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Dwindling water supply and its socio-economic impact in Sekyere Kumawu District in Ashanti Region of Ghana: public opinion on the role of climate change

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Abstract Water remains a vital natural resource necessary for sustaining life and development. Globally there has been increasing demand for water due to increasing population. Water demand has worsened in certain regions where in lieu of climate change water resources are declining. This has created livelihood impacts. Using in-depth interviews and household surveys of household heads and opinion leaders in the district, the study ascertained public opinion on the role of climate change on dwindling domestic water provision and how inadequate water supply affects the socio-economic lives of people at household level in Sekyere-Kumawu District in Ghana. Rising temperature, declining rainfall amounts and stormy weather were some of the perceived changing climatic elements explaining the reduction in the water resource base of the district. Shortage in water supply has great impacts on socio-economic livelihood and health of residents with greater impact on women and children. Households attributed low crop yields, the prevalence of water borne diseases and poverty as some consequences of low water supply owing to bad climatic conditions. The study recommends the development of district level climate change strategies,

incorporating them into the overall national climate change policy to ensure a comprehensive climatic resilient economy to promote sustainable growth and development.

Keywords Climate change · Ghana · Sekyere-Kumawu · Water resource · Water shortage

Introduction

All over the world, water is essential to human and animal lives and therefore must be protected for its sustainability (Potter et al. 2008). United Nations Development Programme (2012) explains water shortage as irregular available water resources to meet the demands of water usage within a region. According to Arthur and Sarpong (2000) if an individual person consumes less than 1000 m³ of water per year, then the individual is facing water shortage. When such a situation persists for a long period of time, then such a condition can be described as water scarcity. The Global Water Supply and Sanitation Assessment report (2000) explains that around 2.8 billion people around the world make use of water and it is estimated that at least 1 month out of every year, more than 1.2 billion people face shortage of clean drinking water. Around one fifth of the world's population currently live in regions affected by water shortages,

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where there are inadequate water resources to meet a country or regional demand (Schaeffer et al. 2013). Vörösmarty et al. (2010) and Goulden et al. (2009) showed that large parts of Africa currently have medium to high threats of blue water (rivers, streams, lakes, reservoirs and aquifers) scarcity less than 1000 m³ per capita per year. Goulden et al. 2009 observed that apart from North Africa and South-eastern Africa, water security threats appear to be particularly high along the Guinea coast and East Africa. The Volta Basin was also said to be approaching situations of water stress (less than 1700 m³ per person per year).

According to Goulden et al. (2009), climate change is expected to affect the timing, distribution and quantity of water resources which will worsen the water stress conditions of most African countries in the coming decades (Schellnhuber et al. 2012). Fung et al. (2011) model scenarios of 2 °C and 4 °C warming of sub-Saharan Africa show decreases in runoff of 60–80% by 2100 above 1961–1990 levels. Water related issues are very critical in development and for this reason, programmes are organised by the United Nations with the aim of sustaining water resources. Such programmes include the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs). The Millennium Development Goal (MDG) 7 and the current Sustainable Development Goal (SDG) 6 aim at increasing access to clean and adequate water supply as well as sound management of freshwater resources (UN 2015). Both goals highlight water shortages and the effort to address water challenges for sustainability.

Many factors contribute to water shortages and these include the elements of climate such as changes in temperatures, rainfall, and humidity. There are also environmental factors which include demographic changes, pollution, economic development, urbanization and others. Weaknesses in institutional regulations and management like lack of public participation pose a challenge to sustaining water for domestic and industrial activities (Arthur and Sarpong 2000).

In Africa, the arid regions frequently suffer from water shortages which may become a major constraint on socio-economic lives of the people at the household level (Achebe 2000). Meanwhile, water use is essential, especially for domestic and industry (Potter et al. 2008). This means that where water is not enough to support households, the impact is felt in the spheres of

health, hunger, education, poverty, gender discrimination of which both men and women as well as children are deeply affected (Archer 2009). According to Schaeffer et al. (2013), changes in climatic conditions, including temperature and precipitation patterns, as well as the incidence of extreme events such as droughts and heat waves, have the potential to undermine human health in Africa. The distribution of vector-borne diseases such as malaria, dengue fever and water-borne diseases such as cholera and dysentery are already being affected by local environmental changes across Africa. Droughts have been associated with diarrhoea, scabies, conjunctivitis and trachoma (Patz et al. 2008).

People walk for hours to fetch drinking water and this exposes them to threats of violence, economic, social and health hazards. Women and girls are the most vulnerable for they walk for hours to fetch drinking water (Dennis 2006). “Measuring the availability of water resources in relation to the number of people dependent on them yields an arguably more meaningful picture of the impacts of climate change on Africa’s populations. Where population growth and economic development are expected to occur, water availability will be a critical factor to consider” (Schaeffer et al. 2013, p. 10).

In Ghana, areas like Kumawu and its environs face water shortages (Arthur 2009). People manage water resources not only for productive uses, but also for domestic purposes; sanitation and hygiene for good health. In Kumawu township, the common source of water supply for households is pipe borne water which is not in regular supply (Dennis 2006). Alternatively, people resort to the harvesting of rainwater, boreholes, wells, water vendors, surface water resources like rivers, lakes, ponds and other water sources as the strategy for household survival (Arthur and Sarpong 2000). According to Ghana Water Company Limited (GWCL) (2013), the supply of water per person for household use has reduced. That is, in 1989–1994 water supply was about 15,000 m³ of which each year was 3000 m³. Unfortunately, from 1995 to 2000 it reduced to 6000 m³ of which each year was 1200 m³. From 2000 to 2013 water supply per person dropped again to 1000 m³ per year causing it to be in short supply. Sekyere Kumawu District Assembly (SKDA 2010) and Ghana Water Company Limited (2013) attributed the dwindling water supply to expansion of economic activities, population growth and other

climatic conditions in the region. This implies that water supply per person drops as population and economic activities grow in Kumawu township and the Sekyere Kumawu District as a whole (Clement 2012).

Despite the widespread literature on the ramifications of climate change on water resources and its implication on domestic water supply, most studies on climate change in Ghana have focused on the impact of climate change on agriculture (Environmental Protection Agency 2007; Arthur 2009; Fosu-Mensah et al. 2010; van de Giesen et al. 2010; Codjoe and Owusu 2011; Friedrich Ebert Stiftung 2012; Laube et al. 2012) with less attention on water resources and the impact on domestic water provision. Some studies have been undertaken on the impacts of climate change on water resources in the country, but it needs to be emphasised that these studies have been on national, regional and catchment basis (Adofo 2005; Kunstmann and Jung 2005; Environmental Protection Agency 2007; Kankam-Yeboah et al. 2011; Sarpong 2013) without examining the ramifications on community and/or household levels. The primary research questions for the study were:

- a) What are the perceptions of climate change at the community and household level on water shortage in Sekyere Kumawu District?
- b) And what are the socio-economic consequences of the dwindling water supply on the community and household activities?

It is in the light of these that this research sought to ascertain public opinion on the role of climate change on the dwindling water provision and investigate how insufficient water supply affects the socio-economic lives of the people at the community and household levels in Sekyere Kumawu District.

Literature review

Since the 1980s, large literature has appeared on the interactions between climate, water resources and the economy (Juana et al. 2012). The empirical works of Kates et al. (1985), Alm et al. (1993), Rosenzweig and Parry (1994) provided theoretical explanations of the interactions of climate change and economic change (Juana et al. 2012). Kates et al. (1985) developed methodologies that assess the impact of climate

change on the economy. Alm et al. (1993) used matrix methods to relate types of climate change effects to qualitative impacts of various economic sectors including fisheries, agriculture and forestry, tourism, settlements and structures among others. Recent works on the socio-economic impact of climate change include Carleton and Hsiang (2016), Gbetibouo and Hassan (2005), Elum et al. (2017). Gbetibouo and Hassan (2005) employed a Ricardian model to measure the impact of climate change on South Africa's field crops and analysed potential future impacts of further changes in the climate. Results indicate that production of field crops was sensitive to marginal changes in temperature as compared to changes in precipitation. Temperature-rise positively affects net revenue whereas the effect of reduction in rainfall is negative.

During the first decade of the twenty-first century, more studies have been carried out to evaluate the socio-economic impact of climate change on water resources (e.g. Andersson et al. 2006; Arnell 2004; Beck and Bernauer 2011; Bou-Zeid and El-Fadel 2002; Juana et al. 2012; Kusangaya et al. 2014). Bou-Zeid and El-Fadel (2002) used a GCM to assess the socio-economic impact of climate change on water resources in the Middle East. The findings suggest that climate change will further exacerbate existing water shortages, but that similar hydrologic impacts would have differing socio-economic consequences, because of differences in region-specific characteristics.

While the above studies have thrown light on the complex relationships between climate change, natural resources, and economic activities, the extent to which these relationships affect human welfare have not been adequately investigated (Juana et al. 2012). Juana et al. (2012) used a computable general equilibrium (CGE) model to analyse the socio-economic consequences of the impact of climate change on water resources in South Africa. It also examined both internal and external policies that could reverse the adverse consequences of climate change on the affected population groups. The results suggest that water scarcity due to the impact of climate change generally leads to a decline in sectoral output (e.g. agricultural output) value added, and household welfare. Bandyopadhyay et al. (2012) quantified the impact of variations in precipitation and temperature on the regional prevalence of diarrhea in children under the age of three in Sub-Saharan Africa. The

results show that shortage of rainfall in the dry season and an increase in monthly average maximum temperature increases the prevalence of diarrhea across Sub-Saharan Africa. There are other studies that have related climate change to health problems (e.g. Kalkstein and Smoyer 1993; Patz et al. 2005, 2008; Yao-Dong et al. 2013). For instance, Yao-Dong et al. (2013) found that daily mean surface air temperatures above 26.4 °C increase the death risk for the people in Guangzhou, especially the elderly are vulnerable to variations in temperature. According to them heat waves can cause insomnia, fatigue, clinical exacerbation, or death from heatstroke.

Climate is the primary determinant of agricultural productivity hence concerns over the potential effects of climatic change on agriculture has motivated a substantial body of research over a decade (Adams et al. 1998). Research has explored the impact of changing conditions of climatic elements on agriculture, such as changes in crop and livestock yields, as well as the economic consequences of these potential yield changes (Carleton and Hsiang 2016; Deressa et al. 2011; Elum et al. 2017; Korres et al. 2017; Mendelsohn 2014). For instance, Mendelsohn (2014) explored the impact of climate change on crops in Asia using Richardian Model. The results reveal that warming would cause damages to Asian agriculture. The study showed that a 1.5–3 °C warming would reduce crop net revenues by 13% (US\$93 billion year⁻¹) - 28% (US\$195 billion year⁻¹). Elum et al. (2017) observed that recent weather data revealed that the climate parameters have significantly changed over time and these were substantiated by farmers' experiences. Vulnerability of households in agricultural sector to climate change have also received much attention in recent studies (e.g. Adu et al. 2018; Paavola 2008; Shah et al. 2013). Shah et al. (2013) applied Livelihood Vulnerability Index (LVI) in a comparative study of two wetland communities in the agricultural and natural resource-dependent in Trinidad and Tobago.

Impact of climate change and population on water stress have also been widely studied (e.g. Alcamo et al. 2000; Arsisoa et al. 2017; Bradley et al. 2002). Arsisoa et al. (2017) investigated water demand and supply prospects for the City of Addis Ababa by applying the Water Evaluation and Planning (WEAP) hydrological model using scenarios of population growth trends and climate change. Based on a population growth rate of

(3.3%) and rising climate change projections, there will be severe shortage of water in the city. Research has also revealed that population growth of cities or urbanization results in an increase in the total water demand for domestic services and to promote economic development (e.g. Bradley et al. 2002; McDonald et al. 2014, 2011). Generally, there is much literature on the socio-economic impacts of climate change on water resources, however, most of these studies are focussed on global, national, regional scales especially the empirical models with little attention on the micro scale. Causes and impacts of water scarcity varies across space owing to variations in factors such as climate, economic activities, lifestyle, culture among others hence micro scale studies of the socio-economic impact of climate change on water resources at community level is imperative.

Background to the study area

Kumawu District is located between latitude 0°20'N and 1°20'N and longitudes 6°52'W and 7°32'W (Fig. 1). It covers an estimated land area of 3500 square kilometers (Ghana Statistical Service 2014; Sekyere Kumawu District Assembly 2014). The district shares common boundaries with other districts in the region. They are Sekyere Central to the West, Sekyere East and Asante Akim North Districts to the South. Besides sharing boundaries with these districts in the Ashanti Region, it also shares boundaries with other districts outside Ashanti Region. They are Kwahu North District in the Eastern Region to the East and the Sene District in the Brong Ahafo Region to the North. Kumawu is the district capital (Ghana Statistical Service 2014; SKDA 2014; www.ghanadistricts.com) (Fig. 1).

Kumawu town, the district capital and 5 other major settlements (Table 1) have a population of 23,899 constituting 26% of the district's population (Ghana Statistical Service 2010). The composition of females and males in the population is 50.7% and 49.3% respectively. The economic activity, settlement expansion and other climatic conditions are posing threat to the water supply system in the locality (Sekyere Kumawu District Assembly 2010).

Climatic conditions in the district conform to that of the middle belt of Ghana (Sekyere Kumawu District

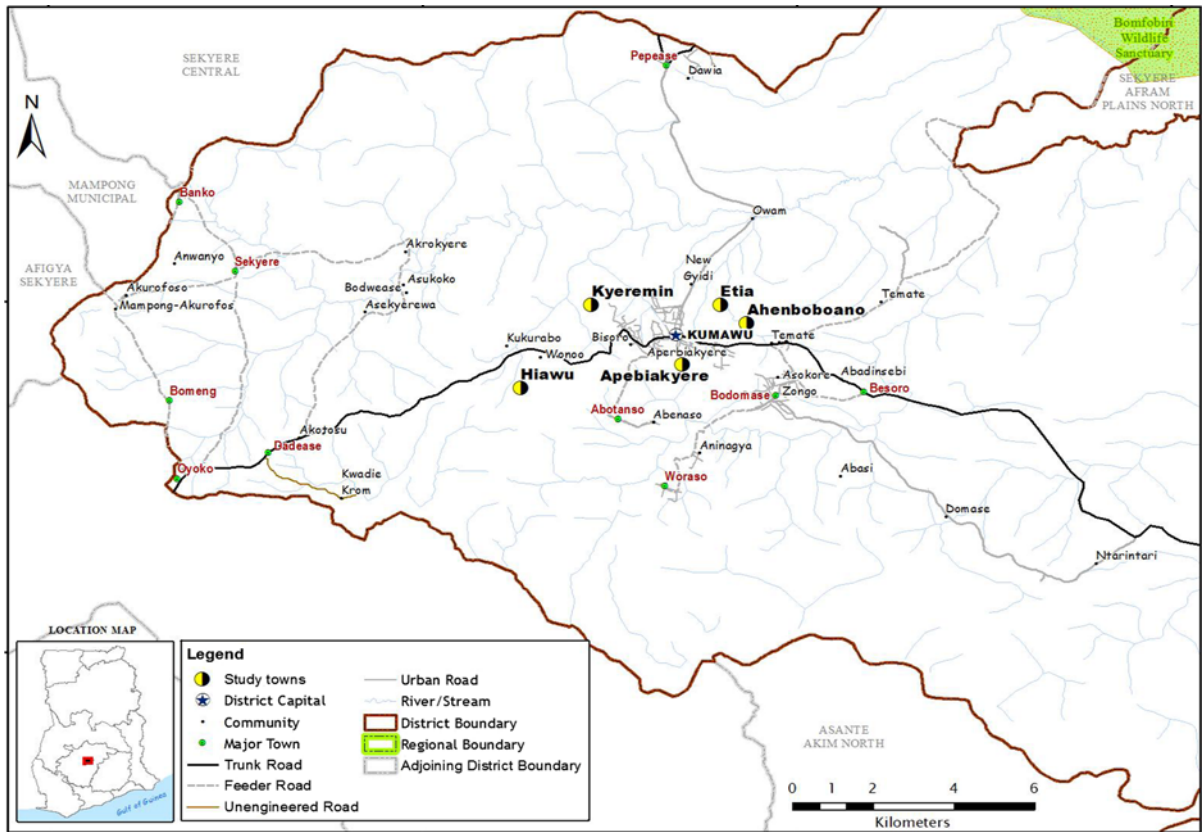


Fig. 1 Map of Sekyere-Kumawu District. Source: Centre for Remote Sensing and Geographic Information Services (CERSGIS), University of Ghana

Table 1 Population of the communities. Source: GSS (2010)

Community	Population	Sample distribution
Ahenboboano	6738	57
Etia	5890	50
Hiawu	4343	36
Kyeremin	3872	33
Apebiakyere	3056	26
Total	23,899	202

Assembly 2014). It has double maxima rainfall with the first rainy season occurring between March and July and the second starts from September to October every year. The mean annual rainfall is between 125 cm and 174 cm. The dry season is distinct and starts in November and ends in February. The district has monthly mean temperature of 26 °C with a maximum about 29 °C (Sekyere Kumawu District

Assembly 2010). The southern part of the district is covered with semi-deciduous forest. The northern part is covered with Guinea Savannah and consists of short deciduous fire-resistant trees. Basically, the vegetation consists of transitional and forest zones (Sekyere Kumawu District Assembly 2010). The transitional zone covers about 70 percent while the forest zone covers about 30 percent (Sekyere Kumawu District Assembly 2014). Within the district is a forest reserve called the Boum Fum Forest Reserve (Sekyere Kumawu District Assembly 2014). The soils in the area are derived from 4 geological formations Granitic, Birrimian, Voltaian and Alluvium rocks. Soils of the formation are Kumasi, Asuansi, Akroso, Nta, Ofin and Densu series. The soils are not good aquifers due to the low pore state of the soils (Sekyere Kumawu District Assembly 2014).

The main economic activities of the people in Sekyere Kumawu is agriculture which involves the cultivation of food and cash crops, animal husbandry

and small-scale processing of agricultural produce (Adofo 2005). Over four out of every five households (81.1%) undertake an agricultural activity (Sekyere Kumawu District Assembly 2010). The food crops grown are maize, cassava, plantain, cocoyam, yam and vegetables.

Methodology

This is a cross-sectional research of mixed methods (Tewksbury 2009; Teye 2012). The study was carried out by undertaking household surveys, in-depth interviews and observations (Luci 2012; Sarpsford 1999). The household survey was conducted using questionnaires and in-depth interviews with interview guides. The study area was visited, and questionnaires were distributed to households to elicit responses on the causes and effects of water shortages on their livelihoods. In-depth interviews were conducted with key stakeholders that had relevant information on climatic conditions for the past 30 years and how shortage in water resources is affecting livelihoods in the district.

For the questionnaire administration, five towns namely; Etia, Apebiakyere, Kyreremim, Hyiawu and Ahenboboano were selected (Fig. 1). Yamane (1967) formula (Eq. 1) for sample size calculation was employed to determine the sample size of the study:

$$n = \frac{N}{1 + N(e^2)} \quad (1)$$

where n = sample size, N = the population size, and e^2 = margin of error.

The sample size was calculated at a confidence interval of 93% with a margin of error (e) = 0.07:

$$n = \frac{23,899}{1 + 23,899(0.07^2)}$$

$$n = 202$$

The sample size for the household survey was 202 respondents and 20 stakeholders for the in-depth interview. Using the proportional allocation formula, the sampling unit for each settlement was determined using the formula,

$$S = \frac{sP}{TP} \times n \quad (2)$$

where S = sampling unit, sP = Population of settlement, TP = Total population and n = sample size (Table 1). The systematic sampling technique was used to select households and the sampling interval was 5, thus every 5th household was chosen for the administration of a questionnaire in each community.

Purposive sampling was used to select interviewees for the in-depth interviews. One person was interviewed at Ghana Water Company Limited (1), Unit Committee Persons (5, *one from each community*), Gender, Children and Social Protection Department (1), farmers (7), food vendors (6). In-depth interview is unique since it helps solicit detailed information from experts in the field of study. Interview is also said to be a reliable method as it brings quick and factual response on subject being investigated (Sarpsford 1999).

Data on the following climatic elements; temperature and rainfall of Kumasi (*nearest weather station*) was obtained from the Ghana Meteorological Agency (GMET) to corroborate the perceptions of people from the social survey. Questionnaires were analysed using Statistical Package for the Social Science version 20.0 (SPSS) and results processed into descriptive forms such as tables and charts. The climatic data was processed in excel to line graphs to show trends and regression equations and co-efficients of determination of the charts were extracted to determine the nature/pattern of changes in the climatic elements over the period under consideration.

Results and discussion

Perception on water scarcity

The concept of water scarcity was demonstrated in several ways; the case of water shortage or insufficiency in water availability, problem of accessibility to water resources, poor water quality, increasing cost of water, lack of investment in water supply infrastructure to increase water production and supply and length of time spent in accessing water which are in line with the two broad concepts of water scarcity; physical and economic scarcity of water. It was stated by interviewees that it appears in Sekyere Kumawu District, the population's demand for water has outstripped the available water resources. The sources

of water to these communities are without doubt limited. There is heavy reliance on pipe borne water and the other alternatives like ground water and rainfall. From the three sources of water, majority (60%) of respondents depended on pipe as their principal source of water supply, groundwater constituting 38% and 2% for rainfall. They reported that access was limited mainly due to the unreliability in the supply of pipe-borne water. According to a respondent during field interviews she indicated that, “it is quite difficult relying solely on pipe water. You must wake up early to fetch the water if you don’t have tap in your house otherwise if day breaks you will meet very long queues. It is mostly frustrating for those of us who do not have the pipes in our houses” (52 years old mother at Ahenboboano).

The heavy dependence on pipe water by residents in Kumawu township and the rest of the district according to some residents is as a result of the pollution and siltation of rivers and streams. The Ghana Water Company Limited (GWCL) was quite reliable in their supply of good and clean water at inception. Consequently, many people shifted from streams/rivers and boreholes to pipe borne water. According to a septuagenarian “the rivers have been heavily silted and polluted because no one is responsible for their protection. People cut trees along the banks leaving huge amounts of debris (leaves, tree barks, branches) in the water to decay, silting the water course and exposing the rivers to the sun causing them to dry up” (72 years old male resident). According to the manager of the GWCL in Kumawu “the water treatment plant has been relocated from its former location (on the Onwam River) to the Afram River due mainly to the low levels of water recorded on the Onwam River.” Flow records at intake point of Onwam River before relocated shows a continues decrease in water levels in the river particularly in the dry season from 1990 to 2015. The width and depth of the river decreased by 2.5 and 0.3 m in the wet season and by

1.3 and 0.3 m in the dry season from 1990 to 2015 (Table 2). Besides these issues, GWCL indicated the lack of financial support to expand and improve on existing lines coupled with irregular supply of electricity are major challenges to their operations.

Though they count on pipe borne water however, owing to its unreliability they do resort to the alternative sources at certain times. For example, according to a woman “The pipe water is clean and good, but it is so unreliable now, and I spend so much time queuing for water. That is the reason I mostly go and draw water from the well” (46 years old woman at Hyiawu). Furthermore, a female trader in another community called Ahenboboano also stated that “we used to spend less time assessing water from the community pipe but now, unless you wake up early otherwise you might not get water. The water vendors spend much time before getting to our neighbourhood due to the expansion of the town hence a lot of people will have to be served before getting to our neighbourhood” (39 years Old Trader, Ahenboboano). An opinion leader made the following comments regarding water scarcity: “the Kumawu communities are facing water problems. People including school children spend good productive hours in search of water. Several promises of extending the pipelines to neighbourhoods for people to connect to their homes have been made but that is yet to happen. Getting water has become stressful in Kumawu” (Opinion Leader, Hyiawu). Also, in Kyeremin an opinion leader stated that “Water is a major problem for us in our community. Look the taps do not flow except for very few people who have connection to their homes. Also, the number of public standpipes is woefully inadequate. We struggle always (school children, parents and others) to get water and the situation if not addressed will affect us greatly” (66 years old opinion leader, Kyeremin). According to a male farmer in Hyiawu: “our community has depended heavily on groundwater for our daily uses. But I tell you that,

Table 2 Seasonal changes in the width and depth of River Onwam (1990–2015). Source: GWCL, Kumawu—2016

Year	Rainy season (June–September)		Dry season (December–February)	
	Width (m)	Depth (m)	Width (m)	Depth (m)
1990	5.5	6.2	3.33	2.1
2003	3.2	6.0	3.0	2.0
2015	3	5.9	2.0	1.9
Flow change	2.5	0.3	1.3	0.2

there are certain periods (dry season) that the wells dry up” (54 years Old Farmer, Hyiawu). These reports from residents demonstrate the struggles people go through daily to have access to water for livelihood activities in the district. This reflects the water scarcity state in the Sekyere-Kumawu District of the Ashanti Region of Ghana.

Perception of climate change as a cause of water resource decline

Climate change has become a global concern in many ways. Many have identified climatic variables as playing a key part in the supply of water resources across the globe. It is often perceived that with increasing temperature and reduction in rainfall in many places especially in the tropical regions, there is concern on shortage in water supply. Residents of Kumawu demonstrated some knowledge on climate change and the resultant effects on their water bodies and other aspects of their livelihoods. As shown in Fig. 2, climate change was perceived as the most important factor accounting for the deteriorating condition in water provision in the study area. Ninety-seven percent (97%) of respondents attributed the continuous decline in water resources of the district to changes in climatic conditions in the locality. Other factors that were enumerated include population increase, deforestation, expansion of

settlements and water pollution. These other factors will be discussed in another manuscript. The community perceived climate change in the form of a decrease in rainfall, rising temperature and stormy/windy conditions during rainfall. In terms of effects, most residents indicated that, apart from anthropogenic factors, climate change seemed to have exacerbated the water shortage phenomenon in Kumawu.

Trends and patterns in rainfall were reported to be changing. Number of rainy months was perceived to be declining. According to the local people, rainy season used to span about 7–8 months (March–October) which facilitated two growing seasons for certain cereals like maize, but it was reported to be less than 7 months (April/May–October) in the past two decades. Onset of the major rainy season is now delayed, unreliable and starts around April/May and is characterised by drought in certain years. This observation by residents agrees with statistical analyses of rainfall patterns in the last 60 years by Laux et al. (2008) which showed that the onset of the rainy season in West Africa has shifted from April to May and dry spells in the rainy season have increased. “The trend will become more pronounced and climatic patterns more unpredictable and erratic, than they were previously” (Laube et al. 2012, p. 754). This increases the probability of the occurrence of extreme events such as droughts (van de Giesen et al. 2010). The changing

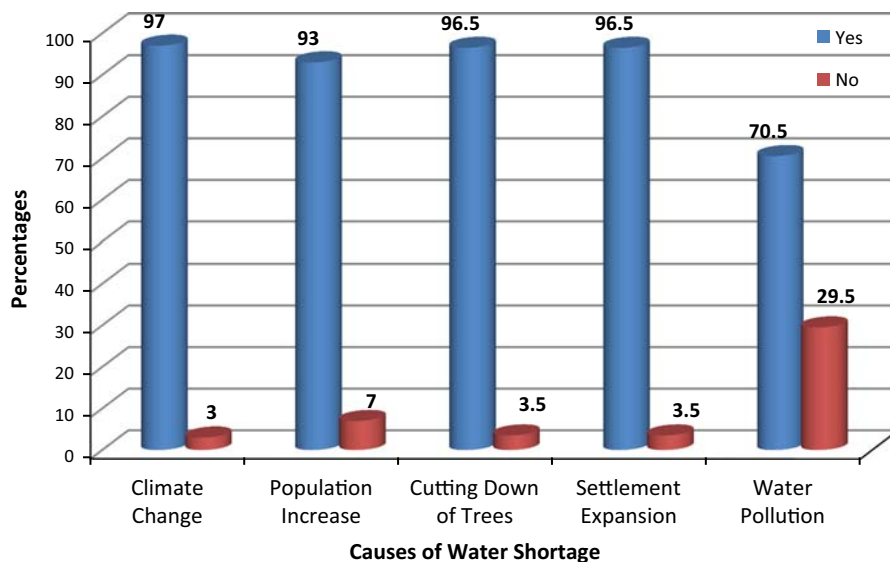


Fig. 2 Perceptions on causes of water shortage. Source: Field data, 2016

patterns in rainfall do not only affect agriculture but also results in low flows in rivers and streams that drain the district hence most of the surface water resources were reported to be drying up. This has dire consequence on domestic water supply as most of these water resources used to be the main source of water for residents. About 37% of farmers indicated that most of the streams they use to draw water from whiles in the farm have dried up and now they must carry water from home to the farms. River Onwam a major river which takes its source from the Boum Fum Forest is disappearing including other minor streams (Table 2).

A female interviewee observed that, the rainfall pattern has changed, and it appears the rainy season has rather been shortened for the past 20 years. She stated that; “Planting usually begins with the rains over here but now the planting season is delayed and unreliable due to changes in the rainfall pattern. Last year my husband’s maize farm dried up because he missed the timing for the first rain” (46 years old female at Etia).

Figure 3 illustrates mean annual rainfall of the region for the past five decades. The people’s perception agrees with that of the rainfall pattern which shows a decreasing trend over the years (Fig. 3). Though rainfall amounts have been decreasing, it is not that significant ($R^2 = 4.8\%$) as compared to the changes in temperature. From 1960, rainfall increased sharply peaking in 1968 with 195.4 cm, thereafter it has been on the decline hitting a record low of 74.3 cm in 1982. The years 1982 and 1983 were exceptional years as the whole country was plunged into serious drought for several months. From the 1960s the West African sub-region especially the Sahel and the semi-arid Guinea-Savannah experienced severe droughts for about three decades, particularly in the late 1970s and early 1980s, and Ghana had its share of this disaster hence the trend from 1970 to 1983 when the drought was more severe across the sub-region. Rainfall averages have since recovered (Hulme 2001) thereof.

Though rainfall amounts have increased from 1984 to 2012, the trend is still lower (mean = 112.5 cm) than records of the 1960s (mean = 134.4 cm).

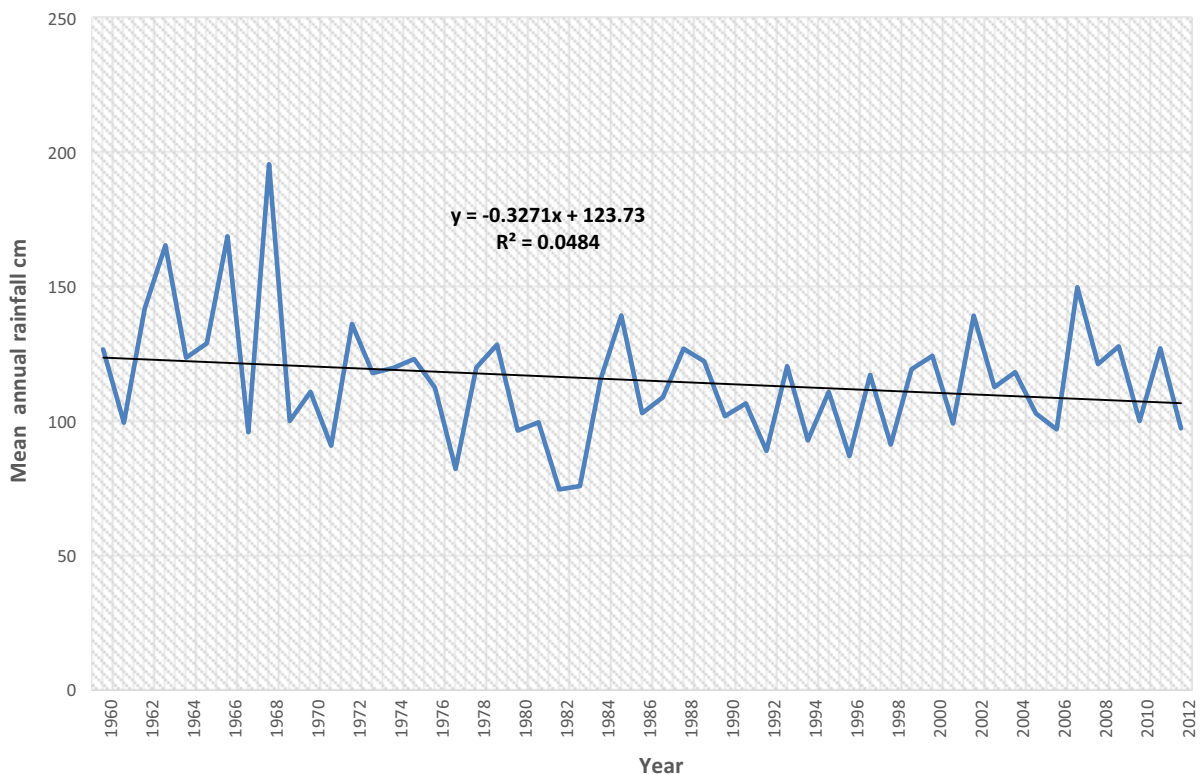


Fig. 3 Mean annual rainfall of Kumasi from 1960 to 2012. Source: Ghana Meteorological Agency, 2017

According to Niasse (2005), long term analysis of rainfall data shows a decrease in mean annual rainfall levels ranging from 10% for the wet tropical zones to more than 30% for the Sahelian zones in most parts of West Africa. For instance, mean precipitation amount decreased by 10% from 1100 mm per year between 1901 and 1969 to 987 mm per year between 1970 and 2002 within the Voltaian Basin (Kranjac-Brisavljevic et al. 1999). Rainfalls in the study area are also said to be characterised by heavy thunderstorms and strong winds which sometimes, ripped off buildings and destroy vegetation. And according to the Ghana Climate Change Policy document (Ministry of Environment, Science, Technology and Innovation 2013), the changing rainfall patterns can cause a reduction in total precipitation per annum, but rainfall events could be torrential resulting in storm damage and flooding. This phenomenon is in consonance with climate change projections which indicate that tropical cyclone-induced storm surges will be some of the impacts of global climate change (Schaeffer et al. 2013).

It was also revealed that temperatures have been increasing over the years. Aged and adults 30 years and above stated that, the weather has become warmer in the past 20–30 years. They described the extreme heat being experienced as a sign of climate change. These are the words of a farmer: “For some years now, the weather has become very hot especially in the evening. You cannot sleep without the fan. This was not the situation when we were children” (54 years old Farmer at Ahenboboano).

The observation of the local people is correlated by temperature records of the region. Temperatures of the region have been rising from 1960 to 2010 (Fig. 4) with the lowest record being 25.3 °C in 1964 and the highest 27.4 °C in 2010 and a mean of 26.4 °C (R^2 of 65.5%). It however dropped from 27.4 °C in 2010 to 26.9 °C in 2011 and to 25.7 °C in 2012. The rising trajectory of temperature conditions are in line with temperature records of the continent. A warming trend in Africa has been observed since the 1960s and this pattern is expected to continue as global mean temperatures rise (Schellnhuber et al. 2012). Schellnhuber et al. (2012) also found out that summer heat extremes greater than 3 standard deviations are projected to become more frequent with climate change. According to climate change models, freshwater ecosystems are expected to be affected by

climate change due to increased temperatures and altered river flows (Schaeffer et al. 2013). Beaumont et al. (2011) opined that freshwater ecosystems covering a significant portion of central Africa, coastal areas of West Africa and Madagascar to be at risk of 3 °C rise in global temperature.

In 2007 using historical data, the Ghanaian Environmental Protection Agency (EPA) projected a steady rise in temperature and a reduction in rainfall over the next decades. Historical data across the country from the year 1960 to 2000 show a continuous rise in temperature coupled with a decrease in rainfall in all agro-ecological zones in Ghana. Based on this data, the Environmental Protection Agency and Ministry of Environment, Science, Technology and Innovation estimated an average temperature rise of 0.6 °C, 2.0 °C and 3.9 °C; rainfall decrease of 2.8%, 10.9% and 18.6% by 2020, 2050 and 2080 respectively (Environmental Protection Agency 2007; Ministry of Environment, Science, Technology and Innovation 2013).

Aside surface water resources, it was also revealed that groundwater yield, as well as groundwater accessibility were becoming a problem. This situation was attributed to climate change because the local people indicated that low rainfalls have an impact on groundwater recharge. Thus, with limited rains, there is the likelihood that groundwater will reduce and that affects groundwater supply. Digging of hand dug wells was also becoming a problem because they claimed intense sunshine dries up the ground and makes the ground hard to dig hand-dug wells. This perception was supported by a male farmer’s views in these words: “The nature of the ground gives us so much stress in trying to tap underground water. The excessive sunshine with declining rainfall patterns means we keep digging deeper into the ground before reaching water. This used not to be the case” (43 years old male at Hyiawu). Deep chemical weathering produces deep soil profiles in the tropics hence weathered rocks can store large amounts of groundwater. Hence van de Giesen et al. (2010) found out that, it is only a more concentrated rainy season that can recharge the groundwater, but if the rainfall is spread out evenly over the season or is low little or no recharge may occur. And according to Scanlon et al. (2006) as evaporation and plant transpiration consume soil moisture leaving chlorides behind, groundwater recharge is seriously hampered. Groundwater is one

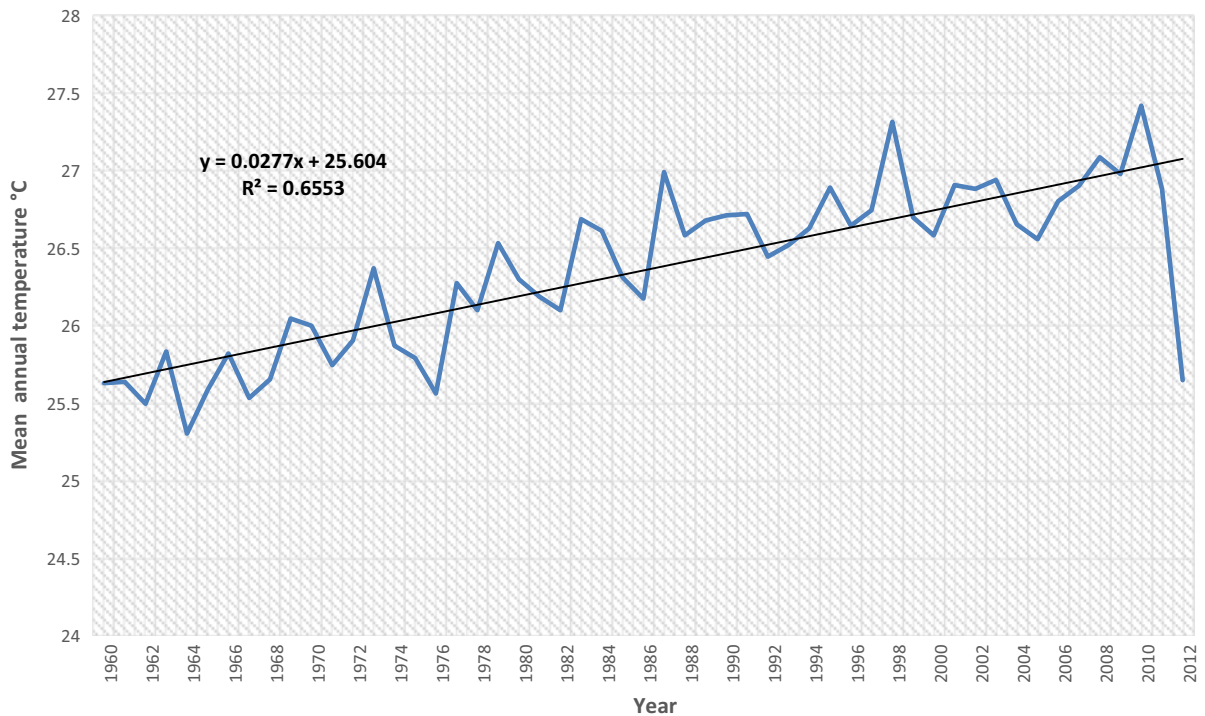


Fig. 4 Mean annual temperature of Kumasi from 1960 to 2012. Source: Ghana Meteorological Agency, 2017

alternative water source in the district. Therefore, the low yields and constraints of digging wells turn to exacerbate the water crisis at Kumawu and surrounding towns. Schaeffer et al. (2013) suggest a decrease in groundwater recharge rates of 50–70% and reductions in annual river discharges in West Africa owing to climate change.

According to the Ministry of Environment, Science, Technology and Innovation (2013), the changing patterns in temperature and rainfall have the potential to negatively impact on natural resources like forests, wildlife, coastal wetlands, rivers and lakes, which are critical resources for national development. Climate change projections indicate potential changes in the terrestrial and aquatic ecosystems which can affect natural resources and associated productivity, which impinges on livelihoods and food security of communities. There are also direct health implications for communities and ecosystems with extreme air temperatures. Temperature and rainfall conditions can influence vector-borne and environmental related diseases such as malaria, diarrhoea, meningitis among others.

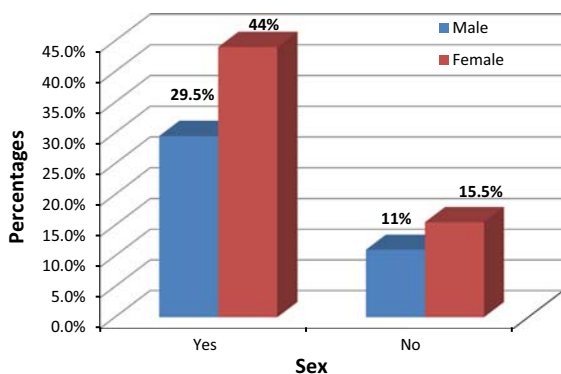
Effects of water shortage on socio-economic livelihoods

Water is a very important resource for the survival of mankind. Many household activities rely on water. Climate change is another known threat on the livelihoods of the rural folks because a larger percentage of the labour force 62% is in the agricultural sector (Ghana Statistical Service 2014). Thus, climate change and consequential impact of shortage in domestic water supply put a lot of stress on the livelihoods of individuals/households of the communities. Table 3 presents the perceptions of respondents on the effects of climate change and water shortage/scarcity on selected aspects of the socio-economic livelihoods of the people. There is a gender dimension to the problem and other impacts include education, food insecurity, health and poverty.

Figure 5 shows that both men and women perceived water shortage to be affecting more women than men in Kumawu. A total of 29.5% males agreed that water shortage affects women more while 44% of the female respondents also concurred to this view. Women are perceived to be more affected by water

Table 3 Effect of water shortage on various variables

Variables (effect of water shortage on...)	Frequency		Percentages	
	Yes	No	Yes	No
Gender	147	53	73.5	26.5
Children's education	193	7	96.5	3.5
Food insecurity	187	13	93.5	6.5
Health	184	16	92	8
Poverty	157	43	78.5	21.5

**Fig. 5** Perceptions on whether water shortage affects women more than men. Source: Field data, 2016

shortages because they oversee the running of homes and therefore must look for water when taps are closed by going to the streams or wells to fetch water. Most of the female respondents, also noted that the shortage of water supply affects their finances and activities too. When asked how water shortage affects their finances and activities, a female respondent gave the following explanation: “I am a food vendor. We use water at every point in time, cleaning of the vegetables, for cooking and for washing of the dishes. So now that the supply of water is not regular, I must pay more to tanker people to fill my tank. Sometimes, the tanker services don't come, and I have to send my workers over long distances to get water and this affects my income”.

Other women also noted that the shortage of water supply has made the upkeep of the household more difficult and expensive. Getting water for cooking, washing, bathing the children, and even drinking has become an added responsibility. This problem has been highlighted by the Ghana National Climate Change Policy document (Ministry of Environment, Science, Technology and Innovation 2013) that increased water stress will also reduce the availability

of water for both consumptive use and non-consumptive use such as hydropower generation which will retard economic growth and development.

The impact of climate change or water shortage on men was in the form of either lack of water to irrigate their vegetable farms or they must spend extra income in procuring water for household needs. This is because Sekyere Kumawu District is a typical male-headed household community (Ghana Statistical Service 2010). Thus, the responsibility of providing the basic needs rests on the man. Hence men typically spend more money in trying to get alternative supply of water especially from water vendors for their household needs. A male respondent in an interview stated: “If the tap does not flow for weeks, I have to give money to the children to get water from a vendor in the neighbourhood. And because the water is not pipe borne, there are fears of it not being clean so sometimes one needs to buy sachet water popularly called “pure water” for drinking and water from the vendors for other household chores. If you want to calculate the amount that goes into water provision, you will become angry”.

As noted earlier, the changing climatic elements are seriously impinging on the major agriculture activities of food and cash crop production (see “Effects of climate change/ water shortage on food security” section). The men also stated that the drying up of water resources, wetlands and shortage in pipe borne water was negatively affecting the cultivation and irrigation of vegetables particularly in the dry season hence most of them become ideal during this season. Since over 60% of the labour force is engaged in agriculture, livelihoods are seriously affected by the unfavourable climate conditions and water supply in the district.

Effects of water shortage on the education of children

Table 4 illustrates respondents' opinions on the effect of water shortages on children of school going at the basic level (7–15 years). The perception that water shortage affects children's education cuts across all the communities. Majority (96.5%) of the respondents indicated that water shortage is the bane on children's education in Sekyere Kumawu. The kids are tasked to ensure water is supplied to their homes each morning and evening. This takes a toll on their education due to the many hours spent securing water needs of the household. They have limited time to study, go to school late and are stress out/tired drawing water for the family. During interview session, one resident indicated that: "Because there is no water in the house, the children have to go and look for water each morning before going to school. Sometimes they must walk several kilometres to the stream to get water. Because of this, they get to school very late and sometimes they are unable to even go to school. This affects their performance due to school absenteeism and even when they go, because they are already tired, they are unable to concentrate on the teaching and learning in class".

Effects of climate change/water shortage on food security

Table 5 shows that 6.5% of respondents disagreed with the notion that water shortage/climate change has not affected food security in the District, while an overwhelming majority of 93.5% agreed to the view that climate change/water shortage has affected food security because their farming activities depend on

Table 4 Effects of water shortage on education in the communities

Community	Yes (%)	No (%)
Ahenboboano	32.5	0
Hyiawu	23	3
Kyeremin	10	0
Etia	14	0
Apebiakyere	17	0.5
Total	96.5	3.5

Table 5 Effects of climate change on food production in the communities

Community	Yes (%)	No (%)
Ahenboboano	21.6	2.5
Hyiawu	13.8	3.0
Kyeremin	10.4	0
Etia	11.5	0.5
Apebiakyere	36.2	0.5
Total	93.5	6.5

nature. From in-depth interviews, it was revealed by farmers that food production has been declining over the years due to lower and unpredictable rainfall pattern. Furthermore, those who used to rely on streams for vegetable gardening are unable to do that due to the drying up of surface water bodies and wetlands. This has resulted in rising cost of food particularly in the late season. According to Schaeffer et al. (2013), local climatic changes can alter the gestation period of crops. Climate change is expected to impact crop production in Ghana through changes in temperature and rainfall variability and this will affect majority of agricultural activities because it is rainfed making it particularly vulnerable to the changes in precipitation patterns. Mancosu et al. (2015) noted that water remains a critical resource in a decade of increasing population and rising demands for food resources. Water therefore is continually needed for food production through irrigation activities. Mancosu et al. (2015) argued that there is the need to make clear policies to the management of water sources to avoid the incidence of scarcity and shortage of water supply. Crop production is expected to reduce across the continent as optimal growing temperatures are exceeded and growing seasons shortened. Ecological zones of crops are likely to shift in response to local climate changes. At warming exceeding 3 °C globally, virtually all the present maize, millet, and sorghum cropping areas across Africa could become unviable for current cultivars (Schaeffer et al. 2013).

Also, certain crops particularly cereals grown in Ghana are sensitive to temperature conditions. For instance, maize crops are very sensitive to temperatures above 30 °C (Schaeffer et al. 2013). According to Lobell et al. (2011), yields are diminished by 1% for

each day a maize crop is subjected to temperatures above this threshold. Similar thresholds have been observed to exist for soybeans and cotton (Schlenker and Roberts 2009). Since maize is one of the major crops grown in the district, the crop will be threatened by the changing climatic conditions of the district. According to the Ministry of Environment, Science, Technology and Innovation (2013), with less predictable weather, uncertain and heavy storms are more likely to pose risks to people, communities and ecosystems. The Ministry observed that the decrease and unpredictability state of rainfall will jeopardize the employment of about 60% of the active population, majority of who are small-scale rural farmers. The shortening of the growing season has a severe impact on food security in these areas which practise rain-fed agriculture. Lower agricultural productivity from extended dry seasons and flooding from storm events are also increasing the pressure on the young and mobile to migrate to the cities in search of jobs. Increased rural–urban migration is one of the major concerns of the National Climate Change Policy as that will add to the pressure on cities’ infrastructure and other urban services (Ministry of Environment, Science, Technology and Innovation 2013).

Effects of water shortage on health

Table 6 indicates that 92% of the respondents across the towns are of the belief that water shortage affects their health while 8% of the respondents indicate that water shortage has no effect on their health. In an interview, a respondent expressed the following sentiments: “We use water for everything. Now that there is shortage in water supply, we buy water from vendors. Sometimes too we fetch from wells and

Table 6 Effects of water shortage on health in the communities

Community	Yes (%)	No (%)
Ahenboboano	29	3.5
Hyiawu	23	3
Kyeremin	10	0
Etia	13.5	0.5
Apebiakyere	16.5	1
Total	92	8

streams. These other sources of water are often not clean like the pipe water so that affect our health. We are not able to bath regularly; we don’t wash our clothes with enough water. Even our foodstuffs that we buy from the market are not properly washed because we are managing the water. So, at the end of the day, we get sick”. Some (24%) of the men also noted that instead of bathing twice, they now bath once or reduce the water quantity to manage with the limited stock. Residents are also compelled to consume polluted water amid the scarcity. They complained of getting infested with water borne diseases and sometimes lose their lives occasioned by these poor and unhygienic lifestyles brought on them by the inadequate water supply in the district.

The perception of these people corroborates statistics on water borne diseases at the Kumawu District Health Directorate which is quite high. For instance, 2013 recorded a total of 192 water related sicknesses. These ailments included 20 reported diarrhoea cases (2 deaths), 60 reported cholera cases (4 deaths) and 82 reported cases of typhoid (3 deaths). In 2015, the total number of cases increased to 229, 19.2% increase over the past two years. Seventy of the cases were diarrhoea (1 death), 74 cholera (3 deaths) and 85 cases of typhoid (5 deaths). Smith et al. expressed the view that access to safe water is a fundamental issue to survival, a basic right and a vital component in providing effective health protection. Further, Tarrass and Benjelloun (2012) noted that an estimated 1.6 million deaths occur every year as a result of water related diseases that emanate from water shortages including the lack of access to portable water, inadequate water supply among others. Model scenarios show that human health will be affected as rates of undernourishment and water-borne diseases (e.g. cholera) are altered by climatic changes (Schaeffer et al. 2013). Similarly, the National Climate Change Policy document also forecast deteriorating health conditions of increasing incidence of diseases due to climate change causing reduced access to water and food (Ministry of Environment, Science, Technology and Innovation 2013).

Effects of water shortage on poverty

Poverty is referred to as a multi-dimensional concept that encapsulates various aspects of human development. According to Gordon (2005) fundamentally

poverty is a denial of choices and opportunities, a violation of human dignity. It means lack of basic capacity to participate effectively in society. It means insecurity, powerlessness and exclusion of individuals, households and communities. It means susceptibility to violence, and it often implies living on marginal or fragile environments, without access to clean water or sanitation. Poverty therefore affects all aspects of human development and its measurement is seen as a lack thereof of the needs of individuals and societies to meet a sustainable livelihood. Results of Table 7 show that the communities perceived that dwindling water supply in the district can cause poverty. Over 78% of respondents indicated that climate change/water shortage is causing poverty in the district. Respondents (99.3%) indicated that water is a necessity. Thus, the extra burden of incurring high cost in the provision of water puts pressure on their livelihoods and exacerbates their economic status. Also, lack of water curtails their economic activity thus impoverishing them. This is the view of a respondent on the issue: “Because I can’t produce more crops to sell, my income has reduced. Coupled with this, I must pay for water every day for the provision of food and general water needs of the house like bathing and washing. We are now struggling to even survive due to this water problem”.

A similar observation has been made by Macheche (2011) about farmers in Limpopo (South Africa). He reported that respondents indicated there was high financial drain on their limited cash as they spent some percentage on water and food as they cannot maintain their vegetable gardens among others. According to the Ministry of Environment, Science, Technology and Innovation (2013) in the Ghana National Climate Change Policy, future growth of the country is still

Table 7 Effect of water shortage on poverty in the communities

Community	Yes (%)	No (%)
Ahenboboano	21.5	10.5
Hyiawu	21	5
Kyeremin	10	0
Etia	11.5	2.5
Apebiakyere	14.5	3.0
Total	78.5	21.5

threatened by the high vulnerability to climate change which is depicted by rising temperatures and unpredictable rainfall regimes across the various ecological zones of the country and thus exacerbating poverty amongst the poorest people, particularly women and children.

Conclusion and recommendations

The study has established that there is water stress in Sekyere Kumawu District and climate change is one factor accounting for the problem. The declining state of water resources in the district has been attributed to increasing temperature and decreasing rainfall patterns over several decades. The consistent water shortage is seriously militating against the livelihoods of the people. Areas of impacts include health, education, food insecurity and increasing poverty in the study area. In terms of gender, women and children were more affected than men. Hence, approaches to solving this problem must look at these gender perspectives. These findings are in line with the documentation by the Ghana National Climate Change Policy that, there is evidence of climate change impact on the national economy in areas such as agriculture, water resources, health and livelihoods and women and children. “It is already affecting national economic output and, therefore, Ghana’s long-term development prospects” (Ministry of Environment, Science, Technology and Innovation 2013, p. 4).

Coping and adaptation strategies with regards to water resources management like storage of water and rainwater harvesting in the short -run should be adopted. Institutional roles on the formulation of policies and programmes by the local assembly and Ghana Water Company on proper water resource management and the exploration of alternative sources like groundwater to augment water supply should be pursued in the short to medium term. Proper environmental management practices such as afforestation should be developed through education and sensitization. Enforcement of regulations regarding buffers around water bodies should also be done by the local assembly to prevent the encroachment of surface water resources. There must be a district level strategy targeted at mitigating climate change, controlling rapid urbanization and vegetation loss and pollution.

This could be achieved through mainstreaming the district level strategies into the national policies to address these issues. Strong collaborations should be established with various government institutions including Environmental Protection Agency (EPA), Ghana Water Company Limited (GWCL) and others. These measures will help the Government of Ghana to respond to climate change concerns of the country, promote sustainable development of the country and put the country on the path to achieving the sustainable development goals by 2030.

Author's contribution Authors have all contributed in the writing of the manuscript and consent has been sort from Mr. Kwame Adjei-Mensah to submit the manuscript for review. Dr. John Kusimi on behalf of Mr. Kwame Adjei-Mensah.

Compliance with ethical standards

Conflict of interest We declare that there is no conflict of interest.

Human and animal rights statement The work was self-funded by the student and did not involve animals but only human beings.

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