Climatic Variability and Food Crop Production in the Bawku West District of the Upper East Region of Ghana

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Abstract

The paper presents an assessment of climatic trends and patterns, and impacts on food crop productivity in the Bawku West District. The study adopted both statistical and descriptive approaches to achieve the formulated objectives. Rainfall and temperature data were obtained from the Ghana Meteorological Agency, Navrongo-Ghana, and the World Bank Climate Change Knowledge Portal. The main instruments used to gather information from the respondents were questionnaire, structured interview guide and field observation. Data were analysed using SPSS version 20 and presented in tables and figures. The study revealed that there were yearly irregularities in the amount and intensity of rainfall with increasing number of dry spells, implying the area is currently contending more with climate variability. It also revealed that climate variability has had negative implications on food crop production in the district such as unpredictability of onset of rains, crop failure and low yield. The current coping/adaptive mechanisms employed by farmers to climate variability in the district include irrigation, fertilizer application, growing improved crops, getting jobs outside agriculture, support from government and NGOs, and migration of the youth. It is therefore recommended that stakeholders provide subsidised farm inputs and ensure sound environmental management to cater for the consequences of climate variability on their livelihoods.

Keywords: climatic variability, coping strategies, food security, dry spells, Bawku West District.

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Introduction

The United Nations Framework Convention on Climate Change (UNFCCC, 2007: 7) defined climate change as ‘‘a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods’’(Article, 1).Climate variability is the short-term changes or variations in weather parameters/elements, while climate change is seen rather as a long-term accumulated effect of climate variability.

Changes in both mean and the variability of climate, whether naturally forced or due to human activities, pose a threat to food crop production globally. However, the manifestation of climate changes and its impact tend to be local or regional rather than global (Gabler, Sager, Brazier & Wise, 1987).Recent advances in understanding the atmosphere indicate that, the impact of these factors on crop yields and quality, especially maize, rice, millet etc, may be more severe than previously thought. World population growth has continued, and although the demand for food production has more than doubled since the pre-industrial era, productivity is declining due to climate change and climate variability (Nti, 2012).

Climate variability and change result from global use of energy due to industrialization, but its impact is manifested through changes in agro-ecological conditions and climatic factors, particularly precipitation and temperature. Precipitation, especially rainfall and atmospheric temperature are the important weather variables affected by climate change. These also play an important role in agricultural production, especially food productivity in sub-Saharan Africa. The unprecedented increases in global atmospheric pollutants emissions especially in the industrialized world have compounded the uncertainties in climate conditions. Although, sub-Saharan Africa, like other developing regions of the world, contributes the least to climate change and variability, it is known that semi-arid countries in sub-Saharan Africa will be the most affected by the phenomenon in terms of food production. Africa is expected to be the continent where the impact of global warming on agriculturally-relevant climatic variables and production will be greatest (IWRM, 2001 cited in Amikuzuno & Donkoh, 2012).

The Ghanaian agricultural-dependent economy is also estimated to suffer severe economic consequences from climate variability and change. Thus, Ghana’s economy essentially depends on climate-sensitive sectors such as agriculture, forestry, and hydroelectric energy (Nti, 2012). The needed capacity for adaptation by these sectors, particularly the agricultural sector is greatly lacking. Albeit Ghana’s lower middle income status, well over 50% of the country’s total workforce currently depends on subsistence-rain-fed agriculture for their daily livelihood. The country’s poverty gap keeps widening and the rural poor who are mainly peasant farmers, stands at a higher risk of climate variability and any extreme event (Nti, 2012). Northern Ghana is considered to be particularly vulnerable to climate variability; this is due primarily to drought and flood. The areas experiences long period of dry conditions, but when the rains come floods are also experienced especially at the peak of the raining season. This two extreme weather conditions worsen the vulnerability of the study area. There is also relatively low precipitation levels, higher temperatures, subsistence-based farming, higher poverty level, poor infrastructure, high illiteracy rate, and limited access to information compared to the other regions of Ghana (Nti, 2012). For instance, high resolution regional climate simulation using explicit dynamic downscaling of global climate scenario indicates a slight increase in total annual precipitation of 5%, but a significant decrease (up to 70%) of precipitation in April—the traditional month for land preparation and commencement of crop production in the Northern Ghana (Amikuzuno & Donkoh, 2012).

The total duration of the rainy season is revealed to have shortened, while dry and rainy season temperatures increased around 1^{o}C and 2^{o}C respectively (Kunstman & Jung, 2005). According to the Country Environmental Analysis Report of Ghana (2006), the current contribution of agriculture to Ghana's total GDP is projected to decline between 3 and 8%by 2050. A major contributory factor to this decline has been closely linked to unfavorable projected climatic conditions that are likely to have adverse effect on agricultural productivity, predominantly in the Northern part of Ghana. The main diet in most Ghanaian homes constitutes mostly cereals – millet, sorghum, maize, and rice – which are produced mainly in the Northern part of Ghana (World Bank, 2010). A decrease in production and/or yields of these commodities as a result of climate variability and change would worsen the already alarming threat of food security, particularly in the Northern sector, and severely affect the economic development of the region.

Climate is changing faster in Northern Ghana, relative to other parts of the country. Prolonged high temperatures and fire outbreaks that burn crops, coupled with erratic rains have characterized the climatic pattern of the region over the period 1983 to 2011. As the poorest and most agricultural dependent region of Ghana, the impact of such climatic conditions is devastating. A clear example is the 2007/2008 prolonged drought season which was followed immediately by a devastating flood in the entire Northern Ghana. Several food crops and livestock were destroyed (some washed away by the flood) causing severe food shortage; farm income declined; buildings, roads and other infrastructure collapsed; yield from crops declined and countless people were rendered homeless (Nti, 2012:64).

Because Ghana's northern savanna zones have historically experienced unpredictable rainfall and periodic drought, as a characteristic of dry land regions, residents have developed coping mechanisms to deal with climate variability over time. Thus, they can draw on past experiences to help themselves adapt to climate change. Traditional ecological knowledge plays an important role in this regard. Nevertheless, people's abilities to adapt will depend on the range of options they have available, which are product of several factors. These factors include social networks, access to capital, household assets and capacities, knowledge, skills, information resources, local institutions that influence resource access and use, enabling policies, and access to infrastructure (USAID, 2011). Traditional coping methods are often based on experience accumulated over the years and transmitted from generation to generation (Cooper, Dimes, Rao, Shapiro, Shiferaw & Twomlow, 2008 cited in Oriangi, 2013). Also, coping mechanisms in reaction to the stress caused by climate variability and change are obtained from a number of studies (Nti, 2012; USAID,2011;Van der Geest, 2004;Van der Geest, 2011;Quay, 2008). These studies indicated the following coping mechanisms; collection of wild foods, purchasing food from the market, in-kind (food) payment, support from relatives and friends, sales from livestock and household valuables, migration and wage labor in exchange for food, reduction in the number of meals served each day, reduction in the portions/sizes of meals and consumption of less preferred foods. According to FAO (2008), people can cope up with climate variability effects through getting jobs outside agriculture, pasture preservation, reducing the herd, asking for food aid and resorting to fruit trees as a strategy to cope with the famine period. According to Carmenza, Nicole, Hammill, & Riche (2011) as cited in Oriangi (2013), communities can also cope up to climate variability and change by accessing alternative natural resources from forests such as burning and selling of charcoal. These findings are generic, and the study had to establish the coping mechanisms that households in the Bawku West District employ in response to experienced effects of climate variability and change.

The above synthesis of literature reveals that the expected variations and changes in climate are diverse and geographic specific, affecting agriculture―particularly rain-fed agriculture in various ways. The communities have responded variously to climate stressor in order to cope and adapt. This study, therefore, investigated the variability and changes in climate and analysed the effects on food crop yields, the coping and adaptation strategies put in place by farmers in Bawku West District. Specifically, the study sought to investigate the extent of climate variability in the district, analysed its impact on food crop production as well as evaluate the coping and adaptation strategies by food crop farmers.

Review of related literature

Climatic patterns and trends in variability and change

The Fifth Intergovernmental Panel on Climate Change (IPCC) report confirms a clear tendency of the probable occurrence of more extreme events in many regions around the world (IPCC, 2013). Tropical regions are projected to experience the largest increments because of prolonged droughts, dry spells, and direct exposure of the region to the sun's rays throughout the year. There is even higher temperature projection by 1.5ºC by 2050 and by 4.3ºC by 2100 (McSweeney, New &Lizcano 2008). Most projections on climate indicate increase in the frequency of hot days and nights in current climate change; annual projections report that 'hot' days will occur on 15 - 43% of the day by the 2060s and 18-73% of days by the 2090s; however, projections indicate a decrease in the frequency of days and nights that are considered 'cold' in current climate (Oriangi, 2013).

Temperature levels are typically high in January, February and March when rainfall levels are generally low and relatively low in June and July when rainfall levels are above average (Nti, 2012). In a UNDP survey, mean annual temperatures for Ghana are projected to increase by 1.0 to 3.0ºC by the 2060s, and 1.5 to 5.2ºC by the 2090s (McSweeney, New & Lizcano, 2012). These temperature observations indicate variable results and underpin the need to understand the projected changes at a local level (Oriangi, 2012). According to Awen-Naam (2011), a cursory look at temperature records for some stations in the Upper East regions from 1991 to 2009 suggests no linear pattern of increase, rather an undulating pattern with a year of high temperature records on the average, followed by a year of a slight reduction in temperature.

It is projected that rainfall for the Sudan and Guinea savannahs will reduce by 2100 (EPA, 2000). Generally, Ghana has experienced a decline in mean rainfall from the period between 1951 and 1970 to the period between 1981 and 2000 (Owusu & Waylen in Yaro, 2010:39). The relationship between increasing temperature and amount of rainfall was studied historically and it was observed that the years 1961 to 1990 have witnessed a reduction in rainfall by 20% and runoff by 30% in Ghana as a whole (EPA, 2000). In a related study, USAID (2011), indicates temperature to be increasing more rapidly in the northern Ghana than elsewhere in the country, and is projected to keep getting hotter. At same time, annual decreases in total precipitation have been documented for the Guinea savanna, and rainfall is projected to decrease in the future in both the Sudan and Guinea savanna zones. Also, Yengoh, Armah, Onumah & Odoi (2010) studied the trends of agriculturally – relevant rainfall characteristics among small – scale farmers in Ghana. They used time series of daily rainfall data from 1960 – 2007 to identify the trends, temporal distribution, occurrence of extreme daily rainfall, the onset of rains, risk of dry spells and coefficient of variability of rain. They noted several outcomes which include the following:

- There were no significant change in the current onset of rains
- A decrease in the number of rain days and
- The probability of dry spells of up to seven and eleven days in the first four weeks of the planting season (Yengoh, Armah, Onumah & Odoi, 2010).

In this current paper the parameters of interest were temperature and rainfall and their influence on the agricultural sector. This is because temperature and rainfall are often the most cited climatic parameters as far as production is concerned.

Effect of climate variability and change on food crop production

Agriculture continues to provide employment and livelihood for a large proportion of Ghanaians, despite its declining contribution to total GDP. Agricultural production is predominantly subsistence or small scale and as results farmers who engage in it are poor due to low productivity level (Schultz, 1964 cited Nti, 2012). Increases in productivity are realized mostly with the addition of new lands to cultivation. Fewer advances in technology combined with the changing climate which is not suitable for producing certain staples makes the agricultural sector the most vulnerable. Climate change is expected to impact agricultural productivity in sub-Saharan Africa, especially cereal production. A study by Sagoe (2006) also indicated an impact on root and tuber production by climate change in Ghana. To him, cocoyam productivity will reduce by 11.8%, 29.6%, and 68% by the 2020s, 2050s and 2080s respectively.

Climate is changing faster in Northern Ghana relative to other parts of the country (Nti, 2012). Prolonged high temperatures and fires that burn crops coupled with erratic rainfalls have characterized the climatic pattern of the region over the period 1983 to 2011. As the poorest and most agricultural dependent region of Ghana, the impact of such climatic conditions is devastating. A clear example is the 2007/2008 prolonged drought season which was followed immediately by a devastating flood in the entire Northern Ghana. Several food crops and livestock were destroyed (some washed away by the flood) causing severe food shortage; farm income declined; buildings, roads and other infrastructure collapsed; yield from crops declined and countless people were rendered homeless (Nti, 2012:64).

Also, Antwi-Agyei, Fraser, Dougill, Stringer, and Simelton (2011) provide a comprehensive map of vulnerability in crop production to climate change, particularly drought, for all the regions in Ghana and some selected districts across the country. They used a three-stage method (crop yield sensitivity index, exposure index and crop drought vulnerability index) to determine the vulnerability of crop production (specifically maize at the regional level, as well as sorghum and millet at the district level) to drought. The crop (or maize) yield sensitivity indices for all the ten regions showed the Upper East and Upper West Regions as the most sensitive regions to drought. In terms of adaptive capacity to drought, the three regions in the northern sector: the Northern Region, Upper West and Upper East, were identified to have the lowest capacity to cope with drought. These regions invariably were noted as the most vulnerable to drought in Ghana. A study by Nti (2012) indicates that changes in the onset and cessation of rain pose a serious threat to household food production and security since maize is the staple of most Ghanaians especially in the Northern part of Ghana. Crops are vulnerable to climate variability as evidenced by obviously lower yields during drought periods and less dramatically by year-to-year variation in productivity. Variability can take many forms, such as less total annual precipitation, delayed onset of the rainy period, higher temperature or sub-optimum moisture during critical growth stages. Changes in average climate values in the regions currently could limit the growing of some crops and could reduce yields to non-viable levels. This could cause a shift towards agro pastoral systems (USAID, 2011).

Coping and adaptive strategies to climate variability and change on food production

Coping mechanisms to deal with climate variability over time include social networks, access to capital, household assets and capacities, knowledge, skills, information resources, local institutions that influence resource access and use, enabling policies, and access to infrastructure (USAID, 2011). Traditional coping methods are often based on experience accumulated over the years and transmitted from generation to generation (Cooper, Dimes, Rao, Shapiro, Shiferaw & Twomlow, 2008 cited in Oriangi, 2013).

Strong trends in climate variability are already evident, the likelihood of further changes are occurring, and the increasing scale of potential climate effects give urgency to addressing agricultural adaptation more coherently (IPCC, 2007; UNFCCC, 2003). Also, it should be recognized that "adaptation" is an ongoing process that is part of good risk management, whereby drivers of risk are identified and their likely effects on systems under alternative management are assessed. In this respect, adaptation to climate change is similar to adaptation to climate variability (Smith & McCathy, 2001 cited in Oriangi, 2013).Furthermore, the means and capacity in developing countries to adapt to variations and changes in climate are limited due to low levels of human and economic development which include low levels of technology, low education levels, limited supporting institutions and limited access to financial assets. These conditions combine to create a state of high vulnerability to climate variability and change in much of the developing world and greatly affecting food production (IPCC, 2007; FAO, 2008).However, the major challenge is how to adapt to climate variability and change without threatening sensitive livelihood systems. This will require analyzing and changing farming and food systems, learning from community based approaches, generation and use of technology, overcoming biotic stress in crops through crop breeding, targeting investments in understanding where different biotic stress dominate, and matching crops to future climate in a way that accounts for uncertainties (Smit & Wandel, 2006 cited in Oriangi, 2013). According to Schneider, Semenou, Patwardhan, Burton, Magadza, Openheimer, Pittock, Rahman, Smith, Suarez &Yamin (2007), there is evidence of an adaptation deficit and acting now to narrow the deficit can yield immediate benefits (Nail, Adejuwon, Barros, Barton, Kulkarni & Lasco, 2008 cited in Oriangi, 2013).

Conceptual framework

This section of the paper concerns the conceptual issue that underpins the paper. The driving forces, pressure, state, impact and response DPSIR framework is used for the research.

Figure 1 show the principal components involved in climate variability and food crops production. It discusses the linkages between the various processes of the subject matter. In achieving these objectives, the driving forces, pressure, state, impact and response (DPSIR) framework was used to explain cause-effects relationship on how food crop farmers' households are impacted by climate variability and change. This framework is an extension of the pressure-state-response model developed by the Organisation for Economic Cooperation and Development (OECD, 1993). The framework has been adopted by the European Environment Agency (European Environment Agency, 1995). The framework is a simplified conception of reality and a pragmatic approach to structure information. This conceptual framework was chosen to structure and analyse the research topic because it assumes cause-effect relationships among interesting components of social, economic and environmental systems. It helps to discriminate between inherent characteristics of environment (climate) and causes for change (Figure 1).

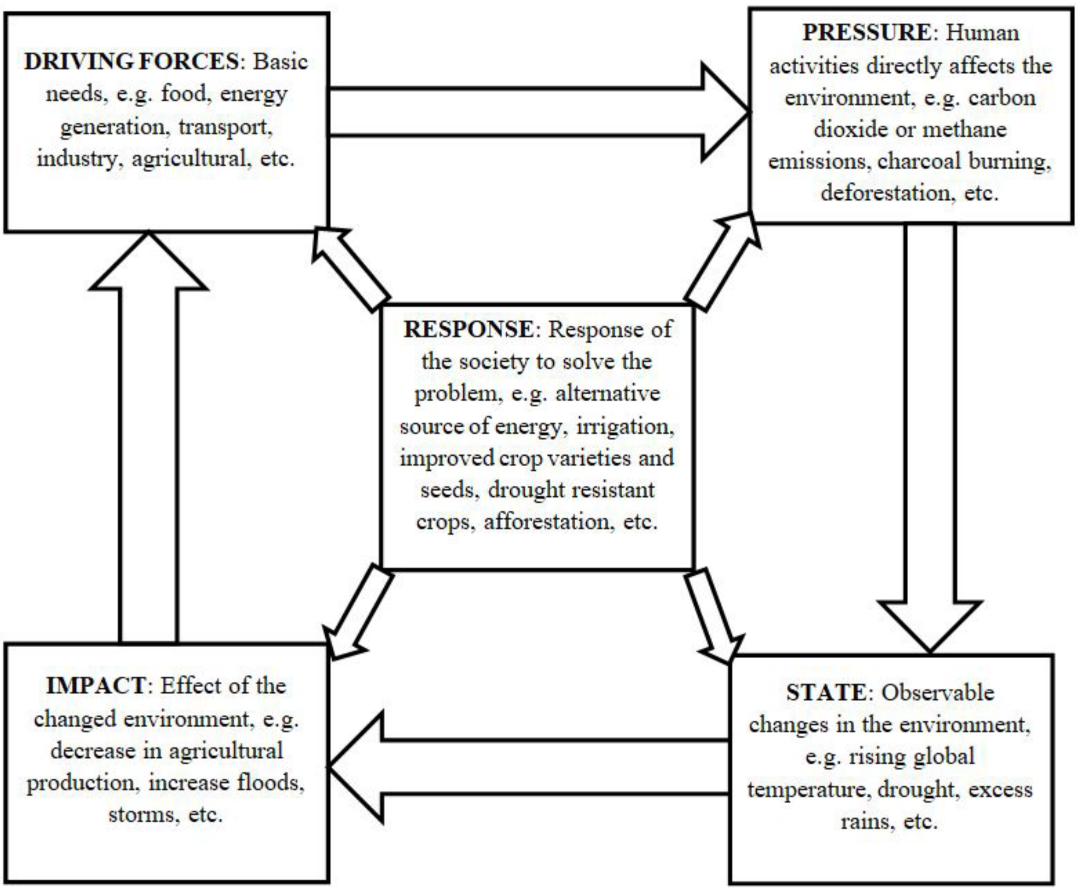

Figure 1: Driving forces-pressure-state-impact-response (DPSIR) model

Source: Adapted from European Environment Agency, 1995

In the context of the current study:

- Driving forces are the socio-economic and cultural forces driving human activities; this includes food security (cereals and grains), energy generation, transport, industry and agriculture among others. These increase or mitigate pressures on the environment.
- Pressures are the stresses that human activities place on the environment, such as carbon dioxide or methane emissions, excessive demand of water, poverty in the case of the three regions in the northern part of the country, flooding, etc.

- State, or state of the environment, is the condition of the environment such as rising global temperatures, drought, excess rains, or low rains, etc.
- Impacts are the effects of environmental changes including decrease in agricultural production, floods, migration, fire outbreak, destruction of food crops and livestock, etc.
- Responses refer to the reactions by society to the environmental situation such as irrigation, improved crops varieties, tree planting, alternative source of energy, drought resistant crops, etc., aimed at preventing, minimize or mitigate driving forces, pressures, impacts and the state.

According to USAID (2011), Ghana's northern savanna zones have historically experienced unpredictable rainfall and periodic drought, and as a result residents have developed coping mechanisms to deal with climatic conditions. Thus, they employ traditional ecological knowledge which includes social networks, access to capital, household assets and capacities, knowledge, skills, information resources, local institutions that influence resource access and use, enabling policies, and access to infrastructure.

In the context of the present study, the framework was applied to evaluate the extent to which climate variability impacts on food crop production in northern Ghana. The study area is an agrarian economy that depends mostly on the extent and duration of rainfall and other climatic variables in their agricultural production. Culturally, the production of food crops and the commencement of the planting season are driven by the weather. The erratic nature of rainfall in this area influences the adaptation strategy of the farmers which in most cases place enormous pressure on the environment (farmers and land). The current state of the study area is such that excessive temperature and unpredictable rainfall makes the area unfavourable for food crops production, thereby reducing the food crops yield. These situations affect livelihoods of the people. As a result, there is a need for the local people to develop a coping strategy such as planting drought resistant crops, use of pesticides, organic fertilizer, migration of people, and other adaptation strategies.

Study site

The study was conducted in the Bawku West District located in the Northeastern part of the Upper East Region of Ghana. Its geographical coordinates are longitudes 0º20' and 0º 35'East of the Greenwich meridian and latitudes 10º 30' and 11º 10'North of the equator. The northern section is bounded by the province of Zabre in neighbouring Burkina Faso, on the east by the Binduri District, on the west by the Talensi and Nabdam Districts and south by and Mamprusi District. The district stretches over an area of 1,070km^2. The 2010 census approximates the population of the district to be 94,034 with a population density of 87.88 persons per square kilometer. The study area falls within the Sudan savanna agro-ecological zone which forms part of the semi-arid areas of Ghana. The area has a unimodal rainy season lasting 4-6 months (from May to October) and a long dry period of 6-8 months (from November to April) in a year. The average annual rainfall for the area varies from 900 mm to 1150 mm and temperatures are high, averaging about 28.5ºC annually. The maximum length of growing period for rain-fed crops in the district is less than 60 days according to Atta-Quayson (1995) cited in (Nti, 2012). Figure 2 is a map of the study area.

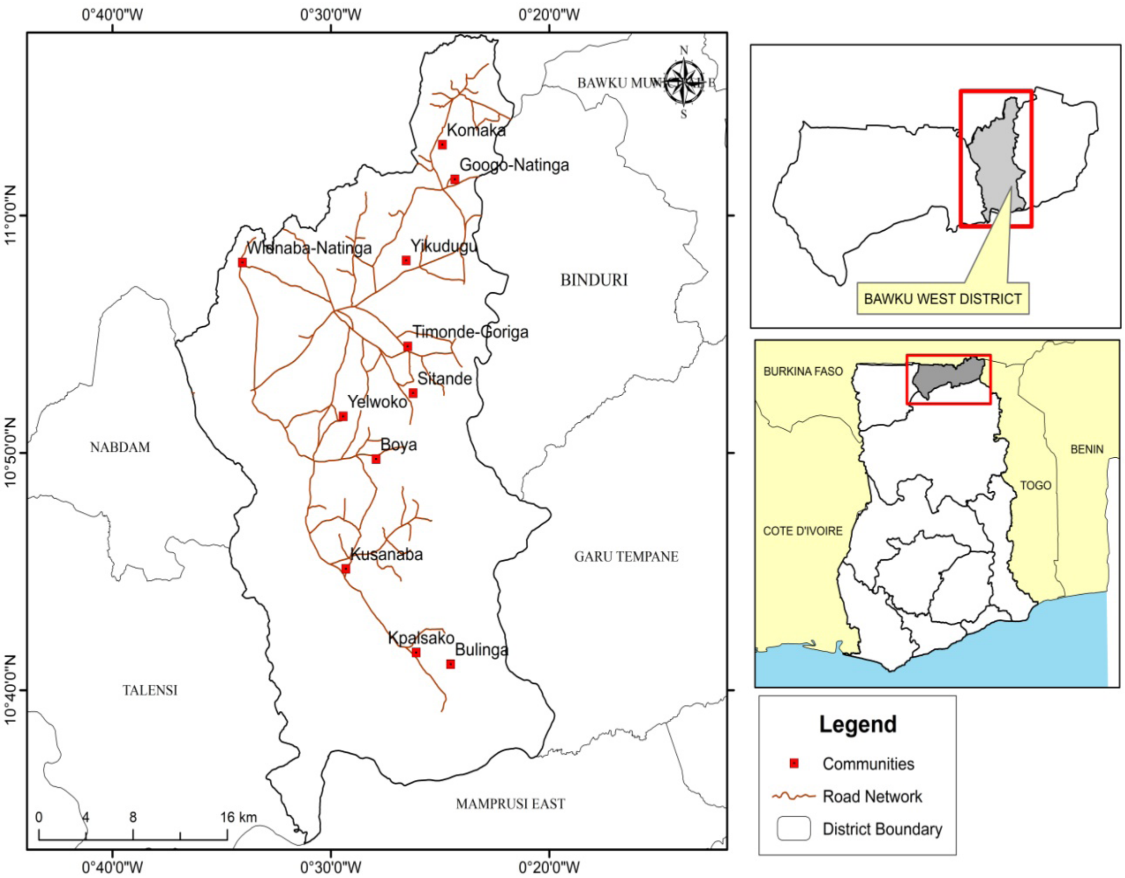

Figure 2: Map of the study area in regional and national context

Source: Department of Geography Education, UEW (2019)

Methodology

The research approach adopted was the mixed method with survey design. In-depth interviews and questionnaire were used to gather the needed data for the study. The data were collected from both secondary and primary sources. The secondary sources of data include published textbooks, journals and periodicals, while some unpublished theses and dissertations were consulted as well. The primary data sources were collected by the means of questionnaire administration to respondents in the field during survey. In addition, the climatic data on annual rainfall and temperature ranged from 2000 to 2013 were collected from the Ghana Meteorological Agency, Navrongo, while data on crop yield was collected from the District Department of Agriculture.

Since the issues studied were focused on climate variability, and their effects on food crop yield, coping mechanisms and adaptation strategies, the main target population of the study consisted of food crop farmers in the study area. Farming is the pre-dominant economic activity in the district. Agricultural households that engage in crop farming, dominantly food crops are about 98% (Ghana Statistical Service, 2014).The sample size for the research was Fifty three (53). These consisted of Fifty (50) farming households from the farming villages selected within the Bawku West District who understand what constitute agriculturally relevant rainfall characteristics as indicated in (Yengoh et al 2010) and have been practicing agriculture in their communities for more than three years. The farmers were selected through accidental sampling, that is, any farmer who was prepared to offer information was interviewed until the number required was derived from each community. The choice of the sample used was by random selection with the guidance of the agricultural extension officers in the communities. For the remaining three (3) respondents, two (2) workers were from the District Department of Agriculture (Agriculture Extension Officers) and one (1) from the Ghana Meteorological Agency, Navrongo. These were selected through purposive sampling technique as result of their knowledge and the information they possessed.

The whole district was divided into three zones and ten (10) villages from the zones were selected. The zoning of the area is in response to the monitoring mechanisms used by the agriculture extension officers in the area (Ministry of Food and Agriculture, 2015). Each of the zones is supervised by an officer to ensure proper monitoring and reporting. The zoning was based on the already established area councils in the district as shown in Table 1.

The study largely employed qualitative and quantitative data analysis procedures to analyse the data collected. The qualitative data obtained from the in-depth interviews were classified into themes and relevant responses that have relationship presented and some of them were directly quoted to support the quantitative data. Using descriptive statistics, quantitative data were analysed in terms of frequency distribution and percentage using SPSS version 20. Frequency and percentages, tables as well as line graphs were used to provide graphical representation of the responses.

Table 1: Distribution of sampled villages

Zone	Area councils	Villages interviewed	Total no. of villages	No. of households interviewed
Zone A	Binaba-Kusanaba, Zongoyire and Gbantongo	Bulinga, Yelwoko, Kusanaba and Boya-Kpalsako	60	20
Zone B	Zebilla, Tanga-Timonde and Tilli-Widnaba	Widnaba-Natinga,Yikurugu, Timode-Goriga and Sitande	71	20
Zone C	Sapeliga	Googo-Natinga and Komaka	28	10
Total			152	50

Source: Field work, 2016

Results and Discussion

Socio-demographics of respondents

The information gathered under this sub-section is the socio-demographic characteristics which includes; sex, age, level of education and number of years in farming of the respondents.

Table 2 shows that 39 (78%) of the respondents interviewed were males, while total of 11 (22%) were females. This implies that majority of the population engaged in agricultural activity are the male population. This could be that the social organization in Northern Ghana is based on patrilineal descent, therefore power is ascribed to men, and the allocation of resources, status and duties between men and women is determined by factors such as descent, succession and paternity. Access to land is therefore mediated by men, who tend to control the decision-making powers of the allocation of resources within the household.

Table 2: Gender distribution of respondents

Gender	Frequency	Percentage (%)
Male	39	78.0
Female	11	22.0
Total	50	100.00

Source: Field work, 2016

From Table 3, it can be observed that age bracket of 21-25 years were the least represented, while the highest number of respondents falls in the age bracket of 36 and above. This implies that farming is done mostly by the older population in the study area. This could be that unreliable climatic conditions and negative implications on farming are discouraging the youth from engaging in farming as an economic venture; hence most youth normally migrate to the south for greener pastures which are mostly non-exiting.

Table 3: Age distribution of respondents

Age Distribution	Frequency	Percentage (%)
21-25	1	2
26-30	8	16
31-36	6	12
36 and above	35	70
Total	50	100

Source: Field work, 2016

In Table 4, it can be seen that 25(50%) of the respondents had no formal education, 10 (20%) had basic education, 9 (18%) had education up to the secondary/technical/vocational level, while a total of 6 (12%) of the respondents went to a higher institution (tertiary).

Table 4: Educational level of respondents

Educational level	Frequency	Percentage (%)
No No formal education	25	50.0
Basic education	10	20.0
Secondary/technical/ vocational	9	18.0
Tertiary	6	12.0
Total	50	100.0

Source: Field work, 2016

Table 5, shows that 20 (40%) of the respondents have been into farming for 26 and above years. Twenty-two (22%) of the respondents have spent 6 – 10 and 16 – 20 years respectively in farming. Also, group 11 – 15 and 21 – 25 years have the same percentage (8%) in farming. It can be deduced that majority of residents have been in farming for long now. This is not surprising because most people in the northern part of Ghana are engaged in agricultural activities as a form of livelihood support.

Table 5: Number of years spent in farming activities

Period (Years)	Frequency	Percentage
6-10	11	22
11-15	4	8
16-20	11	22
21-25	4	8
26 and above	20	40
Total	50	100

Source: Field work, 2016

Variability in rainfall and temperature

This section examines the climatic variability and change situation in the study area by analyzing the critical elements of rainfall and temperature trends. The purpose of this was to ascertain the nature and trends of climate in the area. Thus, in order to assess changing weather patterns, annual rainfall trend for the district was first analysed as illustrated in Figure 3.

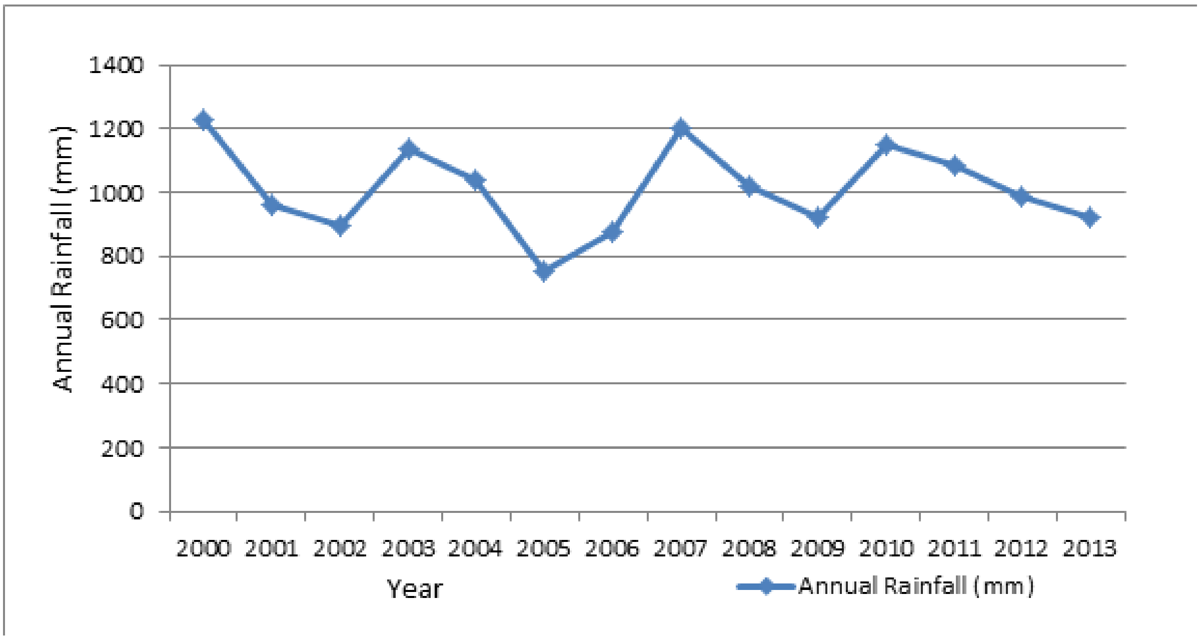

Figure 3: Annual rainfall patterns from 2000-2013 in the savannah zone

Source: Ghana Meteorological Agency (GMET), Navrongo (2016)

As indicated in Figure 3, the annual rainfall distribution shows a highly irregular trend during the period understudy. With rainfall values as high as 1230mm, 1204mm and 1147mm for the years of 2000, 2007 and 2010 respectively on one hand as compared with very low rainfall figures like 896mm, 750mm, and 877mm for the years 2002, 2005 and 2006 respectively. One can attest to the incidence of variability in rainfall. Thus, the difference between the highest year (2000) and the lowest year (2005) is 480mm. Such striking inter annual differences can affect farmers predictability for agricultural activity. Farmers may find it difficult to have a fair idea on how the ensuing year's rains would be and which agricultural activity to carry out in order to maximise output. This finding is in agreement with a projection by USAID (2011) — that rainfall would decline in the future in both the Sudan and Guinea savannah zones.

Efforts were also made to further assess the extent of weather extremes by paying attention to the issue of drought (dry spells) which is a critical manifestation of the phenomenon of climate change with regard to food crop production. In making the drought analysis, one would notice (as illustrated in Figure 4) that, the period under study 2000-2013 reveals 98 dry spells, with an average of 8 dry spells per year (planting season). A dry spell is defined as a period of 6 consecutive days where no rainfall is recorded (daily rainfall = 0mm, with a threshold of 1mm for a rainy day) (Lax, 2009). Figure 3 indicates a steady increase of the number of dry spell. Aside this, it can also be deduced that 2013 recorded the highest number of dry spell for the entire period under consideration. This finding confirms the perception of farmers on the occurrence of dry spells in the present time. As compared to data from 15-30 years ago, with 44 out 50 respondents, representing 88% having an opinion that there was a noticed increase in the number of dry spells in rainy seasons.

This was what one respondent had to say:

> *"the rate at which there are 'breaks in rains' during the planting season these days, in fact, it is a big worry to us here".*

This information perhaps is an indication that climatic conditions in the area are changing for the worst. This finding is in line with views expressed by Yengoh, Armah, Onumah, & Odoi, (2010) in their work titled "trends in agriculturally relevant; rainfall characteristics for small-scale agriculture in Northern Ghana" pg 3.

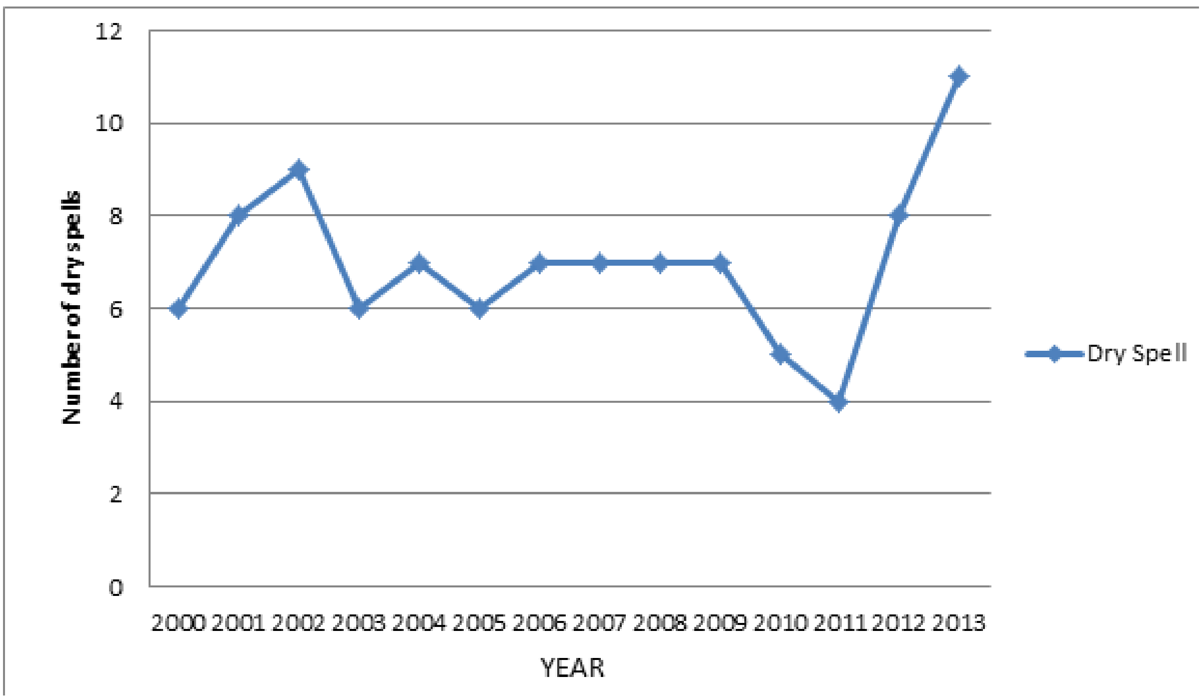

Figure 4: Number of dry spells for the period 2000-2013

Source: GMET, Navrongo (2016)

The average monthly temperatures for Ghana at location (10.92-0.5) from 1900 to 1930, 30-year periods are presented. It was revealed that, temperature levels are typically high in January, February and March when rainfall levels are generally low and relatively low in June and July when rainfall levels are well above average. Maximum temperature rose in the 1930-1960 periods from 31.67°C to 32.14°C, with the minimum temperature also rising from25.68°C to 26.04°C. The 1990-2009 periods also had an increase in both minimum and maximum temperatures of 26.06°C and 33.02°C respectively, an indication of a changing climatic pattern in Upper East (World Bank, 2015).This finding confirms that of Nti (2012), which indicated an increasing trend in both maximum and minimum temperatures in Ghana. This trend is expected to continue since temperature levels are projected to rise in coming decades, unless certain measures are put in place to reverse the direction of the changing climate.

Perception of respondents on climate change

The study delved into the knowledge level of respondents regarding climate change and variability. Forty-nine (49) respondents (98%) perceived that there is climatic change in the study area. This finding is supported by the literature dealing with climate change and local perceptions in Ghana (van der Geest, 2011; Rademacher-Schulz & Mahama, 2012).

Perception on predictability of the onset of rains was also investigated. The onset of rainfall now, as compared to 15 or 30 years ago is largely unpredictable. 80% of the respondents have an opinion in this direction about the onset of rains being unpredictable. The perception that rainfall is now unpredictable supports the view of an officer from the Navrongo Meteorological Station, thus, data indicates that the occurrence of the onset of rain for the period 1980-2012 ranges from first week of March to second week of April, hence difficult to predict because of the wide variation. This was also supported by household perception as:

> "*The rainfall patterns have changed, at most, the rains use to come in April where we plant but now we wait until late May or June. It is the shift in rainfall pattern that has affected the types of crops we grow".*

The fact that agricultural production in Bawku West District is largely dependent on rainfall suggests that it is largely affected since farmers cannot easily predict the onset of rain, hence negatively affecting their plans for farming activities as well as the expected yields. Due to the changing seasons and patterns required, cropping time is difficult to predict and hence planting and harvesting times are also affected.

Also, 29 respondents representing 58% were of the opinion that, the rains do not fall when expected, 10 respondents representing 20% were of the opinion that the rains sometimes come and other times do not, while 22%, that is, 11 respondents agreed that the rains fall when expected. It was also revealed that 45 (90%) respondents agreed to have had uncertainty in arrival of rain, resulting in late planting, while 5 (10%) respondents have not experienced any uncertainty in rainfall arrival. To those responding on the uncertainty, the arrival of rains has not changed. On rising temperatures, 8 (16%) respondents think that the temperature is not increasing, while 42 (84%) respondents believe that temperature is hot.

Effect of climate variability on food production

The study analyzed the annual yield per hectare for the major staple crops (maize, millet, sorghum and rice) in the Bawku West District between 1998 and 2014. As shown in Table 6, the annual yield per hectare (in metric tons) depicts fluctuation for all the four staple crops below 3.0 metric tons per hectare throughout the years considered. The most encouraging annual yield per hectare data for maize, millet and rice was recorded in 2010.

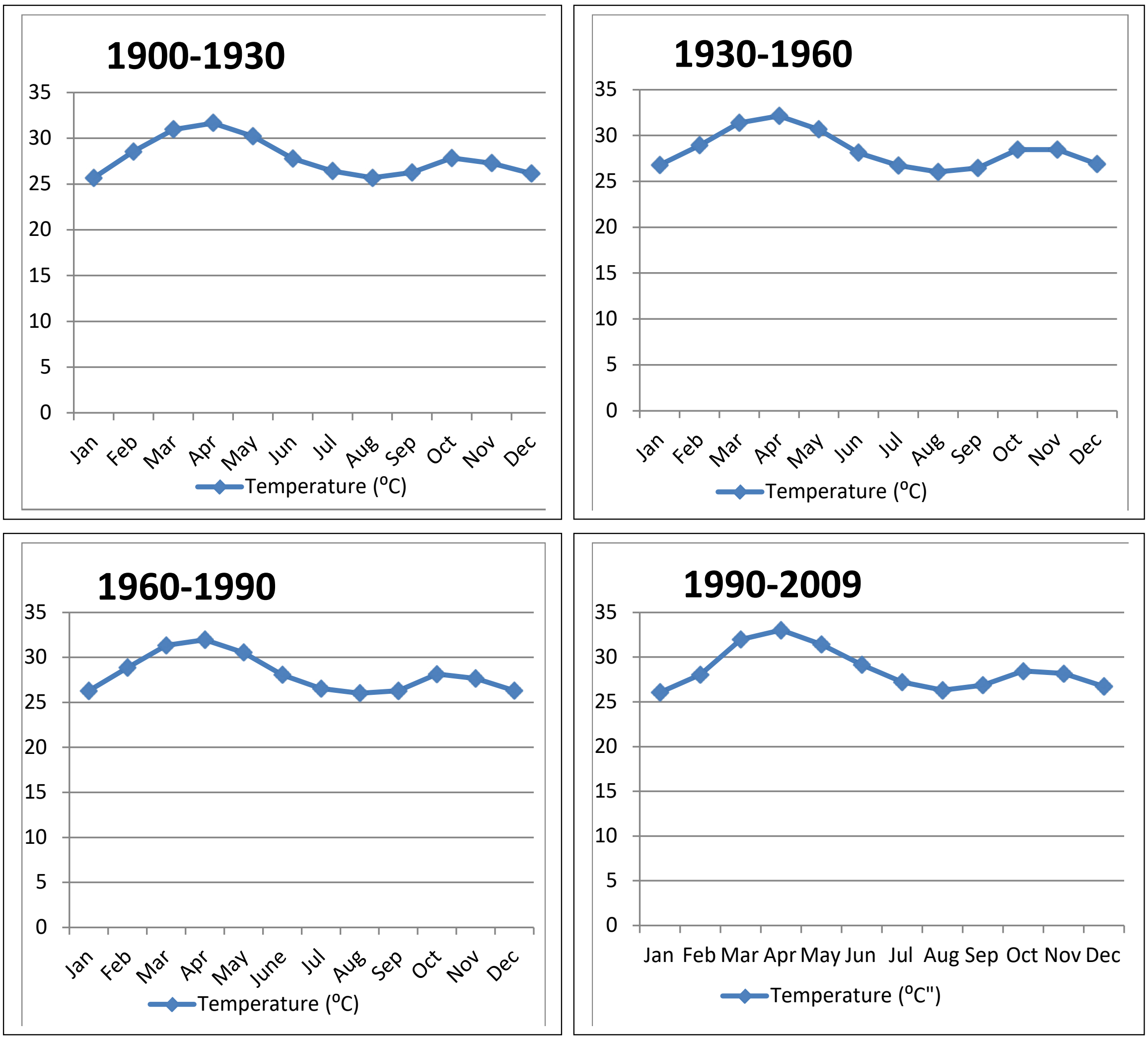

Figure 5: Average monthly temperature for Ghana at location (0.92,-0.5)

Source: Data adapted from the World Bank Climate Change Knowledge Portal, 2016

This can be linked to the positive amount of rainfall and minimal number of dry spells in that year as depicted in Figures 5. Also, the annual yield data for all the four crops indicate a decline in yield per hectare from 2012 to 2013 (maize – [1.70 to 1.60], millet [1.30 to 1.00], sorghum [1.40 to 1.32], and rice [2.80 to 2.00] —all in metric tons). This can also be linked to the decline in amount of rainfall and increase in the number of dry spells from 2012 to 2013 as depicted in Figure 5. This finding is supported by Sagoe (2006) on the impact of climate change on root and tuber production in Ghana. The study largely depended on the state of rainfall as the main driving force/ proxy on food crop production in the study area and Ghana as a whole. In view of this, all other variables including farm inputs are dependent on the distribution and amount of rainfall recorded in the area. In the light of this, the absence of the other variables in the analysis is considered as the limitation of the paper.

Table 6: Annual yield per hectare of major staple crops for Bawku West District from 1998-2014 (Metric Tons)

Year	Maize	Millet	Sorghum	Rice
1998	1.2	0.72	1.01	2.1
1999	0.63	0.7	0.84	1.87
2000	0.61	0.75	1.12	2.1
2001	1.45	0.89	1.01	2
2002	1.52	1.8	1.24	2.54
2003	1.52	1.3	1.3	2.54
2004	1.68	0.62	1	2.52
2005	1.1	0.62	0.71	1.48
2006	0.64	1.3	1	1.1
2007	1.41	0.55	0.75	1.9
2008	1.16	1.18	1.34	2.91
2009	1.54	1.29	1.06	3
2010	1.6	2.8	1.14	2.81
2011	1.7	1.3	1.1	1.95
2012	1.6	1.3	1.4	2.8
2013	1.6	1	1.32	2
2014	1.3	0.97	1.1	2

Source: Ministry of Food and Agriculture (MoFA), Bawku West-Zebilla, 2016

The study also delved into the views of respondents on the role of climate on food production. It was recorded that three 3 respondents, representing 6% have the opinion that climatic factors do not have effect on their crop yield, while 47 (94%) of the respondents believe that climatic factors affect their yields. Out of the total household respondents, 70% had experienced flood event at least once. The respondents who had ever experienced flooding could be those with their farmlands close to either the White or Red Volta. The other 30% of the respondents had never experienced the incidence of flooding, and these were farmers that had their farms in upland areas where impact of flooding was absent. Views of respondents on the effects of floods in the area are shown in Table7.

Table 7: Effects of flood on households

Effect of flood	Frequency	Percentage (%)
No response	15	30.0
Destroyed crops	19	38.0
Destroyed house	5	10.0
Destroyed livestock	1	2.0
Destroyed crops, livestock and house	10	20.0
Total	50	100.0

Source: Field work, 2016

From Table7, 35 sampled households are affected by flood. It was recorded that 38% of the respondents reported destruction of their farm or farm produce including maize, millet, rice, sorghum and cowpea. While some farmers reported that their harvested crops (including seeds) were washed away by the flood;

others had their farms inundated and crops which were yet to be harvested got destroyed. Crops that were able to withstand the flood produced poor yields. Moreover, 10% of the respondents reported destruction of their homes by the flood. This rendered some of the inhabitants' homeless for a period, until they were assisted by the government and non-governmental organizations. Again, 2% of the households recorded their livestock got affected. Others (20%) had a triple impact of flood on their livelihood: destruction of crops, livestock and buildings. From a more holistic view, flood effect on households is reduction in food production, derived from the decline in environmental quality. This could cause severe food shortage or starvation among farming communities. A respondent said;

> "*The rains are now irregular, it is difficult to plant groundnuts and the cowpea too, the dry season will soon come when they are not yet matured. Now the rain can stop for a long time and when it comes too it comes heavily and floods the whole place".*

These findings are supported by a study by Nti (2012) that showed the destruction of crops as the major effect of flood on households. Other effects included food shortage and destruction of livestock and places of abode.

On drought, 46 (92%) of the respondents interviewed, had witnessed drought conditions before. This agrees with an early research conducted by Nti (2012), which revealed that occurrence of drought conditions is seen as a "normal" phenomenon in the district due to the climatic pattern there. However, the intensity of the drought periods changes per annum.

Some respondents (46) recounted having experienced several impacts from drought as shown in Table 8. Poor yield or harvest was reported by 52% of the respondents affected by drought. Most farmers in the district usually cultivate their land after the first rain. A delay in the rains as a result of drought resulted in poor crop yield and harvest. Also, 12 (24%) of the respondents agreed that both their crops and livestock were badly affected during drought events as shown in Table 8. Grasslands for livestock grazing got dried up which caused the death of several animals as well as farm crops were wilted and subsequently dried up. However, 16%of drought affected households encountered severe water shortage since most water sources (rivers and streams) got dried up

Table 8: Effect of drought on households

Effect of drought	Frequency	Percentage (%)
No response	4	8.0
Poor yield or harvest	26	52.0
Destruction of crops and livestock	12	24.0
Water shortage	8	16.0
Total	50	100.0

Source: Field work, 2016

Coping/adaptive strategies to effect of climate variability on food crop production

Results on adaptation strategies to climatic stressors undertaken by households are presented in Table 9. The major adaptation mechanisms include; irrigation (90%), fertilizer application (80%), growing improved crops (76%), getting jobs outside agriculture (62%), support from government and NGOs (58%)

and migration (48%).This implies that climate variability is not a new phenomenon to the people of Bawku West District. The adoption of the aforementioned strategies is likely due to limited institutional capacity, low financial capability of the households, and limited farm technology. From the data gathered, one would notice that virtually all the households are involved in the different ranges of response strategies.

These strategies are not strange but have a close relationship to those carried out elsewhere. Burton et al. (2002) cited by Oriangi (2012) reported adaptation strategies carried out in Bangladesh, Netherland and USA. These strategies are; changing topography of land, changing of farming practice, changing timing of farm operations, using different crop varieties, researching into new technologies, and change of government and institutional programs.

Driving forces are the socio-economic and cultural forces driving human activities, like the need to ensure food security, energy generation, transport, industry, agriculture, among others. These increase or mitigate pressures on the environment. In relation to the conceptual framework used for this paper, it could be seen that the driving forces that influenced the activities of respondents in their environment was the need to produce food for survival, and to improve the livelihood and economic fortunes of the population in the areas of study. The activities that are involved in producing food put pressure on the land and the environment in general, including impact of climate. This is seen in changes that occur in climatic conditions which in turn pose challenges to food production. The response of the farmers to the impact of climatic variations is the coping strategies identified above. The strategies adopted by communities in different regions depend on their level of economic development, technology, financial capacity, institutional support and traditional knowledge.

Table 9: Household coping/adaptive strategies to climate stressors

Strategy	Yes/agree	No/don't agree	Total (%)
Irrigation (%)	45 (90%)	5 (10%)	50 (100)
Fertilizer application (%)	40 (80%)	10 (20%)	50 (100)
Growing improved crops (%)	38 (76%)	12 (24%)	50 (100)
Getting jobs outside agriculture (%)	31 (62%)	19 (38%)	50 (100)
Support from government and NGOs (%)	29 (58%)	21 (42%)	50 (100)
Migration (%)	24 (48%)	26 (52%)	50 (100)

Source: Field work, (2016)

Conclusions

Based on the findings, the following conclusions are drawn. There are considerable variations and decreasing amounts of rainfall, coupled with increasing number of dry spells in planting season and uncertainty of the arrival of rains in the area. The temperature of the district has been on the increase over the years as depicted in the periods1900 – 2009 and 2000-2013. The occurrence of flood events coupled with drought conditions in the study area as confirmed by farmers, threaten food crop production and security. Thus, extreme weather conditions in the study area, which is excessive rainfall and prolonged drought, have had negative impact on food crop production.

Due to these, the farmers and households have devised some strategies to cope with the situation. These include seasonal migration, growing improved crop varieties, getting jobs outside agriculture, getting Government/NGOs support and irrigational/dry season farming. Some of these strategies have largely remained the same and less refined over a long period of time, as they have shown to be less sustainable. It is therefore expected that this paper would not only help throw more light on this critical issue of concern, but would also offer the avenue for constructive engagement by stakeholders with the primary aim of meeting the challenges raised and discussed, in order to ensure an improved food system and security, especially among rural poor farming communities.

Policy recommendations

The following recommendations are made;

- Development and extension of climate resilient crop varieties such as early maturing crops, drought and flood resilient crops by the District Department of Agriculture, the Assembly and existing NGOs.
- Construction of dams by the government through the Assembly and NGOs (like Action aid, World vision etc.) for dry season gardening to ensure local food farming throughout the year. In like manner, the farmers can also be encouraged by the district agricultural personnel and NGOs on the use of organic fertilizer while the government also subsidises farm inputs.
- Human activities such as bush burning, charcoal burning, and bad farm practices should be stopped through the enacting and enforcement of local rules and regulations by the Assembly, the traditional institutions and the communities' initiatives to protect the environment.
- Knowledge of the effects of rainfall and temperature variations in Bawku West District should be integrated into both water resources management and agricultural practices by the District Department of Agriculture through the agricultural extension services. Forecast of the yearly climatic conditions should be made available by the Ghana Meteorological Agency stations in the region to farmers before they embark on crop planting.

This implies that weather conditions should be well publicized and brought to the knowledge of peasant farmers. In other words, there should be regular updates of seasonal information by GMET through the district MOFA and the local radio stations and information centers, and importantly should be in the local language.

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