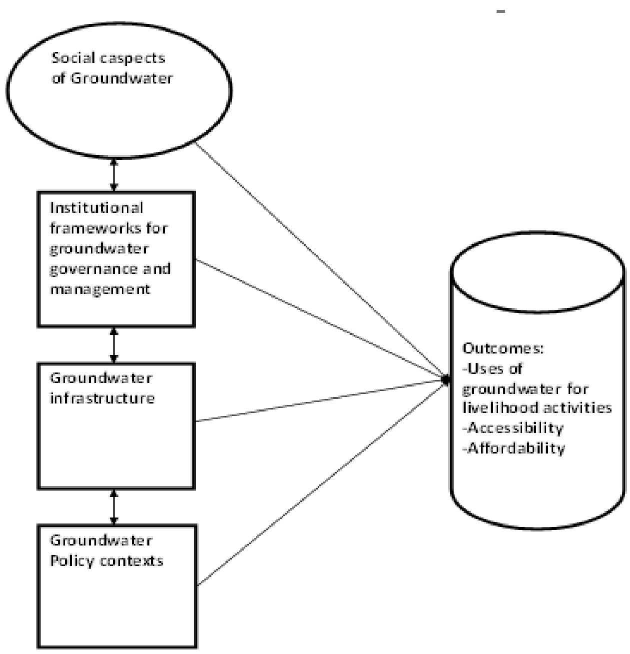

Figure 1. Conceptual framework of social aspects of groundwater use and management.

Figure 1 shows the linkages between the various aspects of social characterisations of groundwater. How the governance and management of groundwater resources in conformity with policy provisions is achievable by an institutional framework and the effectiveness of their roles were ascertained in this study. Previous research findings on these aspects by Bukari et al. (2023), were about the role of stakeholders in Ghana's water sector in general, and not only groundwater. This study prioritised only institutions that are relevant to groundwater management.

In terms of groundwater infrastructure, Adank et al. (2013), Bukari and Aabeyir (2022), and WHO and UNICEF (2015) among several others identified mechanised boreholes, hand pumps and dug wells as rural groundwater point source infrastructure, but these studies covered a wider scope rather than focusing on rural groundwater infrastructure and their distinguished characterisations, requiring further research in that aspect.

In the policy context, the practical implementation of the MDGs and SDGs referred to basic and limited water services (WHO & UNICEF, 2015; Wang, Zhu, Liao, Manga & Wang, 2019).It was concluded from the review that apart from the infrastructural facilities for the various services which show implied linkage to surface water (through tap systems) and groundwater technologies (through boreholes), no adequate coverage on groundwater was made in the water policy documents(Wang, Zhu, Liao, Manga & Wang, 2019).In this study, relevant targets of SDG 6, and the National Water Policy of Ghana were recalled, and compared to existing groundwater management practices to ascertain gaps between policy and practice.

Figure 1 shows the outcomes as the dependent variable component of the conceptual framework. It further shows that this study also accessed the effectiveness of groundwater governance and management, infrastructure, and policy implementations as independent variables, which influence the outcomes, such as groundwater use for livelihood activities, accessibility, affordability, and challenges. In terms of water use, Baguio Water District (2016), asserts that the uses of water from various sources depend on the category of consumers, such as residential, government and commercial. As this paper targets rural households with basically residential uses, WaterAid (2012), lists examples of such uses to include drinking, bathing and other hygiene related uses, cooking, sanitation, and gardening, which mark the primary livelihood activities of households. The study also covered the accessibility of groundwater points (by distance and waiting time at the water points); and affordability (water pricing and ability to pay). The study also ascertained the challenges associated with groundwater governance and management. Thus, issues such as deep and confined aquifers and drilling outcome, dry well situations in the dry season, among others, which informed the recommendations made in this study to address them.

Materials and Methods

This section describes the methods, techniques and procedures used to conduct the study.

Research design

The concurrent triangulation mixed research design was used. It comprises the use of quantitative and qualitative methods and approaches transversally, and epistemologically dictated by postpositivism in terms of philosophical orientation. This was by adopting the philosophical positions of objectivism and subjectivism to reality, in the measurement of research results, involving the application of quantitative and qualitative methods concurrently. The quantitative approach involved the collection of data and presenting them in quantitative forms such as numbers, percentages, tables, and graphs. Close-ended questions were set in structured interview guides for households and questionnaires for institutional officials.

The qualitative approach involved the methods used in collecting and expressing data in non-numerical forms or in words. These were presented through quotations, narrations, descriptions, tables, maps, and pictures. Qualitative data were obtained from questionnaires with open-ended questions for formal sector institutional respondents, focus group discussion guides for CWSMBs and observation checklists for physically observable phenomena, such as cultural practices that pollute groundwater.

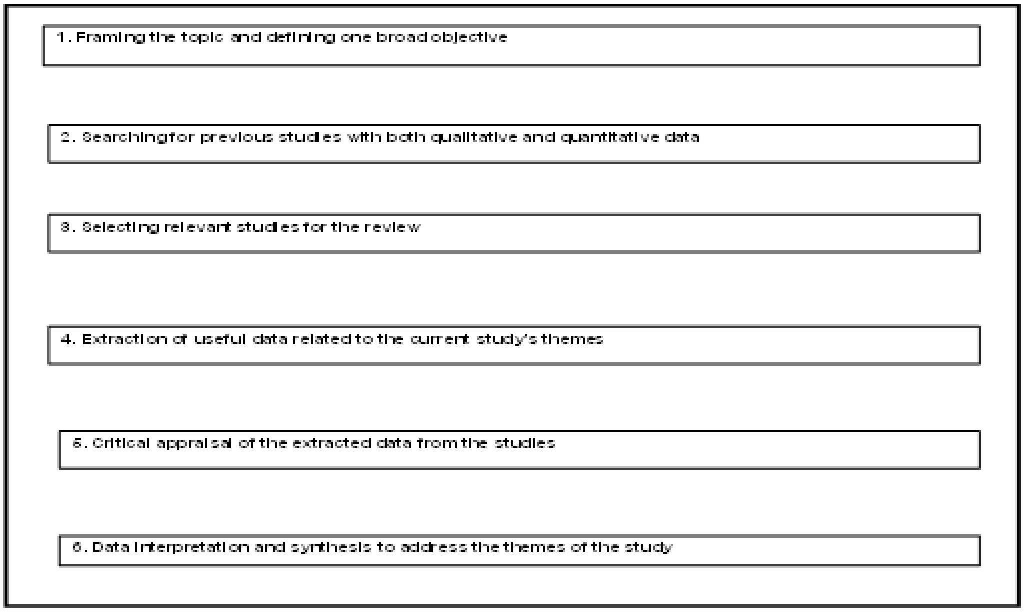

Figure 2. Systematic review process

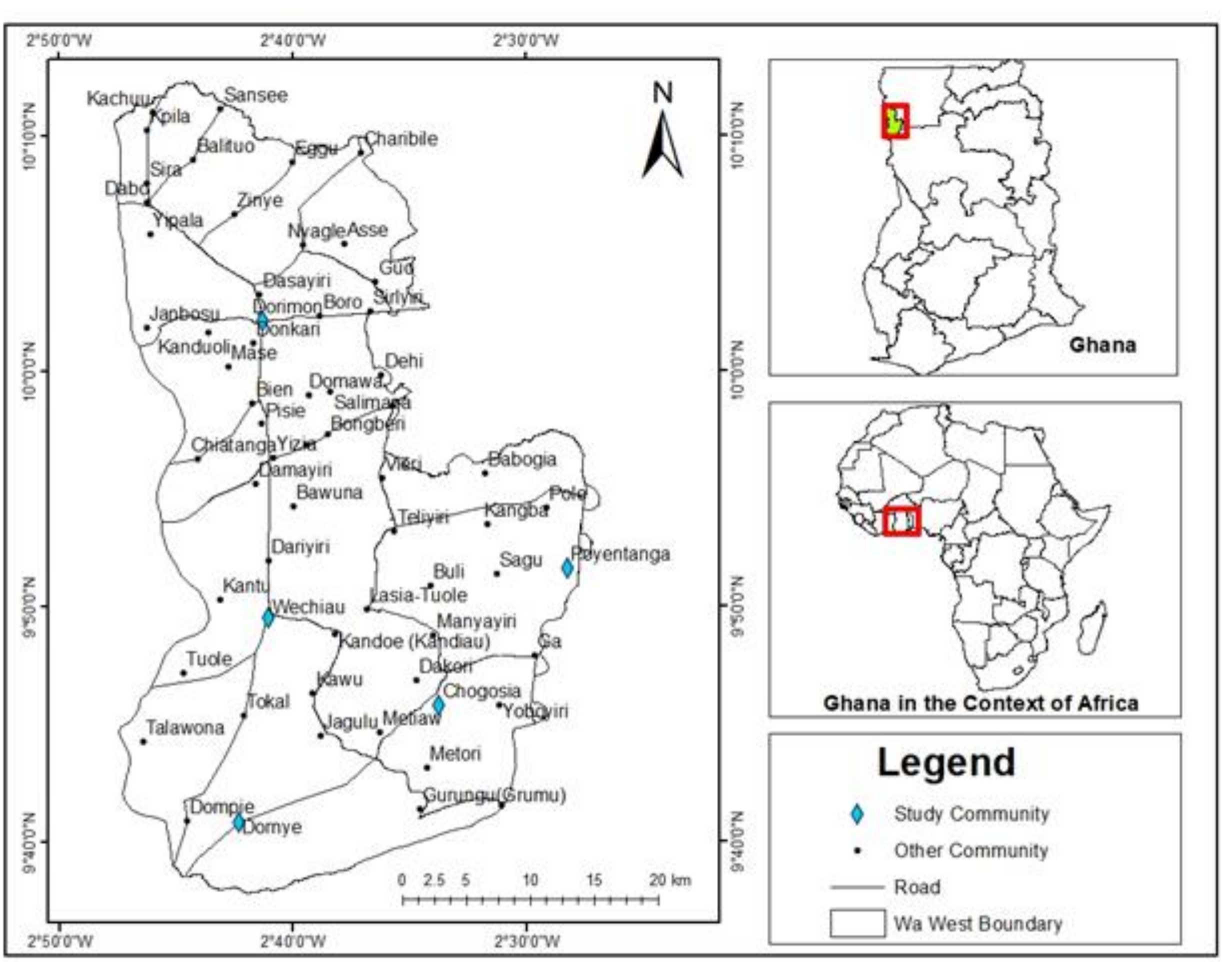

Figure 3. Study communities in the Wa West District Context

Inclusivity criteria for secondary data and literature

Literature review was done using the systematic review method, illustrated in Figure 2. By this, relevant literature was reviewed using published articles, books, and other internet sources. The selection criteria involved choosing documents that were relevant to the objectives of this study, credible in terms of academic peer reviewed articles, textbooks, and published student theses. In the case of secondary data, desk review of relevant and genuine institutional reports in hard copies or published on the internet via websites were used. At least, 85% of all sources cited were not more than a decade old.

Selection of relevant texts for literature from the internet was aided using the Boolean search terms. By this, combined keywords related to the specific research objectives, using AND, NOT and OR as operators were used in the online search to generate the required literature for further interpretation and synthesis (Bukari et al., 2023).Examples of search terms used in this study were the uses of groundwater, groundwater governance and management in the rural communities, accessibility of groundwater, affordability of groundwater, and livelihood effects of groundwater use. Both primary and secondary data sources were gathered and analysed based on these thematic areas or search terms woven around the research objectives.

Sampling

Given limited resources and time, convenience sampling was used to select 5 communities of the Wa West District for this study. In other words, the researchers considered the proximity, existence of boreholes with hand pumps, relevant institutional structures for the management of the boreholes and for providing relevant information, flexibility of language selection for the data collection process and expressed willingness to participate in the research (see Nikolopoulou, 2023), which were assessed by reconnaissance survey. The locations of the communities are shown in Figure 3. Table 1 specifies the communities and their settlement status.

Table 1: Selected Study Communities

SN	Communities	Settlement Status
1	Wechiau	Peri-urban
2	Dornye	Rural
3	Dorimon	Rural
4	Poyentanga	Rural
5	Chogsia	Rural

Sample frame and sample size

The sample frame included the households that used boreholes in the five selected study communities. This means the study was not based on using the total population of the study communities. Instead, cross-sections were taken based on observed location of boreholes fitted with hand pumps. At the stage of reconnaissance, cross-sections of the study communities were determined based on the availability of boreholes and other factors listed earlier as the basis of convenience sampling. The population sizes of these cross-sections within the larger study communities were not known. Consequently, we estimated a sample size for the study population in the five communities using the formula below (see also, Subramaniam, 2019):

$$\text{Sample size (n)} = \frac{t^2 x p(1-p)}{m^2}$$

Where n = required sample size
t = Confidence level of 95% was chosen (standard value = 1.96)
p = Estimated prevalence of households depending on boreholes with hand pumps (best decision is 50% or 0.5)
m = Margin of error of 5% was chosen (standard value = 0.05).

Therefore, $$n = \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2}$$

= 384

The sample size of 384 was rounded off to 400. It was rounded off because the 384 only indicates that it was the minimum number of people as a sample size for accuracy and normality of research results, but the larger the sample size, the more accurate the results would be (Branner, 2007). The figure of 400 also made it possible to be divided equally among the five study communities, giving 80 household respondents for each study community indicated in Table 2. For each community, the location of the community borehole with hand pump was selected and 80 structured interview guides with close-ended questions administered to household respondents who were 18 years or older. One respondent was selected from each of the sample size of 80 houses depending on the borehole as a source of water. The houses were selected accidentally, and once in each house, the first household member met who qualified as a sampling unit was selected (accidentally) for interview after the purpose of the interview was explained and permission was sought. Members of the same household as the respondent could join.

Other elements of the target population were the leadership of the Community Water and Sanitation Management Boards (CWSABs), Hydrologist of the Community Water and Sanitation Agency (CWSA), Community Development and Works Department Officers of the Wa West District Assembly, an Environmental Health Officer, and a respondent from the District Health Directorate.

Table 2: Sample size of Study Communities per District

SN	Communities	Settlement Status	Number of respondents
1	Wechiau	Peri-urban	80
2	Dornye	Rural	80
3	Dorimon	Rural	80
4	Poyentanga	Rural	80
5	Chogsia	Rural	80
		Total	400

Purposive sampling was used for the CWSMBs leaders of each community for focus group discussions for a time frame of 30 minutes to 1 hour, and for officials of the government departments named above for questionnaire administration. This was because such respondents have the experience, expertise, and in-depth knowledge of the thematic areas of the study for which data were required from them, especially issues of groundwater management and use.

It was preferred to use questionnaires for formal sector officials because these are literates. Focus group discussion guides and questionnaires had open-ended questions to facilitate the collections of detailed information for qualitative data to cross-triangulate the quantitative data from the household level. Questions on the instruments for all categories of respondents were based on providing answers to the research objectives. Designations and contact numbers of respondents were taken to facilitate follow-up interviews if it became necessary.

Data collection and analysis

Both primary and secondary data collection and analysis began in June 2019 and ended in August 2019. Data presentation and analysis also began in September 2019 and ended in March 2020. All data presented inthis article therefore chronologically belong to 2019 and 2020. Current sources were however being used to update the literature up to the period of acceptance of this paper for publication. Both quantitative and qualitative methods of data presentation and analysis were used. The quantitative methods involved descriptive statistics with the aid of Microsoft Office Excel, presented in the form of absolute numbers and percentages in frequency tables and graphs. The qualitative methods were by narrations, direct quotations, pictures, and maps. These methods were applied concurrently and supplemented by literature and secondary data to facilitate cross-triangulation and comparison. The information was presented under analytical themes derived from the research objectives.

Results and Discussion

This section is a presentation and analysis of the results of the study, which measures and establishes the relationship between the variables, objectives, conceptual, theoretical, empirical literature, methodological, thematic, policy contexts and philosophical bases in order to establish meanings to the research results. It has been arranged under themes framed from the objectives of the study and conceptual framework.

The Nature of Groundwater infrastructure

This section addressed the first research objective, which is related to the nature of groundwater infrastructure in rural communities. The Wa West District is entirely rural, with the only peri-urban community being the district capital, Wechiau. This is the reason why studies in aspects of infrastructure for groundwater prospecting and use are essential, since groundwater constitutes the main source of safe water to rural communities in northern Ghana (Cobbing, 2020). Table 3 shows that groundwater constitutes the major source of water to the rural and peri-urban household respondents.

Wechiau, the capital town of the Wa West District had 11.25% of respondents having access to public standpipe services through a mechanised borehole for a small-town piped water system. Hower, 67.5% and 21.25% of the respondents still depended on boreholes with hand pumps and dug wells respectively. Although Dorimon has piped water connections from a treated surface water service extension from Ghana Water Company Ltd., which is not within the scope of this study, it still had higher percentage of 75% respondents depending on boreholes and another 25% depending on dug wells. The rest of the communities depended on boreholes and dug wells as at the time of field work for this study in 2019.

Table 4 presents data on the number of functioning boreholes relative to population size in the Wa West District as a whole and the study communities. It shows that there were 316 functioning boreholes out of 378, for a population of 81,348 as of 2019, as reported by Community Development Office of the Wa West District Assembly. Only 62 of the boreholes were not functioning. Given that one borehole fitted with hand pump can serve 300 people (Community Water and Sanitation Agency, 2010), Table 4 shows that the 316 functioning boreholes could serve 257 people in the Wa West District as a whole. This signifies adequacy of borehole infrastructure.

In response to a question on the number and adequacy of boreholes in the district, the Community Development Officer stated that:

> The Wa West District as a whole has 316 functioning boreholes which are capable of serving 94,800 people. The district's total population is 81,348, but a greater number of 64,509 or 79.3% of the people depend on boreholes with hand pumps. The major challenge is ensuring effective community participation for the management of the available boreholes for sustainable services; even though there is uneven distribution among the individual communities.

Table 4 also shows that the study communities met water needs as population per borehole was below the standard of 300. This information calls for further inquiry into other characterisations of the boreholes with hand pumps to assess how well they satisfy users.

Table 3: Types and Accessibility to Groundwater Infrastructure

Community	Groundwater dependent public stand pipes through mechanised boreholes	Groundwater dependent pipe connections outside dwelling through mechanised boreholes	Boreholes with hand pump	Dug well	Total
Wechiau	9 (11.25%)	-	54(67.5%)	17(21.25%)	80(100%)
Dornye	-	-	49(61%)	31 (39%)	80(100%)
Dorimon	-	-	60(75%)	20(25%)	80(100%)
Poyentanga	-	-	49(61%)	31(39%)	80(100%)
Chogsia	-	-	57(71%)	23(29%)	80(100%)

Source: Field survey, 2019.

Table 4: Population and Functionality of Boreholes

Community	Population	Functional boreholes	Non-functional boreholes	Total number of boreholes with hand pumps	Population served by functioning boreholes
Wa West District	81,348	316	62	378	257
Wechiau	2,187	19	3	22	115
Dornye	1,595	14	2	16	114
Dorimon	1,461	11	3	14	133
Poyentanga	1,263	11	2	13	115
Chogsia	1,157	9	2	11	128

Source: GSS (2014), field survey, 2019.

Table 5: State of Water Flow from Boreholes in the Rainy and Dry Seasons

Season	Wa West Communities	Does not flow regularly	Flows regularly	Total
Rainy Season				
	Chogsia	0%	100%	100%
	Dorimon	2.50%	97.50%	100%
	Dornye	22.50%	77.50%	100%
	Poyentanga	0%	100%	100%
	Wechiau	5%	95%	100%
	Average	6%	94%	100%
Dry Season				
	Chogsia	15%	85%	100%
	Dorimon	30%	70%	100%
	Dornye	57.50%	42.50%	100%
	Poyentanga	17.50%	82.50%	100%
	Wechiau	22.50%	77.50%	100%
	Average	28.50%	71.50%	100%

Source: Field Survey, 2019.

Seasonal variations in borehole water flow

Table 5 shows that there was an average of over 94% response rate for regular boreholes water flow in the rainy season, and 71.5% in the dry season.

Although respondents observed satisfactory borehole water flow in both rainy and dry seasons on the average, communities such as Dornye, Dorimon and Wechiau, show some level of groundwater security threats in the dry season with relatively higher response rates of 57.5%, 30% and 22.5% respectively, for irregular borehole water flow. This gives evidence that borehole water yield, which is the rate at which the aquifer of the borehole yields water under gravity per unit volume of aquifer reduces in the dry season, as precipitation level, and consequently the groundwater table reduce (Michigan Technological University, 2013).

During Focus group discussions with the Community Water and Sanitation Management Board members on why some boreholes do not flow adequately in the dry season, a participant at Dornye stated that:

> If you dig a borehole in the rainy season, you can easily find groundwater everywhere, but whether the water would flow throughout the year depends on the place the borehole is located. If it is located in a valley or places where you see big trees and termite hills you can have enough water in the dry season.

This finding is consistent with that of Janyani et al. (2014) that boreholes constructed near valleys, low land areas, streams or springs have sustainable water yields. This information implies that the location of most boreholes with dry well experiences in the dry season were not appropriate. Any attempt to ensure proper location of boreholes would improve groundwater exploitation for various uses throughout the year.

Groundwater Governance and Management

This section addresses the second research objective of this paper, which is about groundwater governance and management. In other words, it is about the political, social, economic, and administrative systems and practices that influence the use and management of groundwater. The institutional framework in Figure 4 reflects the triangulated and cumulative outcome of the various sources of data, modified from Bukari et al. (2023). The stakeholders in groundwater management for rural communities in Ghana include all those indicated in Figure 4, which also explains their roles. Figure 4 is the institutional framework for rural groundwater governance and management in Ghana. It shows the roles of institutions in the making of policies and regulations to enforce the implementation of such policies in the water sector in general in the first instance (governance), and the institutions in charge of administrative aspects of rural groundwater services to ensure that the policy and regulatory provisions are met (management). In response to a question on stakeholders and their roles in rural groundwater resource management, a Community Development officer of the Wa West District Assembly stated that:

> The Ministry of Sanitation and Water Resources (MSWR) and Ministry of Local Government and Rural Development make policies in common that affect rural water supply; District, Municipal and Metropolitan Assemblies are responsible for the regulation and management of rural water services; the CWSA is the facilitator of rural water, sanitation and hygiene projects; Water Resources Commission acts for the conservation and awarding water abstraction rights; and Environmental Protection Agency is for water pollution control, environmental impact assessment and permits for water projects, which all affect groundwater management.

Table 6 also shows household respondents' description of how rural community members participate in the management of boreholes with hand pumps.

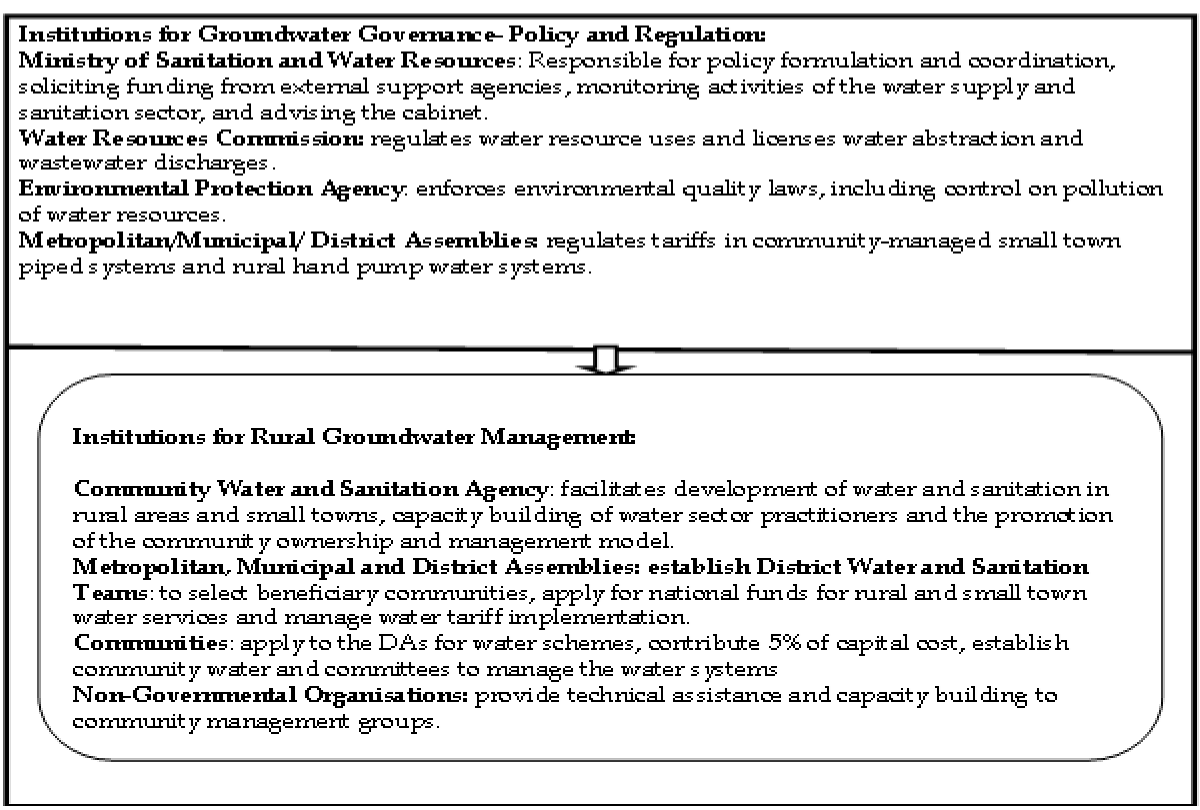

Figure 4. Institutional framework for rural groundwater governance and management in Ghana.
Source: Modified from Bukari et al. (2023)

Table 6: Rural Community Participation in the Management of Boreholes

Aspect of community participation in borehole management	Agree	Disagree	Total
Provision of site for borehole construction	65%	35%	100%
Communal labour during borehole construction	68%	32%	100%
Presence of Community Water and Sanitation Management Boards	92%	8%	100%
Contribution for borehole maintenance and repairs	97%	3%	100%
Payment of rigorous tariffs for borehole water use for the economic value of water	4%	96%	100%
Average	65.2%	34.8%	100%

Source: Field survey, 2019

Table 7: Governance Gap Analysis

GAP	Description	Action Type
Administrative gap	Administrative aspects of underground water resource management were more on water infrastructure with little efforts on sanitation. This affects meeting safe water standards, since poor sanitation impacts on groundwater quality	Need for improvement in sanitation services, including provision for solid, liquid and faecal matter
Information gap	There is lack of adequate research to provide recorded information on hydro-geological maps showing specific communities and their spatial distribution of aquifer depths and widths, their physico-chemical and bacteriological contaminant levels	Need for adequate geological surveys and water quality measurements for all communities dependent on groundwater.
Legal and Policy gap	There is lack of awareness creation on the regulations for groundwater safety as well as institutions responsible for their enforcement	Need for establishment of community level structures, or the extension of the functions of the Community Water and Sanitation Management Boards to include sensitisation of communities on regulations for groundwater use and protection, and institutions involved in their enforcement
Capacity gap	Technological components of groundwater abstraction infrastructure need repair and maintenance. Most Community Water and Sanitation Management Boards lack technical men and women with built capacities to undertake these tasks.	Need for training of local community members to take responsibilities of maintenance and repair of the water facilities, in order to reduce cost of hiring external repairers.
Funding gap	Although the interventions of WaterAid Ghana in groundwater resource development and abstraction are remarkable, local efforts at funding the repairs and maintenance remain a challenge. This is because of the low-income status of rural communities.	Need for stakeholder collaboration for funding livelihood enhancement opportunities to generate income, especially for women in the area who use the water facilities most. This could enable them to contribute for additional projects, maintenance, and repair of existing boreholes.
Technological gap	There were some broken down boreholes dating from the 1960s and 1970s without spare parts other than aquifer depletion. It was also found that unconfined or shallow well drill was commonly used since most borehole construction failures were due to underground rocks. The deep nature of aquifers mostly beyond 50mbgl does not make shallow ell drilling suitable in study area.	Need to use ultra deep well drill technologies that penetrate rocks with adequate aquifer sizes beneath them. This technology would also ensure adequate water yield in boreholes on deep aquifers throughout the year.

Source: Field survey, 2019; Cobbing (2020).

The data in Table 6 reveal that 65.2% of all respondents agreed with the various aspects of community participation in the management of boreholes, with the presence of Community Water and Sanitation Management Boards (CWSMB) and users' contributions for the maintenance and repair of boreholes being their major strengths by highest response frequencies of 92% and 97% respectively. It, however, shows the rural households do not pay rigorous tariffs for the use of groundwater points with a 96% response rate. Given the low-income status of rural communities in Ghana, the non-payment of tariffs for rural borehole water use is consistent with the Ghana National Water Policy, specifically the principles of fundamental rights of all people without discrimination to safe and adequate water to meet basic human needs (Ministry of Water Resources, Works and Housing [MWRWH], 2007).

The findings further concur with a response by the official at the Wa West District Assembly to the question on stakeholder participation, stated below:

> The Community Water and Sanitation Management Boards provide the borehole construction sites, contribute communal labour to cover part of the cost of construction, and are responsible for the repair and maintenance of the boreholes. NGOs such WaterAids and SNV, and also philanthropists who hail from the communities in the diaspora also contribute to capacity building, technical support and direct intervention in the provision of groundwater infrastructure.

The identification of the role of the CWSMB in the management of rural groundwater points falls in line with the principle of subsidiarity to ensure participatory decision making at the lowest appropriate level in society, of the National Water Policy of Ghana (Ministry of Water Resources, Works and Housing [MWRWH], 2007).

Despite these institutional roles, there are obvious governance gaps in the rural groundwater management sector. Table 7 presents a summary of the major gaps in groundwater governance. It highlights the administrative, information, policy, capacity, funding and technological gaps. The associated action types, such as improvement of sanitation, sensitization of communities on groundwater regulations, training communities for repair and maintenance of boreholes, geological surveys for water quality monitoring, stakeholder collaboration for funding and ultra deep well drilling technologies for confined aquifer prospecting have been advanced. The findings were obtained from multi-site and multi- focal group discussions in the five study communities, and consistent with that of (Cobbing, 2020).

The solutions to the gaps identified in Table 7, alongside other alternatives could optimise groundwater use for the rural areas to be able to achieve national and international policy targets.

Accessibility and affordability of groundwater services

This section addresses the third and fourth objectives of this study, related to accessibility and affordability of groundwater points respectively. Table 8 presents data on the average distance and time spent on accessing water from boreholes in the study communities.

Results show that the minimum and maximum distances and time to access a borehole in the Wa West District are 100m and 600m, and 5 minutes to 1hour respectively. The average distance to access a borehole for the five communities is 400m, while the average time to access water in the rainy and dry seasons are 26 minutes and 33 minutes respectively. Wechiau and Dorimon communities exceeded both the standard distance of 500m and time of 30 minutes to access boreholes, Dornye also exceeded the standard time, while the rest of the communities met the right time and distance specified by the CWSA (2012). However, these are small-towns and so benefit from small-town piped water services of the CWSAas in the case of Wechiau, and extension of the urban water services of GWCL to Dorimon, due to its proximity to the Jambuse Water Treatment Plant of GWCL and the Black Volta River for water abstraction, treatment plant and delivery main pipes of GWCL's urban water supply system. Dorimon therefore has a surface water resource ownership claim. Under such circumstances, Galaa and Bukari (2014) report that water resource owning rural communities not served by GWCL in northern Ghana caused illegal damage to delivery main pipes for extraction of treated piped water by some residents, leading to non-revenue water losses.

In terms of affordability, this study found that all the communities do not pay rigorous tariffs for borehole water services, but only for repair and maintenance. Rigorous water tariff meansa price per unit of water supplied, which is determined by regulation or country's public utility laws and imposed by a public company for water supplied to its customers, the purpose of which is to recover the cost of services (Brook & Smith, 2001; OECD, 1987, as in Bukari, 2017). Table 9. It shows the community members' willingness and ability to pay for the maintenance of boreholes. The non-payment of water tariffs in the rural communities is consistent with the Ghana National Water Policy's principle of fundamental rights of all people without discrimination, to safe and adequate water to meet basic human needs (Ministry of Water Resources, Works, and Housing, 2007).

The roles of NGOs and philanthropists who contribute to provide the boreholes also relates to the principle of solidarity, expressing profound human companionship for common problems related to water (Ministry of Water Resources, Works, and Housing, 2007).

. This is achievable using basic service level technologies, suitable to the socio-economic status of rural people. However, some communities such as Dornye, Poyentanga, Nakori and Gberu, expressed inability of some household members to pay levies for maintenance. This is the effect of poverty, requiring further interventions through livelihood improvement projects (Bukari&Abagre, 2013).On the average, three out of the five communities are satisfied with the distance and time (accessibility), as well as the expressed ability to pay for the maintenance of boreholes. This finding draws the Wa West District Communities close to archiving SDG 6, which aims at Clean Water and Sanitation for all (United Nationsm, 2015).

Livelihood Outcomes of Groundwater Use

This section solved the fifth research objective about the outcomes of groundwater use. Following this study's conceptual framework, this was measured by the effects of groundwater use on livelihoods of the rural people. Using standard quantities of water per person per day for various livelihood activities by WaterAid (2012), WarerAid's standard was used because it does not only give a detailed breakdown of quantities of water needed per day per person, but also the livelihood activities dependent on water, which is the focus of this study. The CWSA of Ghana only snot pecifies that a rural person needs a minimum of 20 litres of water per day (CWSA, 2010), which does meet the objective of this study.

Table 10 shows the breakdown of water related livelihood activities. The averages were computed by summing up the total water requirements for each activity for all respondents in the district and dividing by the total number of respondents. The results are shown on a district basis because the original survey from which this article was extracted involved three districts and 15 communities. So, it was convenient to show results on district basis to ovoid congested tables. It is still beloved that the findings in Table 10 still measure up to the geographical scope of the title of the paper. The findings in Table 10 show that households in the Wa WestDistrict study communities failed to use the estimated quantity of water for the various livelihood activities, based on WaterAids' standard. This requires further interventions to improve water use.

Table 8: Distance and Time of Accessing Borehole Water

Wa West Communities	Average distance to access borehole from the house	Satisfaction with distance	Average waiting time to draw water from the borehole in rainy season	Average waiting time to draw water from the borehole in dry season	Satisfaction with time spent at borehole
Chogsia	100m	Satisfied	5minutes	10 minutes	Satisfied
Dorimon	600m	Not satisfied	40 minutes	45minutes	Not satisfied
Dornye	400m	Satisfied	30 minutes	35 minutes	Satisfied
Poyentanga	300m	Satisfied	10 minutes	15 minutes	Satisfied
Wechiau	600m	Not satisfied	45 minutes	1 hr.	Not satisfied

Source: This study, 2019

Table 9: Willingness and Ability to Pay for Water Facility Use

Wa West Communities	Water facility users are willing to pay for maintenance	Water facility users can pay for maintenance	Amount paid	Frequency of payment for maintenance
Chogsia	Agreed	Agreed	Not standardised	Each time maintenance or repairs is needed
Dorimon	Agreed	Agreed	Not standardised	Each time maintenance or repairs is needed
Dornye	Agreed	Agreed	GHc 5 per house	Annually
Poyentanga	Agreed	Agreed	GHc 5 per house	Annually
Wechiau	Agreed	Agreed	GHc 5 per man and GHc 2 per woman	Annually

Source: FGD with CWSMBs of the study communities

Table 10: Uses of borehole water for livelihood activities

Source: Field survey, 2019; Water Aid (2012)

Aspects of livelihood activities in household water use	Standard quantity of safe water needed per household member per day (in litrs)	Average for Wa West District Communities
All uses	WaterAid: 280 litres	100 litres
Drinking	WaterAid: 10	3.6
Bathing and general body hygiene	WaterAid: 30	10.7
Washing	WaterAid: 40	14.3
Cooking	WaterAid: 20	7.14
Domestic home cleaning	WaterAid: 50	17.86
Backyard gardening	WaterAid: 60	21.4
Sanitation and waste disposal	WaterAid: 70	25
Regulated population size for rural water services in Ghana (by CWSA)	200 -672	200 -672
Estimated average rural population	436	436
Estimated quantity of water needed for decent living by the population	WaterAid: 122080	WaterAid: 122080
Estimated actual quantity of water used by the population		43,600
Water use deficit in the project communities across the districts		WaterAid: -78,480

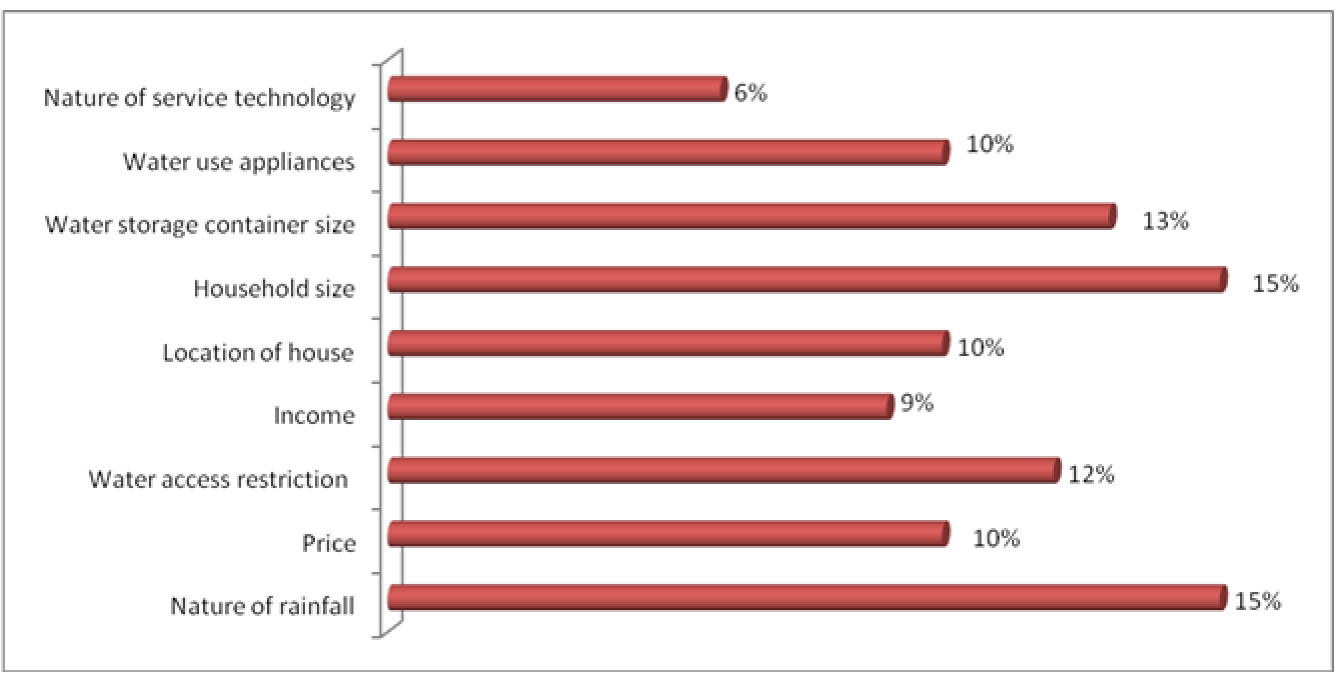

Figure 5. Factors Influencing Water use Behaviour.

When people do not drink enough water, it causes illnesses such as dehydration and constipation, with the effects of fatigue and digestion disorders respectively (Bukari, 2017). Also, insufficient water for bathing and washing of clothing causes rashes, scabies, and bad body odours (Funari, Kistemann, Herbst & Rechenburg, 2011). Thus, whereas both study communities did not perform badly in terms of groundwater access, an inquiry into factors influencing water use behaviour yielded the results in Figure 5.

In Figure 5, the nature of rainfall, which influences seasonal variations in water availability; household size, which influences household demand and competition for water use; the type and number of water use appliances, as a determinant of quantity of water used per day; the size of water storage containers and practices to regulate waste of water through restriction strategies, such as locking down of water points, are among the major factors influencing water use behaviour in the communities.

The findings are consistent with the assertion by Jorgensen et al. (2009), that households water use is contingent on situational conditions (e.g. rainfall), pricing and regulation (e.g. tariff level), household characteristics (e.g. household size), and water using appliances (e.g. water closets). The lower the magnitude of each influencing factor, the lower the quantity of water used, which would not mean the same as inadequate water use. Rural populations would therefore have lower values of water use, compared to urban households using water closets, laundry machines, and poly tanks for water storage. However, given the fact that two (2) out of the five (5) communities studied did not meet expectations in terms of accessibility and affordability of groundwater points, further progress is needed in the management and governance of water for achieving SDG 6.

Socio-cultural challenges of groundwater governance and management

Related to sanitation as an aspect of water resources management as expressed in the groundwater governance gap analysis in Table 7, this study investigated the effects of cultural and social practices that impact on groundwater quality. Examples are the construction of graves, pit latrines and soak-aways. . Figure 6 shows the closeness of a mechanised buffer, about 30m just away from the community cemetery at Chogsia in the Wa West Districts. Also indicated are boreholes close to family graves nearer homes and chemical runoff from a tomato farm closer to a borehole. Focus group discussion results in all the communities indicated that indiscriminate and unregulated digging of graves is a major threat to groundwater quality.

Most of the graves are unlined, and without conformity to standards that protect the water table from contamination. Contamination of groundwater through contact with dead carcass of humans and other animals releases the parasites *cryptosporidium hominis* and *C. Parvum* in the water. These cause a disease known as cryptosporidiosis, which causes diarrhoea, vomiting and nausea (Levitt, 2015).

The Environment Health and Sanitation Department of Wa (Upper West Regional capital town) also disclosed that contamination of groundwater with human remains causes typhoid and cholera. The department further disclosed that such situations arise due to non-conformity to the standards that safeguard the quality of groundwater. Table 11 indicates the regulated depths for the construction of various structures for liquid and faecal waste management, as well as graves, and the actual practices in the study districts.

Table 11 shows that all the various structures constructed in the study district have depths lower than the groundwater table. However, while pit latrines and soak-aways are a bit shallower than the regulated depths, pit latrines, as well as graves (which exceed regulated depths) are mostly without concrete floors for the protection of underground water resources, which could fluctuate in levels away from the average. For example, in the rainy season groundwater table could be much lower and could be contaminated by any of the sources indicated in Table 11. Furthermore, although the structures are less deep than the water table, contamination of groundwater is still possible if permeability is possible (Poeter, Fan, Cherry, Wood & Mackay, 2020). Table 12 is a summary of the health effects of the above human activities that impact on groundwater quality.

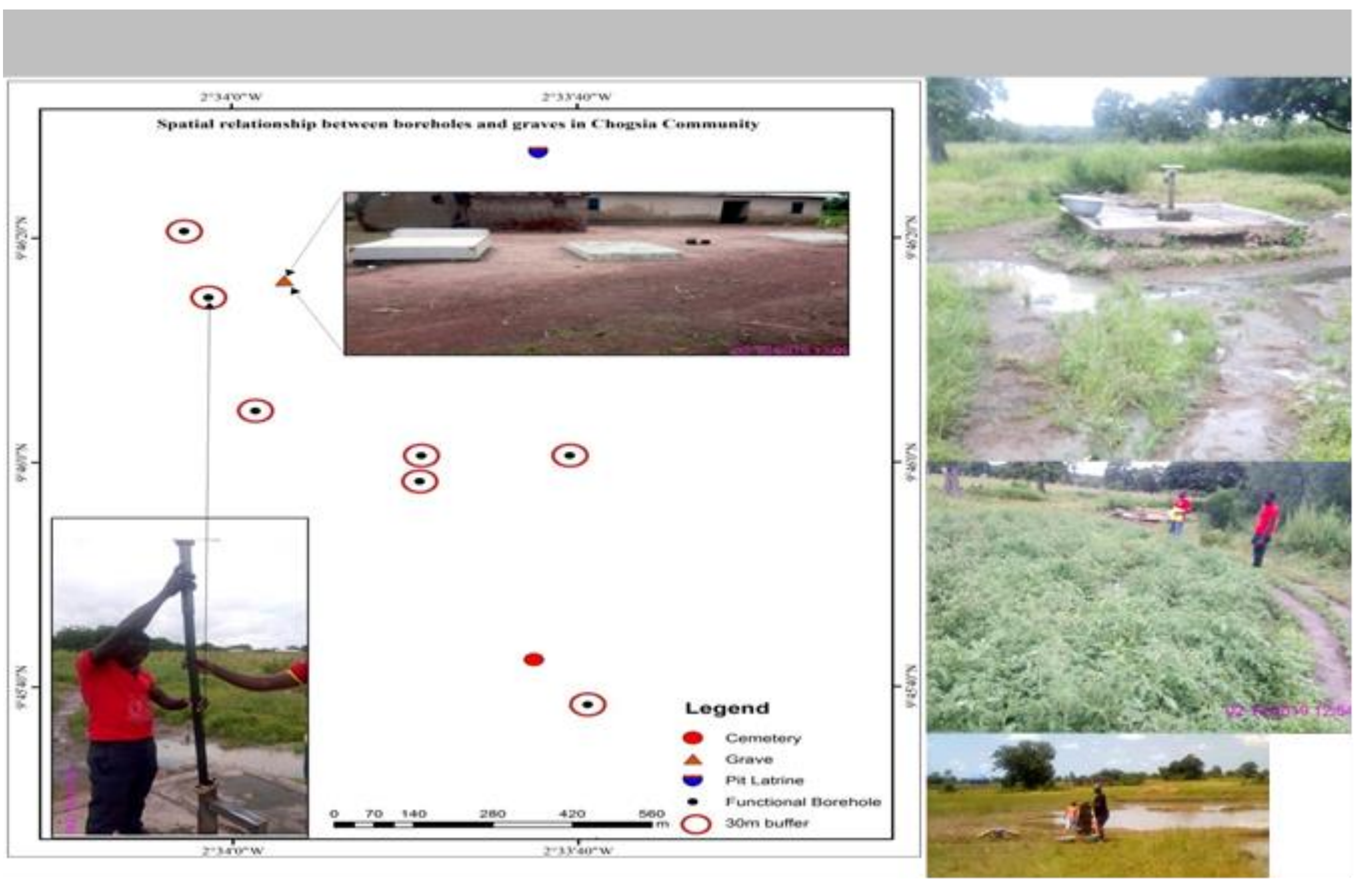

Figure 6: Spatial relationship between graves and boreholes in Chogsia Community, Wa West District

Table 11: Regulated and Unregulated Depths of Various Underground Structures

District	Average depth of groundwater table	Unregulated depths of pit latrines	Regulated depth of pit latrines	Unregulated depth of grave	Regulated depth of grave	Unregulated depth of soak-away	Regulated depth of soak-away (ft)
Wa West	53m(174ft)	8ft (2.44m) mostly without concrete floor	10 ft (3.048m) with concrete floor	7ft (2.134m) mostly without concrete construction	6ft (1.83m) with concrete construction	2ft (0.61m) without concrete lining	3ft (0.9144m) without concrete lining

Source: Environmental Health and Sanitation Department-Wa, 2019.

Table 12: Health Effects of Various Underground Structures

Practice	**Contamination risk**	**Health threat (add disease if applicable)**	**Municipal/District where practice is most common**
Drilling a borehole near a solid waste dump site	Possibility of seepage of heavy metals and disease pathogens contaminating groundwater	Contraction of skin diseases and faeco-oral diseases e.g. typhoid, cholera, poliomyelitis	Wa West e.g. Siriyir community
Drilling a borehole nearer to a grave yard	Possibility of seepage of disease pathogens and human hair into groundwater depending on the type of soil within the locality of the graveyards	Likelihood of causing cancer and contracting communicable diseases e.g. CSM, poliomyelitis, cholera	Wa Municipality and Wa West
Drilling a borehole nearer to pit latrines	Direct contamination of groundwater with faeco-oral diseases e.g. diarrhea, typhoid, etc. Indirect contamination of groundwater by bacteria and other disease pathogens depending on the type of soil within the locality of the pit latrines	High possibility of cholera and typhoid infection	Wa Municipality and Wa West District
Indiscriminate defecation near water bodies		High possibility of cholera and typhoid infection in times of floods	Wa Municipality and Wa West District

Source: Environmental and Sanitation Health Department, Wa, 2019.

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The findings in Tables 11 and 12 negatively impact on the 'clean water and sanitation' objective of SDG 6.

Summary, Conclusions and Recommendations

In line with the first objective related to the nature of groundwater infrastructure, this study found that 59% and 51% of rural and peri-urban household respondents respectively, relied on boreholes with hand pumps. The entire district is blessed with 316 functioning boreholes capable of serving 94,800 people, compared to its relatively lower population of 81,348. Only 6% of household respondents reported challenges of borehole water flow in the rainy season, but for the dry season the proportion increased to 28.5%. Wrong site selection for borehole construction was blamed for irregular flow of borehole water.

Despite the relatively greater number of boreholes per capita, their distribution was uneven over the entire district. In the policy context, the findings show closeness of the Wa West District to achieving SDG 6, which is about clean water and sanitation for all by 2030.

The second objective dealt with groundwater governance and management in the rural communities. In this regard, some stakeholder institutions and their roles were found to be the Ministry of Sanitation and Water Resources (MSWR) and Ministry of Local Government and Rural Development in rural water policy; District, Municipal and Metropolitan Assemblies in the regulation and management of rural water services; the CWSA facilitates rural water, sanitation and hygiene projects; Water Resources Commission for the conservation and awarding water abstraction rights; Environmental Protection Agency for water pollution control; Community Water and Sanitation Management Boards foster community participation; NGOs and philanthropists contribute to direct provision of groundwater infrastructure. However, groundwater governance in the communities was constrained by administrative, policy, information, funding, capacity and technical gaps. The role of the CWSMB in the management of rural groundwater points is consistent with the National Water Policy of Ghana's principle of subsidiarity in order to ensure participatory decision making at the lowest appropriate level in society, which has not been assessed by most studies.

In terms accessibility and affordability of services of groundwater points as the basis of objectives three and four of this study, the average distance and time to access a borehole with hand pump in the study communities were 400m for distance and 26 minutes and 33 minutes for time in the rainy and dry seasons respectively. They therefore met the acceptable distance and time of 500m and 30 minutes respectively for access to a safe drinking water point, adding more to their closeness to achieving SDG 6 for safe drinking water. There were, however, disparities in distance and time among the communities as some could not meet the acceptable standards.

In terms of affordability, no rigorous tariffs are charged for borehole water services except contributions for maintenance and repairs, for which on average, respondents were willing and able to contribute. The non-payment of water tariffs in the rural communities is consistent with the Ghana National Water Policy's principle of fundamental rights of all people without discrimination, to safe and adequate water to meet basic human needs.

The final objective had to do with livelihood outcomes of groundwater use. The main uses of water from groundwater points were reported to be drinking, cooking, bathing, and general body hygiene, gardening, washing, home cleaning and basic sanitation. In terms of water use for these livelihood activities, WaterAid (2012), asserts that a rural community with population of not less than 436 needs an acceptable quantity of 122,080 litres of water per day for decent living. But the estimated quantity of actual average quantity of water used per community in the study area was 43, 600, which falls short of the expected standard. Thus, whereas there is adequate coverage, accessibility, and affordability of rural groundwater point source services in the Wa West District, the study communities encounter a water use deficit of -78,480 litres. This suggests that adequate coverage of water points by accessibility, availability and affordability does not imply that there is adequate water use. Water use behaviour of respondents was accordingly assessed for the difference between water availability and water use.

Household size, location of the house relative of the groundwater point, size of water storage container, nature of rainfall, type of water use appliances, water use restrictions and income of the water user were found to be factors influencing the quantity of water used by the households in the communities. This implies that in the assessment of the impacts of the implementation of SDG 6, a focus on coverage would be inadequate. Actual quantities and water use behaviours should also be assessed to ensure that basic needs and standard requirements are met.

This study went further to investigate the socio-cultural challenges of groundwater governance and management. Some of these included improper construction of pit latrines, soakaways, and graves without conforming to regulated standards, with implications of groundwater contamination and health concerns, which jeopardise the achievement of the safe water dream of SDG 6 and the National Water Policy of Ghana.

Conclusively, by revisiting the conceptual framework of this study, the social aspects of groundwater was assessed by the institutional framework of groundwater governance and management, characteristics of rural groundwater infrastructure, the accessibility, affordability, and use of groundwater for various livelihood activities. It is recommended that in the spatial allocation of groundwater infrastructure, the population of each beneficiary community should be ascertained and the standard population of 300 people per borehole taken into consideration by the District Assemblies for even distribution of boreholes among communities. The CWSA should sensitise communities about the relevant stakeholders for the exploration and use of their groundwater resources, so that they know where to go for addressing their safe water needs.

To avoid fluctuation of borehole water yield between the rainy and dry seasons, best indigenous knowledge of the physical and biological indicators of the location of economically feasible aquifers should be explored and used by the stakeholders for determining the location sites of boreholes.

The CWSA and NGOs such as WaterAid should also educate the communities on the rite amounts of water to use for various purposes in conformity to acceptable standards. This would ensure the availability of quantitative and objectively verifiable indicators for the achievement of SDG 6, The Environmental Health Department should also sensitise communities on the acceptable standards for the construction of graves, pit latrines and soakaways to avoid contamination of the groundwater.

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