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Assessment of Off-season Water Supply Situation: The Case of Abetifi in the Kwahu-East District of Ghana

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Authors' contributions

This work was carried out in collaboration between all authors. Authors JAK and POA designed the study and wrote the protocol. Authors POA and BN managed the data collection and statistical analysis. Author POA managed the literature searches and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The study aims to investigate the characterising features of off-season water supplies in the Kwahu-Abetifi Township, situated in the Kwahu-East District of Ghana.
A descriptive cross-sectional survey was employed for this research.
The study was conducted in the Kwahu East district of Ghana during August 2017 to December 2017.
A stratified sampling technique was employed to select 200 respondents for this study. Respondents were interviewed using prepared and validated questionnaires. Data obtained from the completed questionnaires were analysed by using the statistical Package for the Social Sciences (SPSS).
The community people including school-going children, covered long distances and stayed in long

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queues to access water. They, however, spend long time in accessing water for their use in homes during the dry season. Durations respondents (n= 200) used in accessing water and returning to their homes were as follows: Approximately 15 minutes (10%); 20 minutes (16%); 35 minutes (22%); and more than 40 minutes (52%). The accessed water was perceived to be good (68%) and could be used for several domestic purposes including drinking (19%), cooking (47%), bathing and washing (34%). The study underscored the need for the revamp of broken down water supply systems in the study area and expansion of existing ones by Government to ease and improve accessibility for adequate and potable water supplies mainly during the dry season.

Keywords: Potable water supply; off-season; accessibility; proximity; affordability.

1. INTRODUCTION

Ensuring the provision of adequate and potable water supplies to communities across all facets of life around the world is very critical. Among primary aspects of life, good health, livelihood enhancement and sustainable development, are the main reasons to supply of clean and sufficient quantities of water that can be reliable at all times [1,2]. Worldwide, it is estimated that the total cost of water insecurity affecting the global economy is US$500 billion [3]. Over the years, there have been incessant concerns at the international, regional, sub-regional and grass root levels concerning issues of potable water supplies to people. Aside the concerns, water supplies in most parts of the world face challenges including but not limited to scarcity. It, therefore, becomes very prudent to address water related issues in context of scarcity and security, sanitation and health crisis with infrastructure deterioration and destruction to reverse the threatening supply and quality trends.

Despite the enormous efforts to improve the supply of potable water to people worldwide, 663 million people suffer inaccessibility to 'improved' drinking water resources [4]. Moreover, the 'improved' water is perceived by many as unsafe, unreliable or not affordable. Regarding water safety, arsenic levels above World Health Organization (WHO) standards limits in drinking water is consumed by 45 million people in Bangladesh and has been documented [5].

In Ghana, scarcity situations have not been different as some communities continue to suffer severe water shortages usually during the lean season. Several water connectivity exist within communities in Ghana, but a considerable number of communities continue to receive their share of supply challenges, perhaps as a result of frequent system break down and other factors.

1.1 Objectives of the Study

The main objectives of the study were:

(i) To determine the challenges that face water supply accessibility in Abetifi-Kwahu in the Eastern region of Ghana during the dry season.
(ii) To ascertain the perceived quality of water supplied in Abetifi-Kwahu in the Eastern region of Ghana during the dry season.

2. THE GLOBAL WATER CYCLE AND SITUATION

Water, is an essential element of life, cycles between land, oceans and atmosphere through solid, liquid and gaseous phases. Precipitation from the atmosphere gets to land, underground aquifers and oceans. Rivers get their supplies from groundwater as water moves through sediments and rocks. Rivers also provide freshwater discharge into seas. Water finally evaporates or transports from ocean and land into the atmosphere to complete the hydrological cycle.

Earth's water resources including rivers, lakes, oceans and underground aquifers are under stress in many regions worldwide. Among 70% of the Earth's water cover, only 2.5% is freshwater. This limited resource is to support an estimated 9.7 billion of the world's population by 2050 [6]. In sub-Saharan Africa, high population growth triggers a high consumption rate of this limited resource. Worldwide, some regions are endowed with freshwater compared to others as a result of global circulation patterns that translate to distinct wet and dry phases of multi-annual climate cycles.

Although developed countries have more water available than most of the countries in Africa,

Asia and the Pacific, some areas are water-stressed because the available water sources are being depleted at very high rates [7]. It is envisaged that, global water demand would increase by 50% in 2030 [8]. Water supply situation is estimated to be worsened with an approximately 3.9 billion (over 40%) of the world's population, to dwell in severely water-stressed basins [6]. Consequently, in vicinities with water-stressed situations, people seek water from distant sources. With water scarcity affecting over 40% of the world's population, there is a need for urgent interventions and implementation of highly workable strategies [9].

The United Nations and the international community, however, set targets to reduce the number of persons with inadequate potable water and sanitation by 2015. Meeting this target was to provide an excess 260,000 people per day with safe drinking water and 370,000 people per day with improved sanitation through the year 2014 due to the escalating global water demand [10].

2.1 Community Water Supplies in Ghana

In most of the rural communities of Ghana, people rely on all sorts of water resources during the wet season including streams, rivers, dug wells, ponds, boreholes, rainfall, etc. but face the challenge of dryness or severe drought getting to the end of the year. Most commonly, people who dwell in these areas resort to the available water sources which might not be potable but use them unknowingly at the highest health risk [11]. Thus the supply of clean water is imperative in ensuring that people do not suffers detrimental diseases and other associated health risks problem.

Personal hygiene is highly essential, and receives more attention due to water inaccessibility [8]. Per capita water consumption is reliance on accessibility, and could primarily be defined by distance, time, reliability and cost [12]. There is a higher health benefit when water is preferably at the household level. Interventions by Governments, International organizations, and Non-Governmental Organisations have made it possible for several rural communities in Ghana to boast of pipe-borne water and their accessibility, reliability, permanence, and cost-effectiveness are also great matters of concern.

Potable water accessibility challenges limit personal and household hygiene, which intend to affect public health. A supply system that would ensure the everlasting needs of people and also accessible to all without denying the living poor and the healthy living is critical for the development of human lives. There is the utmost need for an affordable and efficient rural water supply system which is sustainable and hinges on an effective logical management framework [13].

Sustainable water management is very fundamental in realising most of the sustainable developmental goals especially Sustainable Development Goal (SDG) 6. Thus ensuring the sustainability of rural water supplies through effective management systems is worth considering. This will make people, and their immediate environments continue to obtain the right quantities of potable water for growth and development. In most instances, rural water systems unreliability occurred due to system breakdown, financial constraints, lack of sense of responsibility for service payment leading to systems failure, inadequate or no system evaluation and the failure in implementing evaluation recommendations. These factors limit the efficient performance of rural water supply systems.

2.2 Description of Study Area

The study area, Abetifi-Kwahu is located in the Kwahu-East District of the Eastern Region of Ghana. It is geographically located on (6° 40' 0" N, 0° 45' 0" W). A total of more than 15,000 population of the study area are engaged in several economic activities including farming, trading and public service work. Abetifi-Kwahu is still known for its severe perennial dry season water crises, making life difficult for its inhabitants. The town is well connected to the water lines of the Kotoso water treatment station making it easier for people who live mostly in bungalows accessed water in their homes. For the past two decades, the supply lines connected to this water station are damaged and have not been fixed properly, making the people access quantities of water that are scarce and frustrating to find during the dry season. Towns like Nkwatia and Mpraeso are connected to the Ghana Water Company Limited lines, but Abetifi has not yet seen its share of this connectivity. During the dry season, rivers, streams dry up leaving only a few constructed boreholes with standing pipes and dug wells for the use of the over 15,000 inhabitants of the community (Fig. 1).

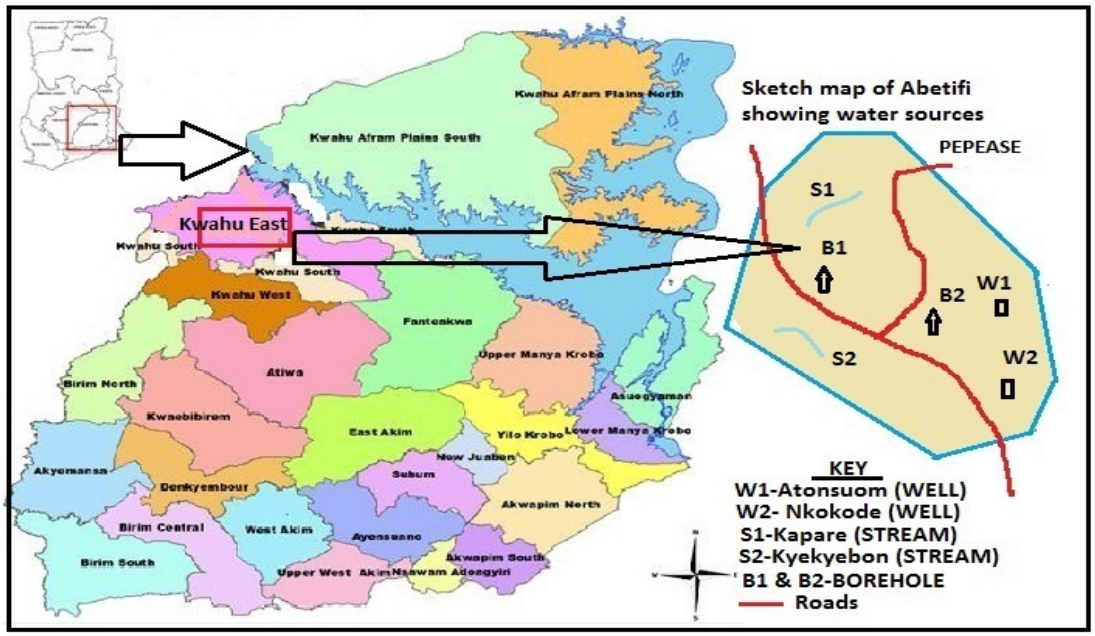

Fig. 1. Sketch map of study area showing water sources

2.2.1 Climate and rainfall

Lying within the semi-equatorial region, Abetifi is characterised with major and minor rainy seasons in a year. The major rainy season begins from April and ends in July while the minor starts from September and ends in October. Annual rainfall averages between 1580 mm and 1780 mm. The town experiences warmth and dryness between November and March as it is hit by the Tropical Continental (cT) air mass [14]. Within February, the highest form of dryness with 23 mm of rainfall is experienced. The town in Ghana is located about 2080ft above sea level and prides itself with a very serene weather condition with monthly temperature averaging 30℃ during dry season and falls to 26℃ during the wet season. Relative humidity ranges from 75% to 80%.

2.2.2 Vegetation

The town lies within the Semi-Deciduous forest zone of Ghana [14]. The vegetation is characterised by a dense tree cover with shedding off of leaves mostly during the dry season. There exist the lower, middle and upper layers in terms of the tree coverage in the forest. Specifically, these layers include the canopy, understory layer, shrub layer, herbaceous layer and the forest floor. The canopy, the uppermost layer of the vegetation, consists of the upper leaves and branches of the tallest trees. Beneath the canopy, the understory layer comprises small, shorter trees. Beneath the understory layer is the shrub layer consisting of woody vegetation tending to be less than 10 feet high. The herbaceous layer is found beneath the shrub layer and consists of small, soft-stemmed plants such as wildflowers and ferns, as well as grasses. The forest floor, the lowest layer of this forest vegetation, consists of fallen leaves, twigs, and branches, as well as small plants such as mosses and lichens.

The forest vegetation is rich with several flora most of which, are of immense commercial and scientific values. Trees of economic importance can be identified in the area and include Odum, Wawa, Mahogany, etc. [14]. Moreover, trees of commercial and scientific values, which abound in the forest, include Onyina, Emire, Ofram, Bompagya, Kyenkyen, etc. Until a few centuries ago, the impact of human populations on both the vegetation and cohabiting species was minimal because of a small population. In recent times, destruction of this vegetation in the study area caused by human population and economic pressures is considered a major threat to the natural environment. The natural vegetation cover continues to deteriorate as a result of activities including farming, logging of wood for timber, indiscriminate bush fires mostly during the dry season. Such activities change the

natural vegetation which tends to affect the dynamics of biodiversity in this area.

2.2.3 Soil

Described as deeply weathered soils, forest ochrosols as the name goes are the type of soils found in the study area [14]. They consist of thin (about 20 cm), dark greyish brown, humus-stained, sandy loam and silt loam topsoil which are usually moderate fine granular in structure and friable in consistency. The subsoil is thick, often more than 120 cm thick over the weathered substratum. The texture of the subsoil varies and may be sandy clay loam, silty clay loam, sandy clay or silty clay with common to many (10-40%) quartz gravels and stones and hard iron and manganese dioxide concretions [15]. The forest ochrosols are generally slightly to moderately acidic in nature in the topsoil (pH 6.5-5.1 in 1:1 soil: water ratio). With good chemical properties, the soils are fertile and support the production of food and cash crops including cassava, yam, plantain, cocoa, coffee, etc.

3. METHODOLOGY

3.1 Sampling and Sample Technique

The stratified sampling technique was used to select the study sample from the study population [16, 17]. This technique was chosen in order to evenly spread the sample across the entire population. Stratified sampling ensures a higher degree of representativeness, thereby reducing the probable sampling error. It ensures that different groups of population are adequately represented within the sample. It combines homogeneity and heterogeneity at different levels. With this technique, the study area was divided into five separate groups called strata with residential location as a criterion (Fig. 2). In each stratum, 40 respondents were selected by simple random sampling employing the lottery method. The method was carried out by preparing a list of names and contact details of 150 persons which constituted the sample frame for a particular stratum. Each person's name was then transferred from the sample frame (i.e., list of 150 persons) and then put onto separate pieces of papers. The pieces of papers were placed in a container and thoroughly mixed. The required number of respondents for a particular stratum (i.e., 40), was selected in a blind manner. The names selected constituted the simple random sample. The same random sampling procedure was performed also for other four strata.

3.2 Primary Data Collection

The study employed a descriptive cross-sectional survey to collect primary data. In all, 200 respondents from individual households including institutional bungalows, flats, compound houses, semi-detached houses, etc. were contacted and interviewed. Both qualitative and quantitative data were collected from the respondents by the use of a set of validated semi-structured questionnaires.

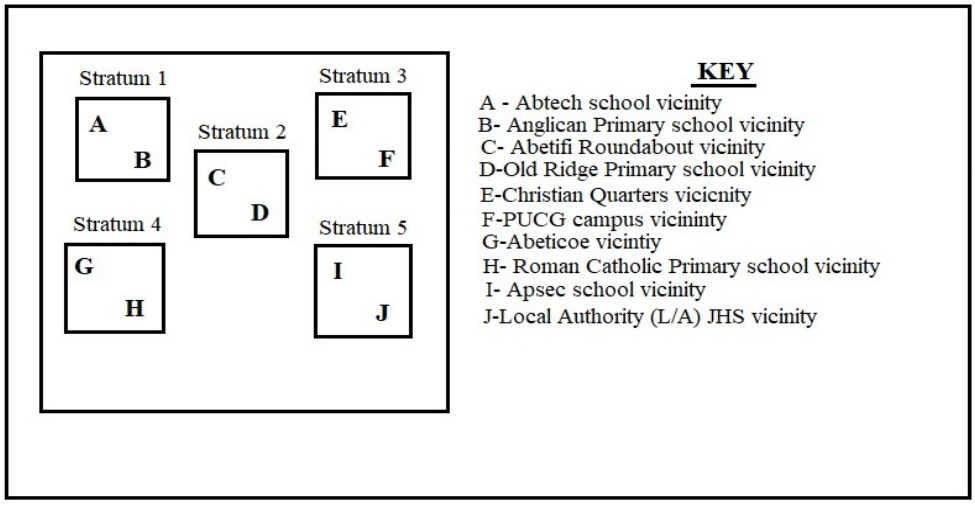

Fig. 2. Layout of Abetifi Township showing various strata where respondents were randomly selected

[Source: The Authors, 2018]

3.3 Data Analysis and Presentation

The data was keyed into the Statistical Package for the Social Sciences (SPSS) and analysed using the interpretative technique to analyse observation and interview information obtained. The descriptive statistical method was used in summarising and presenting data in the form of tables and numerical measure (percentages) in an informative way.

4. RESULTS AND DISCUSSION

4.1 Demographic Characteristics of Respondents

4.1.1 Gender of respondents

Majority of the respondents interviewed were females represented by a proportion of 54% of the total number of the interviewees (Table 1). In contrast, there was 46% male representation for the study sample. Commonly, women and girls are known to be involved in the handling and management of household water for several domestic purposes.

Table 1. Gender distribution of respondents

Gender of respondents	Number of respondents	Percentage of respondents
Male	92	46
Female	108	54
Total	200	100

Source: *Field survey, 2017*

4.1.2 Age of respondents

Majority of the respondents were under the age group of 31-40 years and represented by 34% of the study sample (Table 2). This indicated that majority of the respondents were in the parenting and working ages. Persons in this age group, use water for domestic activities at the household level and other socio-economic activities. Moreover, 26% and 22% of the respondents were in the age groups of 21-30 years and 11-20 years respectively. The respondents over 40 years of age group represented only 18% of the study sample. In all, there was a fair representation of all age groups for the study.

4.1.3 Duration of residency of respondents

Table 3 below indicates that majority of the respondents (24%) have stayed in the study area between 31-40 years. Twenty-three percent (23%) and 21% of the respondents have lived in the study area within the periods, less than 10 years and 21-30 years respectively. Eighteen percent (18%) of the respondents have lived in the area during 10-20 years with the least of the respondents (14%) having been residents of the study more than 40 years. The number of years respondents have stayed in the study area was very important to obtain information that tells the real situation in terms of water supply during the dry season.

Table 2. Age distribution of respondents

Age of respondents (years)	Number of respondents	Percentage of respondents
11-20	44	*22*
21-30	52	*26*
31-40	68	*34*
>40	36	*18*
Total	200	*100*

Source: *Field survey, 2017*

Table 3. Duration of residency of respondents

Duration of residency of respondents (years)	Number of respondents	Percentage of respondents
<10	46	23
10-20	36	18
21-30	42	21
31-40	48	24
>40	28	14
Total	200	100

Source: *Field survey, 2017*

4.2 Proximity to Water Supply Points

Public Stand posts made up of several taps connected to a service line (a borehole) as described by one author [18] and dug wells are primarily patronised by the folks in the study area during the dry season as the available streams are dried up. Several authors [19] described a reliable service like the one which is easy to access without one going through unnecessary stresses. Results of the study refuted this assertion; water accessibility at supply points in the study area has always been faced with challenges during the off-season period. Proximity to stand posts and dug wells have invariably been a significant challenge in rural communities for which the study area was not an exemption. In most times, the community people trek long distances before accessing the available water.

The study revealed that 16% and 22% of the respondents spent approximately 20 minutes and 35 minutes respectively to access water and return to their homes (Table 4). A few (10%) claimed they spent ~15 minutes doing same. A relatively more significant proportion of the sampled population (52%) instead spent more than 40 minutes to access water from the available supply points and return to their homes. The longer duration could have possibly been attributed to longer distances one has to pursue in accessing water amid queuing times. Those who may find queuing to obtain water frustratingly leave their containers in the custody of water sales personnel and thereby stand pipes could be used to serve during their absence. Although such people do not waste time waiting at the water supply point, there is always a longer time before they are able to access the water again in such a water-stress condition. The implication is that households have to manage quantities of water for a period before they could access the water supplies again. Households with larger family sizes are the ones that suffer from this challenge the most.

Table 4. Duration used in accessing water and returning to homes

Duration for accessing water	Number of respondents	Percentage of respondents
Appx. 15 minutes	20	10
Appx. 20 minutes	32	16
Appx. 35 minutes	44	22
> 40 minutes	104	52
Total	200	100

Source: *Field survey, 2017*

4.3 Wholesomeness of Accessed Water during the Dry Season

As shown in Table 5, there were different forms by which people in the study area use accessed water. When asked, respondents gave several application of accessed water. Respondents used accessed water for drinking (19%), cooking (47%), bathing and washing (34%).

Table 5. Uses of water accessed by respondents

Uses of accessed water	Number of respondents	Percentage of respondents
Drinking	38	19
Cooking	94	47
Bathing and washing	68	34
Total	200	100

Source: *Field survey, 2017*

The various uses of accessed water indicated by the respondents were not surprising as the majority of them (68%) claimed the supplied water was good with only a few (32%) making mention of its particulate nature (Table 6). Charrois [20] endorsed that water from dug wells in rural areas has been challenged with the lack of quality tests over the time and as such stands a higher risk of compromising people's health.

It is imperative for community water supplies to be of good quality to ensure the safety of consumers [19]. Consequently, several researchers [21,22,23] have attributed many health challenges and diseases to unhygienic rural water supplies. Most importantly, the supply of good quality water in proper quantities, safeguard primary health of people as well as socio-economic development [24]. The universal water, sanitation and hygiene could not be considered for compromising the water quality characteristics.

Table 6. Perceived quality of available water supply in the study area

Perceived water quality	Number of respondents	Percentage of respondents
Good	136	68
Salty	0	0
Bad odour	0	0
Tainted water	0	0
Particulate water	64	32
Total	200	100

Source: *Field survey, 2017*

Globally, approximately 3.5 million deaths and a daily record of 1,000 child mortality has been occurred as a result of unsafe water, poor sanitation and hygiene [25,26]. When the basic water accessibility level is not attained, achieving proper personal hygiene becomes very difficult to envisage. Time and distance thus play a significant role in determining the volumes of water that people can access to meet their hygiene needs [12]. This study reveals the levels at which people can access water are linked with the assurance of their health (Table 7).

4.4 Community Water Costing and Reliability

Most often, water supply systems have broken down primarily as a result of managerial as well as financial challenges. Over the years, researchers have explained the essence of developing a more efficient system. A primary factor in ensuring the sustainability of rural water supply systems is the ability and willingness of

community people to pay for the service provided. As indicated in Fig. 3, reliable payments for water service will ensure that community water supply management framework works effectively. Such water supplies must be potable, reliable, and easily accessible without spending longer time in accessing them.

The challenge of rural water supply systems sustainability transcends local and regional boundaries. However, there is the utmost need for whole community involvement and support, in the project during its design, construction and management to ensure its sustainability. These would go a long way in ensuring the financial as well as the managerial strength of the system. Sound financial management certainly needs to be strictly adhered to cater for the operational and maintenance needs (O&M) of water supply systems and as well ensure their robustness and sustainability (Fig. 3).

During the study, a 25 litre container of water has been cost around 40 Ghana pesewas (US$0.08) while a 30 litre container of water cost around 50 Ghana pesewas (US$0.10) at water stand posts. However, the respondents described these prices as fair and were willing to pay without hesitation. The volumes of water accessed by the respondents were not affected by cost but perhaps other factors [27]. Some respondents had shown high interest in household connectivity to the Ghana Water Company lines and were ready to pay for bills they would receive from the company if connected

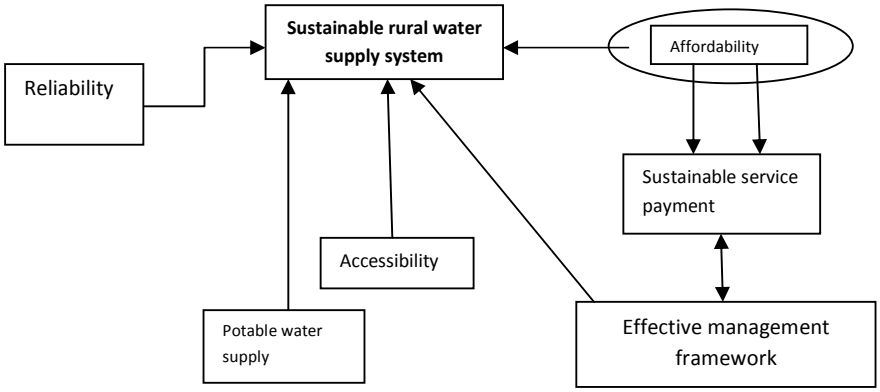

Fig. 3. A proposed structure of a sustainable rural water supply system
(Source: The Authors, 2018)

Table 7. Summary of requirement for water service level (accessibility) to promote health

Service level	Access measure	Needs met	Level of health concern
No access (quantity collected often below 5l/c/d)	More than 1000 m or 30 minutes total collection time	Consumption: cannot be assured. Hygiene: not possible (unless practised at source).	Very high
Basic access (average quantity unlikely to exceed 20l/c/d)	Between 100 and 1000 m or 5 to 30 minutes total collection time	Consumption: should be assured. Hygiene: hand washing and basic food hygiene possible; laundry/bathing difficult to assure unless carried out at source	High
Intermediate access (average quantity about 50l/c/d)	Water delivered through one tap on-plot (or within 100 m or 5 minutes total collection time)	Consumption: assured. Hygiene: all basic personal and food hygiene assured; bathing and laundry should also be assured	Low
Optimal access (average quantity 100l/c/d and above)	Water supplied through multiple taps continuously	Consumption: all needs met. Hygiene: all needs should be met.	Very low

Source: Howard and Bartram, 2003 [12]

to its lines while others called for the construction of more mechanised boreholes at vantage points for easy accessibility of the greater majority during the dry season. This fact was supported by the literature [28] as there is a need to reduce water accessibility distance and encouraged household connections.

5. SUMMARY OF FINDINGS

(1) Majority of the people (52%, n=200) in the study area spend longer period (> 40 minutes) in accessing water from available supply points before they return to their homes during the dry season.
(2) The quality of accessed water in the study area, were perceived to be good (68%, n=200) during the dry season.

6. CONCLUSION

During the dry season, local people use a lot of time to obtain water from the available supplies for their use. Sanitation and health aspects of the community folks could be jeopardised because the per capita water consumption at the household level would not be met with this stemming from insufficient water supplies for homes. Moreover, water supply in Abetifi-Kwahu during the dry season is a challenge to the extent that inhabitants who can only afford resort to purchasing water from neighbouring towns connected to the Ghana Water Company lines by increasing cost of assessing water and consequently living standards during this period. In contrast, accessed water during this period was perceived to be good in Abetifi within the Kwahu-East District of Ghana.

7. RECOMMENDATION

Water should easily be accessible to all in their sufficient quantities and qualities. There is a need for more stand posts and mechanised boreholes to be constructed at vantage points in the study community. Again, household connectivity to water supply lines should be considered, critically assessed and implemented by Government through the Ghana Water Company Limited and all relevant stakeholders. Water quality is very critical in ensuring proper public health and the prevention of water related diseases. It is therefore prudent that water resources used mostly for domestic purposes are highly accessible in their significant quantities and free from all forms of pathogenic materials. The authors consequently recommend a study on the assessment of the water quality of the several standpipes, dug wells and ponds which the community people resort to as there is little or no work done previously in this area.

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COMPETING INTERESTS

Authors have declared that no competing interests exist. The company name used for this research is commonly and predominantly selected in our area of research and country. There is absolutely no conflict of interest between the authors and company because we do not intend to use this company as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the company rather it was funded by personal efforts of the authors.

REFERENCES

1. IDLO. Water tenure reform and pubic access to water as a basic need, International Development Law Organization. Voice of Development Jurists Series; 2006.
2. Quargraine EK, Adokoh CK. Assessment of dry season surface, ground and treated quality water in the Cape Coast Municipality of Ghana. Environ. Monit. Assess. 2010;160:521-539.
3. WWAP (United Nations World Water Assessment Programme). The United Nations World Water Development Report 2016: Water and Jobs. Paris, UNESCO; 2016.
Available:http://unesdoc.unesco.org/images/0024/002439/243938e.pdf.
(Accessed 18 April 2017)
4. Guha-Sapir D, Hoyois P, Below R. Annual Disaster Statistical Review 2013: The

Numbers and Trends. Centre for Research on the Epidemiology of Disasters (CRED), Institute of Health and Society (IRSS), Université Catholique de Louvain, Brussels; 2014.
Available:www.cred.be/sites/default/files/ADSR_2013.pdf
(Accessed 18 April 2017)
Flanagan SV, Johnston RB, Zheng Y. Arsenic in tube well water in Bangladesh: health and economic impacts and implications for arsenic mitigation. Bull World Health Organ. 2012;90:839-846. Available:https://www.scienceopen.com/document?vid=ea6da984-9275-45e6-8c85-efd78fb8adba
(Accessed 18 April 2017)

5. OECD. Environmental Outlook to 2050: the consequences of inaction. OECD; 2012.
Available:http://www.oecd.org/env/indicators-modelling-outlooks/oecd-environmental-outlook-1999155x.htm
(Accessed 15 May 2017)
6. UNEP (United Nations Environment Programme) GEO. Global Environment Outlook 3, London: Earthscan. 2002;150–177.
Available:http://www.unep.org/geo/geo3/english/pdf.htm
Accessed 15 May 2017
7. WWAP (World Water Assessment Programme). The United Nations World Water Development Report 4: Managing Water Under Uncertainty and Risk. UNESCO, Paris; 2012.
Available:http://www.unesco.org/new/en/naturalsciences/environment/water/wwap/wwdr/wwdr4-2012/
(Accessed 15 May 2017)
8. United Nations (n.d.). Water.
Available:http://www.un.org/en/sections/issues-depth/water/
(Accessed 21 May 2017)
9. World Health Organization. Water, sanitation, and hygiene links to health: Facts and figures; 2005.
Available:http://www.who.int/water_sanitation_health/factsfigures2005.pdf
(Accessed 18 April 2017)
10. UNESCO. UNESCO water portal newsletter no. 161: Water-related diseases; 2006.
11. Howard G, Bartram J. Domestic Water Quantity, Service Level and Health. WHO; 2003.
Available:http://www.who.int/watersanitation health/
(Accessed 20 April 2017)
12. Nguyen TN. An Evaluation of Evaluation Systems for Rural Water Supply and Sanitation Systems. International Journal of Environmental and Rural Development, IJERD. 2013; 4-2.
13. Kwahu East – Ministry of Food & Agriculture (n.d.). Accessed 21 May 2017.
Available:
http://mofa.gov.gh/site/?page_id=1518
14. Adjei-Gyapong T, Asiamah, RD. The interim Ghana soil classification system and its relation with the World Reference Base for Soil Resources. Rapport sur les Ressources en Sols du Monde (FAO); 2002. Accessed 15 May 2017.
15. Nketiah-Amponsah E, Aidam PW, Senadza B. Socio-economic determinants of sources of drinking water: some insight from Ghana. In Conference on International Research on Food Security, Natural Resource Management and Rural Development, University of Hamburg; 2009.
16. Wedgwood A, Sansom K. Willingness-to-pay surveys: a streamlined approach: guidance notes for small town water services. WEDC, Loughborough University; 2003.
17. Jordan TD. A handbook of gravity-flow water systems for small communities. London, Intermediate Technology Publications; 1984.
18. IRC, WHO. Management of operation and maintenance of rural water and sanitation programmes–a training package for managers and planners. Geneva, World Health Organization; 2000.
19. Charrois JWA. Private drinking water supplies: challenges for public health; 2010.
20. Esrey SA, Feachem RG, Hughes JM. Interventions for the control of diarrhoeal diseases among young children: Improving water supplies and excreta disposal facilities. Bulletin of the World Health Organization.1985;63(4):757-772.
21. Esrey SA, Potash JB, Roberts L, Shiff C. Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. Bulletin of the World Health Organization.1991;69(5): 609-621.
22. WHO. Health systems: Improving performance, World Health Report, 2000, WHO, Geneva, Switzerland; 2000.

23. Cairncross AM. Health impacts in developing countries: new evidence and new prospects. Journal of the Institution of Water and Environmental Management. 1990;4(6):571-577.
24. UNEP (United Nations Environment Programme). Healthy Environment, Healthy People. Thematic Report for the Ministerial policy review session of the Second Session of the United Nations Environment Assembly of the United Nations Environment Programme, Nairobi. 2016;23–27.
Available:http://wedocs.unep.org/bitstream/handle/20.500.11822/17602/K1602727%20INF%205%20Eng.pdf?sequence=1&isAllowed=y
(Accessed 21 May 2017)
25. United Nations. Sustainable Development Goals. Goal 6: Ensure access to water and sanitation for all, facts and figures; 2016.
Available:http://www.un.org/sustainabledevelopment/water-and-sanitation/
(Accessed 21 May 2017)
26. Howard G (ed). Water supply surveillance - a reference manual. WEDC, Lough borough University, UK; 2002.
27. WELL. Guidance manual on water supply and sanitation programmes, WEDC, Loughborough, UK; 1998.

APPENDIX

QUESTIONNAIRE

RESPONDENTS: COMMUNITY FOLKS IN ABETIFI-KWAHU, GHANA

This study is aimed at finding out the opinions of community folks on the characteristics of off-season water supplies in Abetifi-Kwahu situated in the Kwahu-East District of Ghana. The study requires your truthful and honest opinion as a participant. As such, this request is voluntary so do not feel forced in any way in stating your views.

The research is purely for academic and development purposes and so your responses are assuredly confidential and anonymity is safeguarded.

Thank you for your participation.

INSTRUCTION: Please tick (√) the appropriate answer

#	SECTIONS	RESPONSES
	Demographics	
1	Gender	1. Male **2.** Female
2	Age at latest birthday	1. 11-20 2. 21-30 3. 31-40 **4.** More than 40
3	What is your highest level of education?	1. None 2. Primary 1-6 3. Middle/JHS 4. SSS/Technical 5. University/College 6. Non-formal 7. Others (Specify……)
4	For how many years have you lived in this community?	1. Less than 10 2. 10-20 3. 21-30 4. 31-40 5. More than 40
	Water supply issues	
5	What are the available water sources you have in your community?	1. Borehole 2. Dug well 3. Stream 4. Pond 5. Others (Specify……)
6	Are all available water sources in your community accessible during the dry season?	1. Yes 2. No
7	What are the available water sources you have in your community during the dry season period?	1. Borehole 2. Dug well 3. Stream 4. Pond 5. Others (Specify……)
8	In your view, do you feel there are challenges with accessing water sources in your community during the dry season period?	1. Yes 2. No
9	What is the proximity to available water sources in your community during the dry season?	1. Closer to my house 2. Far away from my house 3. Others (Specify……)

#	SECTIONS	RESPONSES
10	Is the number of water sources available to you during the dry season period adequate?	1. Yes 2. No
11	Do you queue to access available water sources in your community during the dry season?	1. Yes 2. No
12	In your view, approximately how many minutes do you use to access available water sources and return to your home?	1. 15 minutes 2. 20 minutes 3. 35 minutes 4. More than 40 minutes
	Perceived water quality and health issues	
13	How do you perceive the quality of the available water sources during the dry season?	1. Good 2. Salty 3. Bad odour 4. Tainted water **5.** Particulate water
14	What is your UTMOST use of the water you are able to access during the dry season period?	1. Drinking 2. Cooking 3. Bathing and washing
15	Have you ever been taken ill after ingesting the available water during the dry season?	1. Yes 2. No
	Community water costing and reliability	
16	In your view, do you think it is affordable to access water sources during the dry season?	1. Yes 2. No
17	In your view, do you think it is affordable to access water at stand pipes in your community during the dry season?	1. Yes 2. No
18	What is the cost of water at community stand pipes during the dry season?	**…….**
19	Do the community stand pipes frequently break down during the dry season?	1. Yes 2. No
20	In your view, do you think the management of the operations and maintenance of stand pipes in your community is good?	1. Yes 2. No
21	Are you always willing to pay for the water supply service in your community?	1. Yes 2. No
22	Would you prefer household water connectivity in your community?	1. Yes 2. No
23	Will you be willing to pay for bills you will receive from the Ghana Water Company after you have been connected to household connection?	1. Yes 2. No

**Kindly write any other comments and contributions you have concerning the questionnaire/Interview schedule at the back of the last page.*

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