Climate variability and sustainable food production: Insights from north-eastern Ghana

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Abstract

The past two decades have seen invigorated debates on the causal link between climate variability and food crop production. This study[7] extends the debate further by investigating how climate variability has affected the production of four specific food crops: maize, millet, rice, and groundnuts in north-eastern Ghana. The results are based on temperature and rainfall data obtained from the Ghana Meteorological Agency and the Ministry of Food and Agriculture and are supported with in-depth interviews with selected staff from other allied institutions. While an inverse relationship between climate variability and food crop production was established, the effects were not homogenous, as climate variables (rainfall and temperature) did not all exert the same effect across all crops. This suggests that the generalized interpretation of the relationship between climate variability and food crop production should be undertaken with caution and that each variable must be examined on its own merit. We argue that the negative relationship between climate variability and food crop production has the potential to erode the gains made by the state-sponsored development authority SADA in their poverty reduction drive in north-eastern Ghana.

Keywords: climate variability, food crop production, north-eastern Ghana, sustainable development

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Introduction

As the world enters the third millennium, scholars and policy makers have come to the realization that for development to break barriers and to cut across scales, whether technologically or socially, sustainable development is the way forward. In the words of Hyden (2001: 1):

> *sustainable development rests on three fundamental premises: that we must live on this planet not as if we are just short-term visitors but as if we are here to stay; that we must take a holistic approach to dealing with our livelihood predicaments; that people themselves must have an interest and stake in any effort to improve their livelihoods.*

Sustainability as explained by the Brundtland Commission (Mebratu, 1998) means development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. From this perspective, any structural challenge that impairs the ability of a system to function perpetually can be described as an 'enemy' to sustainable development. The hallmark of sustainable development is to reduce poverty and enhance human freedoms. In line with this thinking, the UN General Assembly met in 2015 to adopt what is called 'Transforming Our World: The 2030 Agenda for Sustainable Development'. The Agenda is a plan of action for people, planet, and prosperity. It also seeks to strengthen universal peace and larger freedom.

The 17 Sustainable Development Goals (SDGs) and 169 Targets demonstrate the scale and ambition of this new universal Agenda. They seek to build on the Millennium Development Goals and complete what was not achieved. They seek to realize the human rights of all and to achieve gender equality and the empowerment of all women and girls. They are integrated and balance the three dimensions of sustainable development: economic, social, and environmental. The Goals and Targets aim to stimulate action over the next 15 years in areas of critical importance to humanity and the planet. Among the 17 SDGs, Goal 2 seeks to end hunger and ensure access by all people—in particular the poor and people in vulnerable situations, including infants—to safe, nutritious, and sufficient food all year round by the year 2030. Target 3 also seeks to double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists, and fishers, through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets, opportunities for value addition, and non-farm employment. Finally, Target 4 seeks to ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production; that help maintain ecosystems; that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters; and that progressively improve land and soil quality. Apart from the SDGs, the government of Ghana in 2008 operationalized the mandate of the Savannah Accelerated Development Authority (SADA), which among other things aims at accelerating the development of the savannah ecological zones through specific regional planning and development agenda.

Achieving the aims of SADA and SDG Goal 2 are inextricably linked to the earth's climate. Like other forms of life, the manner in which human beings respond to climate variability is critical not only to survival but also to well-being (IPCC, 2007). Available records (Yaro, 2013; IPCC, 2014) show that the single largest threat to achieving sustainable food production in Sub-Saharan Africa is the threat from climate variability. This is because, as noted by Okunade and Ademiluyi (2009), climate-related risks are the major causes of human suffering, poverty, and reduced opportunity, which lead to large-scale human development reversals. Manifestations of climate variability such as incidents of extreme weather events have left no continent untouched (IPCC, 2014). The 2014 IPCC document further states that almost all regions on the African continent have in recent times experienced, seen, or heard of calamitous incidents (e.g. flooding, droughts, desertification, and hurricanes) resulting from unpredictable climate. The FAO in 2009 emphasized that most land areas in Africa will have warmer weather and fewer cold days and nights and that the continent in the coming years will experience a significant increase in temperature but decreased precipitation (FAO, 2009). The report further indicates that this situation will result in a general reduction in potential crop yields in most tropical and sub-tropical regions, a clear indication that food security will be adversely affected by climate variability. Further projections are that by 2020, some countries in Africa could experience up to 50% reduction in rain-fed agriculture and livestock productivity (IPCC, 2014).

Agriculture is probably the most important natural asset in Ghana, since it is the main livelihood activity of the majority of the population. This sector is the largest in the economy in terms of its contribution to the Gross Domestic Product (GDP) and employment. The sector accounted for 34.5% of GDP in 2009 (ISSER, 2010). Ghana's agriculture is predominantly rain-fed, and the fortunes of the sector have generally followed the rainfall patterns from year to year; but climate variability seems to be taking a devastating toll on crop yield per year (GSS, 2010). This is evidenced from the changes in the onset and cessation dates of the wet season. Statistics indicate that over the past three decades (1970–2000), the country has experienced a 1 ºC rise in temperature (EPA, 2015). Again, there has been a decline in mean annual rainfall from the period between 1951 and 1970 to the period between 1981 and 2000 (Owusu & Waylen, 2009). More importantly, Hulme et al. (2001) concede that the agro-ecological zone of north-eastern Ghana, which has the same characteristics as other Sahel regions, has experienced a high degree of temporal and spatial variations in rainfall and temperature, and the effect has been felt greatly by poor peasant farmers who mostly cultivate millet, sorghum, rice, maize, and sweet potato for food and income. It is further predicted by the Ghana Meteorological Agency (GSS, 2010) that the climatic conditions in the three northern regions of Ghana, especially the north-eastern portion, are expected to be more severely affected by unpredictable rainfall patterns, a situation that will expand the degradation of the natural resource base and increase the frequency and severity of disaster events. This will further reduce the ability of vulnerable farming communities to maintain their fragile landscape and livelihoods.

In Ghana, the literature is replete with accounts of farmers' knowledge and perception of the causes of climate variability (EPA, 2015). Equally, climate variability adaptation strategies have also captured the attention of policy makers and those in academia (Yaro, 2010). While there are some other research studies on the effect of climate variability on food production (IPCC, 2011), these studies tend to concentrate on the climate variability impact on single crops, and the results from such studies tend to be speculative. The literature so far paints a gloomy picture of the relationship between climatic variables (temperature and rainfall) and food crop production. This situation, if not addressed, can lead to a national food crisis, especially in the savannah ecological zone.

The evidence presented in the literature shows that the effects of climate on food crop production are getting worse by the day, making the right to adequate food supply a quest that is becoming more and more difficult to meet. As food supply reaches a crisis point, the locus of global poverty will also spread towards locations without adequate resources to cope. In Ghana, as in other developing countries, this is happening so fast that those communities that depend on rain-fed agriculture are migrating to urban centres, a situation that has also resulted in what is termed the urbanization of poverty (UN-HABITAT, 2008). This makes it imperative that the world uses every means to ensure that food crop production is sustained to cater for the ever-increasing world population. It is for this reason that the present study was undertaken. The objective of this study was to investigate how climate variability has impacted food crop production in north-eastern Ghana, using empirical evidence from yields from maize, millet, rice, and groundnut, the most cultivated food crops in the study area. Our hope is that not only will the results from the study help farmers to plan and develop strategies to meet the challenges of the variation in climate patterns; it will also help in policy formulation on climate variability adaptation strategies, including climate-smart agriculture and livelihood diversification portfolios. The study is divided into six sections. After these initial introductory remarks, the literature is reviewed in the second section. The third section is devoted to the study area and methodology of the study. In the fourth section, we discuss the empirical findings from the field, showing the relationship between climate variability and crop production. The fifth section discusses the findings, and a number of policy suggestions are offered in the final section.

Climate variability and food crop production: Relationship perspective

Scholars pursuing an understanding of the relationship between climate variability and food crop production often argue that the relationship cannot be properly understood without paying attention to how individual climate variables influence specific crops within a broader environmental setting (Hanjra & Qureshi, 2010; Yaro, 2012). Climate variability is often used to describe any kind of change in climate that may be natural or human-induced (Pradhan, 2002). Climate variability is caused by both human activities and natural occurrences (Hegerl et al., 2007; IPCC, 2007). The effects of climate variability come in the form of rising temperatures, unpredictable rainfall, loss of soil moisture, and increased evaporation and transpiration, among other effects (Ofori-Sarpong, 2011). Climate variability has had a significant impact on agriculture in many parts of the world (IPCC, 2007). Drastic changes in rainfall patterns coupled with rising temperatures result in unfavourable growing conditions and changes in the cropping calendar, thereby modifying growing seasons—which can subsequently reduce productivity (Manneh et al., 2010). Temperature and rainfall affect the development of plants, either alone or by interacting with other factors (IPCC, 2007). It has been estimated that even a small rise in temperature (1–2 ºC) at lower latitudes, especially in dry tropical regions, could decrease crop productivity (ibid.).

In general, temperature determines the length of the growing season of a crop by determining the crop's germination and vegetative and reproductive stages (FAO, 2009). Increased temperature leads to increased evapotranspiration and affects water availability, which is very important in the process of photosynthesis (Dawyer et al., 2006). In general, high temperature affects the chloroplasts where photosynthesis takes place through generation of reactive oxygen species (Kreslavski et al., 2007). Water shortage and heat stress are two of the most important environmental factors limiting crop growth, development, and yield (Prasad & Staggenborg, 2008). Warming trends are responsible for the suppression of global agricultural productivity (FAO, 2009). Low temperatures also affect crops by reducing their metabolic reactions (Sage & Kubien, 2007).

Studies have indicated that a 1 °C increase in global temperature will lead to a 17% reduction in maize and soybean (Allen et al., 2003; Thomson et al., 2005). Zhang et al. (2010) report that rainfall and temperature have opposite effects on yield variability of maize and that rice production is highly correlated with the amount of rainfall from June to September (Selvaraju, 2003; Krishna-Kumar et al., 2004). High night temperatures are commonly associated with increased respiration rates, leading to a decline in yield (Mohammed & Tarpley, 2009). High day temperature (32−36 °C) has a significant negative effect on rice grain yield (Peng et al., 2004; Nagarajan et al., 2010; Welch et al., 2010). Ajetomobi et al. also posit that increase in temperature due to extreme climatic events may undermine any positive effects by reducing the net revenue for dry-land rice farms (Ajetomobi et al., 2010; Thapa, 2010). High night temperature has recently become a major rice research area because a narrow critical range of 2−3 °C has been shown to result in drastic grain yield reduction in the tropics (Nagarajan et al., 2010) and sub-tropics (Peng et al., 2004). Krishna-Kumar et al. (2004) analysed the correlation between rice production and monsoon rainfall and showed that the correlation was relatively low. Among the climatic factors affecting variation in rice production, rainfall is the most important limiting factor (Gadgil & Rupa-Kumar, 2006). Rice yields in China have been found to be positively correlated with temperature in some regions and negatively correlated in others (Zhang et al., 2010). However, there is evidence that high temperatures would limit future yields even in cool environments (Semenov & Porter, 1995).

Cereals have been the most important sources of plant food for humans and livestock (Von Braun, 2007). The optimum temperature for sorghum, for example, is 20 ^{o}C, and beyond this temperature, production declines (IPCC, 2007). An increase in the frequency of drought and floods is suggested to affect crop production negatively (ibid.). Rainfall is less a predictor of crop yields at broad scales (Liu et al., 2009) because of its high variability (Lobell & Burke, 2008). Thornton et al. (2009) found that the response of crop yields to climate variability in the dry lands of East Africa is insensitive to increases in rainfall. According to Gadgil & Rupa-Kumar (2006), rainfall does not directly control any plant processes. It indirectly affects many of plant growth and developmental processes. Decreased amounts of rainfall can cause an increase or decrease in developmental rates, depending on the stage of development and on the species or cultivar (Nortes et al., 2009). Some species or cultivars are more drought-tolerant than others (Reason et al., 2005). However, rainfall must be taken into account, since the magnitude and seasonal variation of either or of both can limit the growth and development of crops (ICRISAT, 1980). The combined effects of increased temperatures and decreased rainfall are expected to cause changes in crop yields, cropping seasons, scheduling of field operations, and pest conditions. Climate variability is impacting negatively on Africa through extreme temperatures, frequent flooding, and droughts (IPCC, 2007). In Africa as a whole, food consumption exceeded domestic production by 50% in drought-prone regions in the mid-1980s and by more than 30% in the mid-1990s (WRI, 1998).

Methodology

Study area

The study was conducted in the Upper East Region of Ghana, which is located between latitudes 10º 30′ to 11º north of the equator and longitudes 0º to 1º 30′ west of the Greenwich Meridian within the White Volta River Basin (Figure 1) (GSS, 2010). The region has two international boundaries, with the republics of Burkina Faso to the north and of Togo to the east. The other boundaries are Northern Region and Upper West Region of Ghana to the south and west, respectively (GSS, 2010).

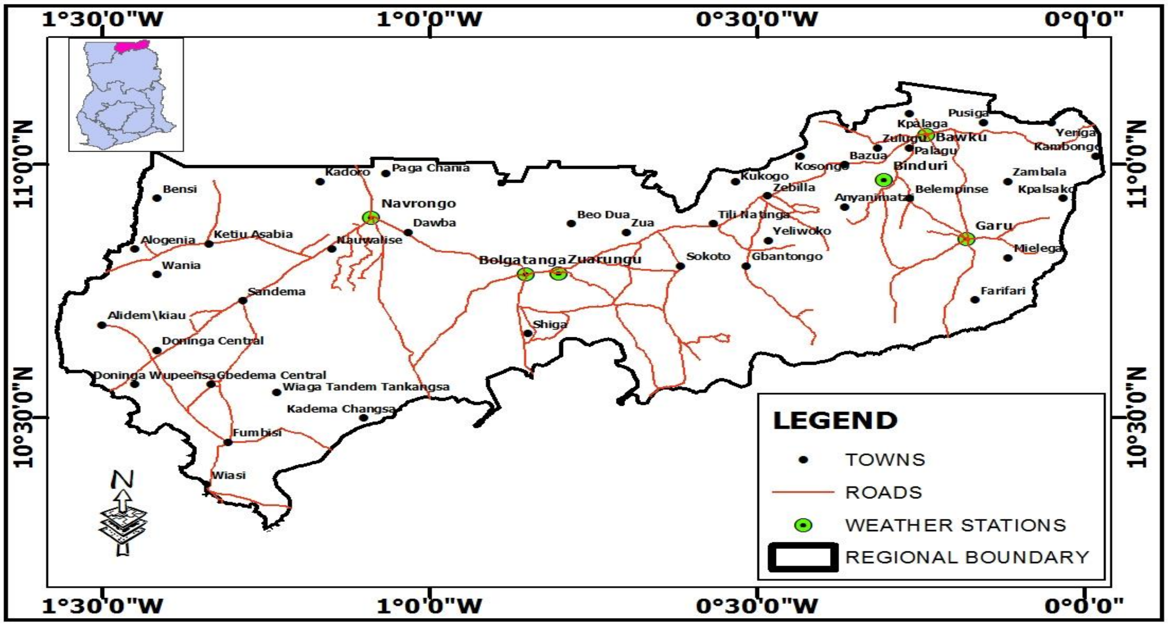

Figure 1: Map of Upper East Region in the national context

Source: DERF Networks, 2015

The movement of the Inter-Tropical Convergence Zone (ITCZ) between the north and south of the tropics brings about dry and wet periods, the two main climatic seasons in Ghana (McSweeney et al., 2012). Dry periods are experienced when the Harmattan wind blows north-easterly across the northern part of Ghana (Gordon, 2006). The Upper East Region lies within the Guinea Savannah and Sudan Savannah climatic zones and has a unimodal rainfall pattern. The natural vegetation is characterized by short, scattered, drought-resistant trees and by grass that gets burnt by bushfire or scorched by the sun during the long dry season (Tetteh, 2007). About 85% of the entire region falls within the White Volta Basin, the Red Volta, and the Sissile River. The Kulpawn River, which has its catchment to the south-west of the region, is joined by the Sissile just before its confluence with the White Volta. Besides these, there are other smaller water bodies that give the region a great potential for irrigation development. As a result, the Tono and Vea dams were constructed to enhance the status of these areas as food baskets in the regional context (Gordon, 2006). The region has an annual average rainfall of 921 mm. It ranges between 645 mm and 1250 mm (GSS, 2010). The region is predominantly agricultural, with about 70% of the economically active population engaged in livestock rearing, farming, or fishing (GSS, 2010). The Tono reservoir was constructed in 1975 but became operational only in 1985, with a volume of 9.26×10^{7} m^3 (Gordon, 2006).

Data collection

Data for the study were selected from six communities in the Upper East Region of Ghana. The communities are Navrongo, Bolgatanga, Zuarungu, Bawku, Binduri, and Garu. These communities were selected because each had a meteorological station and offices belonging to the Ministry of Food and Agriculture (MoFA). It was thus easy to obtain temperature and rainfall data as well as food crop data from these state institutions. Secondly, 384 peasant farmers who cultivated the four crops on different parcels of land were selected equally from all the communities. For each community, 64 participants were randomly selected from data on peasant farmers made available by MoFA. The sample size determination was in accordance with Krejcie and Morgan's (1970) suggestion that for a very large population size, selecting 384 is ideal for any scientific research.

Semi-structured questionnaires were used for the data collection. This was to allow the participants give varied responses from their perspective on the subject matter. A face-to-face approach was used to administer the questionnaire. In all, it took the six researchers who were assigned to the communities three weeks to complete the survey. In many instances, the participants were followed to their farms, where other family members assisted in providing responses to the open-ended questions. Participants were also allowed to express their views on the subject under study. This enabled the researchers to gain farmers' unadulterated perspectives on climate variability and food crop production. In addition, there were eight key informant interviews with some selected staff from MoFA, the Water Users' Association (WUA), the Irrigated Company of Upper Region (ICOUR), and the Northern Rural Growth Programme (NRGP). The key informant interviews provided vital information on institutional perspectives and experiences on climate variability and food crop production. The data collected were coded and edited before analysis was carried out. Pre-running of the data was performed by using a matrix plot. In order to establish the relationship between food crop production and climate variability, we used multiple regression and a matrix plot with Locally-Weighted Scatter plot Smoother line (LoWeSS) to show how climatic variables had impacted food crop production. The LoWeSS enabled trend lines to be seen clearly where too many variations would otherwise have made it difficult or impossible (Krejcie & Morgan, 1970).

Results and discussion

In order to investigate how climate variability was impacting food crop production in the Upper East Region of Ghana, we first examined the annual trend in food crop production per hectare. This enabled us to ascertain the most cultivated crop. The analysis spanned from 1987 to 2014. Our trend analysis indicates that the production of rice and maize have been showing an increasing trend per hectare over the period, as indicated by the blue and red LoWeSS lines in Figure 2.

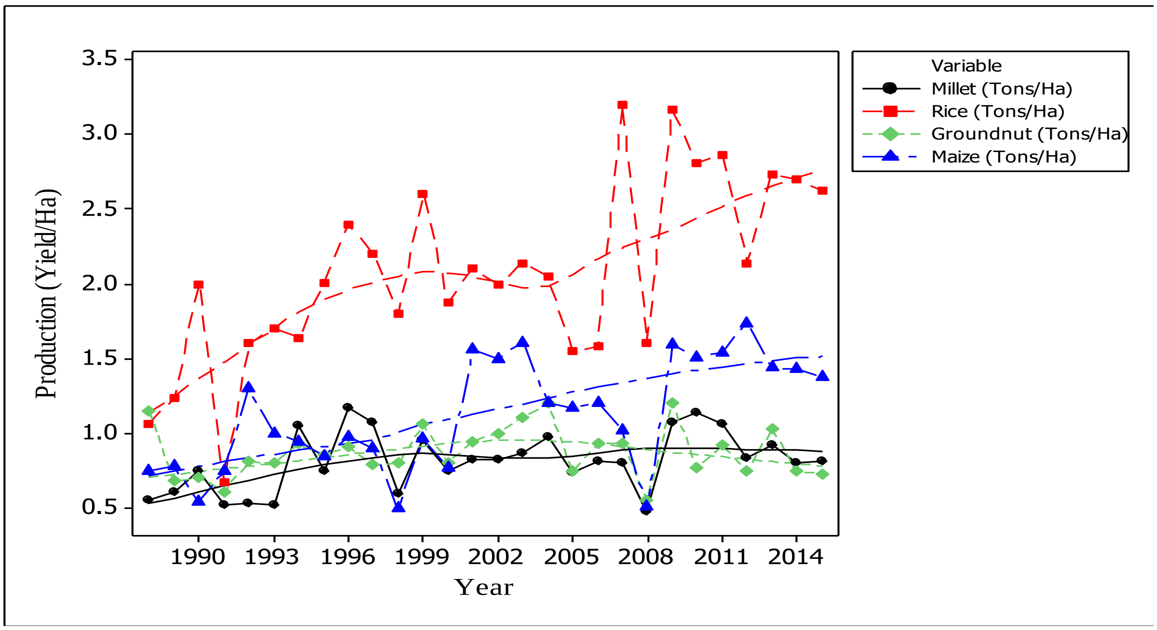

Figure 2: Annual production of food crops (Tons/Ha) in the Upper East Region

Groundnut and millet have, on the contrary, been showing a decreasing trend per hectare. One of the key informants at MoFA explained the reason behind the trend in an interview:

> *MoFA is encouraging farmers in the region in particular and Ghana in general to cultivate more of maize and rice because of the ability of the two crops to reduce food insecurity. Remember, maize and rice are two staple crops that can be prepared into a variety of meals, and therefore it is important we help farmers to cultivate them the more.*

Similarly, an official at NRGP gave reasons for educating farmers to increase the cultivation of maize and rice:

> *You know, beyond planting the two crops on a subsistence basis, they also have high industrial value. Maize, for instance, is used in the livestock industry, while in Ghana the local rice is recognized for its nutrient value—and therefore farmers who plant these crops always have additional income from the sale of the produce.*

The key informant concluded that as a matter of policy, MoFA and some non-governmental organizations such as NRGP, Savannah Research Institute (SARI), and other financial institutions are providing both financial and technical support to farmers in the region to increase output per hectare for the two crops because of their immense economic value. Globally, maize and rice are important human food sources and constitute 94% of all cereal consumption (FAO, 2012). This situation is akin to that of Ghana and the Upper East Region in particular. It was therefore not surprising that the production of maize per hectare continued to increase. According to Nuss and Tanumilardjo (2010), maize provides most of the B vitamins and other essential minerals which are needed for healthy living. The FAO (2012), for instance, indicates that one of the best ways to fight anaemia is the fortification of maize flour with iron and other vitamins and minerals to improve micronutrient intake. In alcohol-producing industries, maize is the primary feed stuff which is used to produce ethanol (FAO, 2012).

Variation in climatic conditions

In Ghana, crop cultivation is climate-dependent (GSS, 2010). The most important climate variable that influences both cultivation and yield is rainfall (Yaro, 2013). To establish the relationship between climate variability and food crop production, we examined the pattern of rainfall from 1954 to 2014 using data obtained from the Ghana Meteorological Agency (GMA). The results showed variations in rainfall pattern but with an overall decreasing trend (Figure 3).

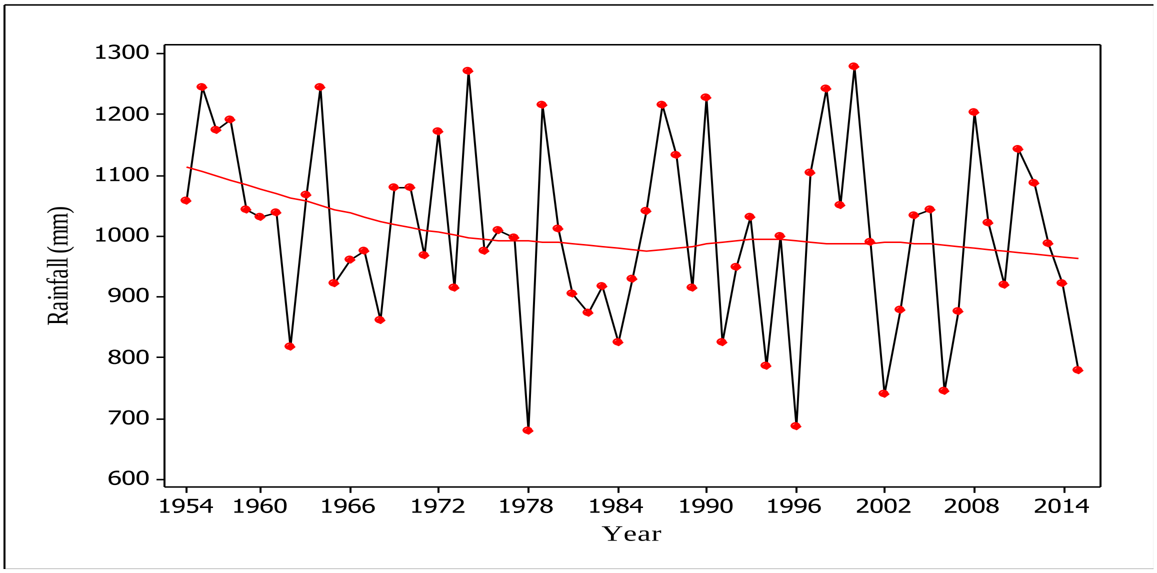

Figure 3: Annual total rainfall from 1954–2014 in the Upper East Region

The decreasing trend and the variations in rainfall affected farmers' ability to determine the onset of the rainy season and also the most suitable planting period. As one farmer indicated during the survey at Navrongo:

> *Unlike at first when the onset of the farming season was in May, this time it is in June; and, at times, we even start the farming season in July. The raining season is actually moving forward.*

Commenting on the decreasing trend in the rainfall pattern, a maize farmer at Zuarungu observed:

> *These days, the rainwater is not adequate for the crops. It rains for only three months and it stops. Sometimes it even rains for two-and-a-half months. How can we have a good harvest from the crops we have planted judging from the fact that maize needs adequate rainwater to mature?*

The responses from farmers further confirmed the rainfall data obtained from the GMA shown in Figure 3. It is therefore imperative that farmers are introduced to short-time maturing crops, drought-resistant crops, and the intensification of dry season farming, as proposed by Yaro (2013).

Variations in maximum and minimum temperatures

Apart from rainfall, temperatures (maximum and minimum) have also been proven (see FAO, 2012) to have a significant influence on crop production. Maximum temperature refers to the highest daily temperature recorded during the day (normally referred to as daytime temperature), and minimum temperature refers to the lowest temperature recorded during the day (normally referred to as night-time temperature). Data obtained from the GMA indicated variations in the maximum temperature recorded in the period 1954–2014. The trend in the time series analysis indicates an increasing trend (Figure 4).

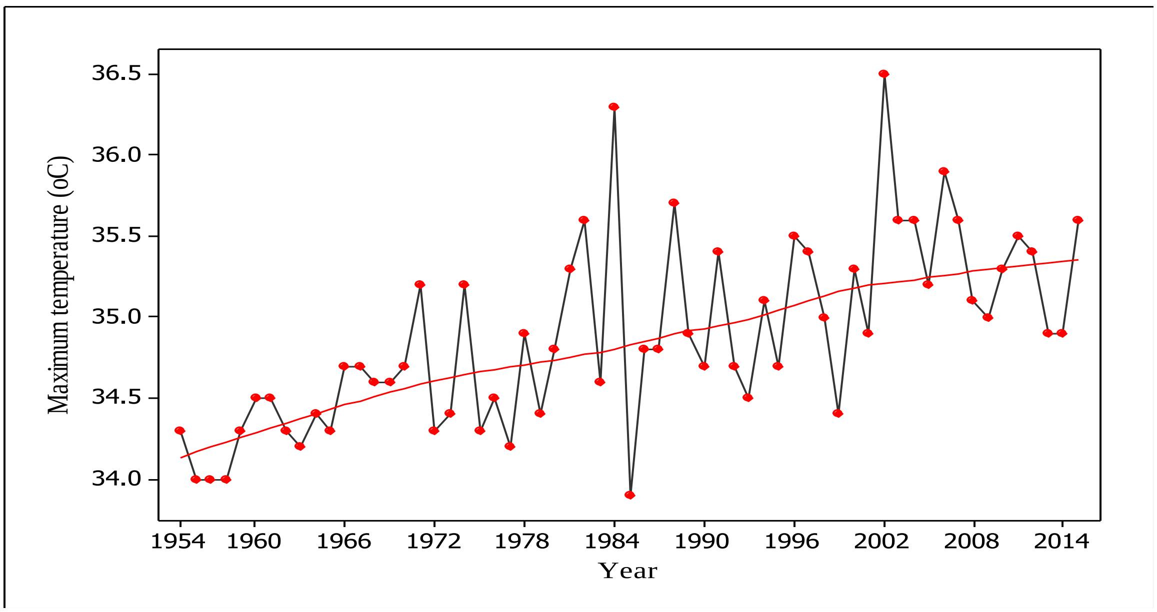

Figure 4: Trends in maximum temperature in the Upper East Region

Similar to the maximum temperature, the minimum temperature also showed an increasing trend, with some asymptotes at 1970 and 1987 (Figure 5).

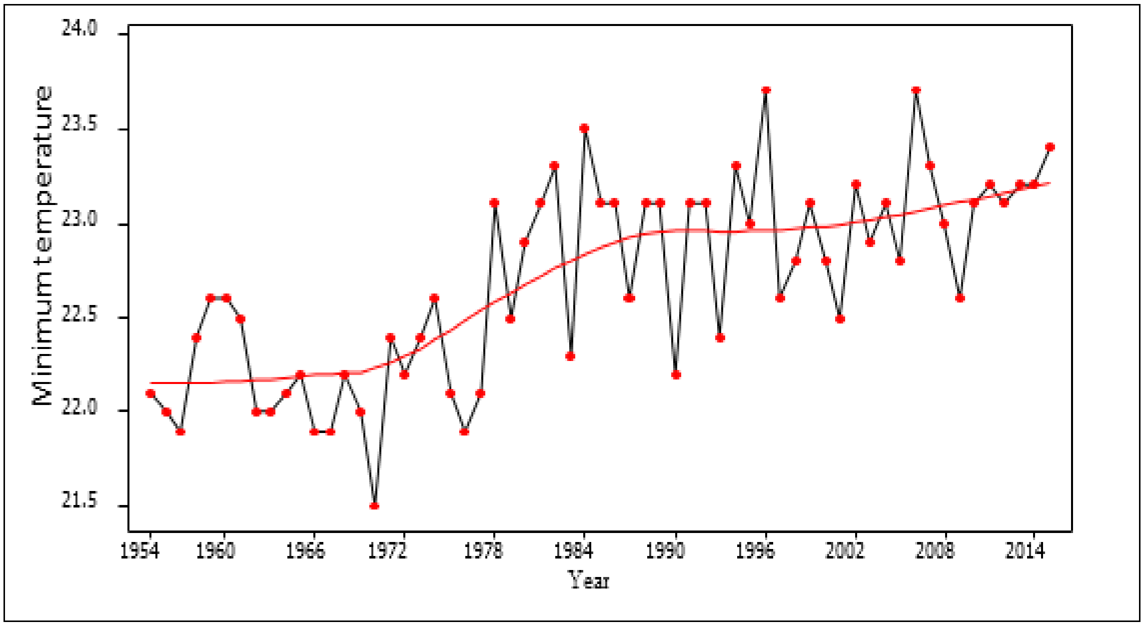

Figure 5: Trends of minimum temperature in the Upper East Region

The increasing night temperatures had implications for crop yield, as many of the crops could not tolerate the changes in temperature. Our key informant at MoFA in Bolgatanga explained how increasing daytime temperatures were affecting farming activities:

> *Farmers in this part of the country are suffering from the increasing temperatures because their crops are withering from the scorching effect of the sun. Maize farmers are always seriously affected because the temperature affects flowering, which in turns affect the ability of the maize plant to produce good yield.*

While farmers were worried about increasing daytime temperature and its effects on crop yield, they were particularly worried about how high temperatures during the day limited their ability to work for longer hours and at the same time its effect on their health. As a farmer from Binduri noted during a face-to-face interview:

> *These days if you want to work for longer hours, then you must come to the farm very early in the morning. If you come late, the sun will not allow you to work because the rays are hard-hitting. If you want to continue and work, you may fall sick eventually.*

The majority of the farmers who participated in the study shared similar sentiments.

Relationship between food crop production and climate variability

This section examines the relationship between food crop production and climate variability, having identified the trends in food production and the trends in climate variables in the selected communities. We observed that a linear relationship between the food crops and climate variables were significant only between rainfall and rice production; and between daytime temperature and groundnut production at 5% level of significance (Table 1).

Table 1: Correlation coefficient and P-value of climate variables and crop production

Variable	**Groundnut**	**Millet**	**Rice**	**Maize**
Rainfall	-0.243	-0.305	0.737	-0.168
P-value	0.213	0.114	0.000	0.393
Daytime temp	-0.028	-0.661	0.126	0.669
P-value	0.908	0.002	0.523	0.000
Night-time temp	0.281	0.636	0.290	0.629
P-value	0.147	0.001	0.179	0.001

Rainfall and rice were highly correlated, at 0.737. This means that increased rainfall also resulted in increased rice production. Groundnut, millet, and maize all showed a negative correlation with rainfall, at -0.243, -0.305, and -0.168, respectively. The implications are that excessive rainfall also affected the prospects of these crops. It was in line with these findings that Bancy (2000) suggested that in order to counter the adverse effects of rainfall variability in maize and millet production, it was necessary to use early maturing cultivars and practise early planting so that millet and maize can be harvested early enough before they are destroyed by rain. Daytime temperature negatively correlated with groundnut (-0.028) and millet (-0.661). This suggests that as daytime temperature increased, production of groundnut and millet also declined.

To buttress the theoretical analysis of the relationship between the food crops and the climatic variables, we used the matrix scatter plot with a LoWeSS line plot to further clarify the relationship between the variables. The graph in Figure 6 shows a clear relationship between the climatic variables and food crop production.

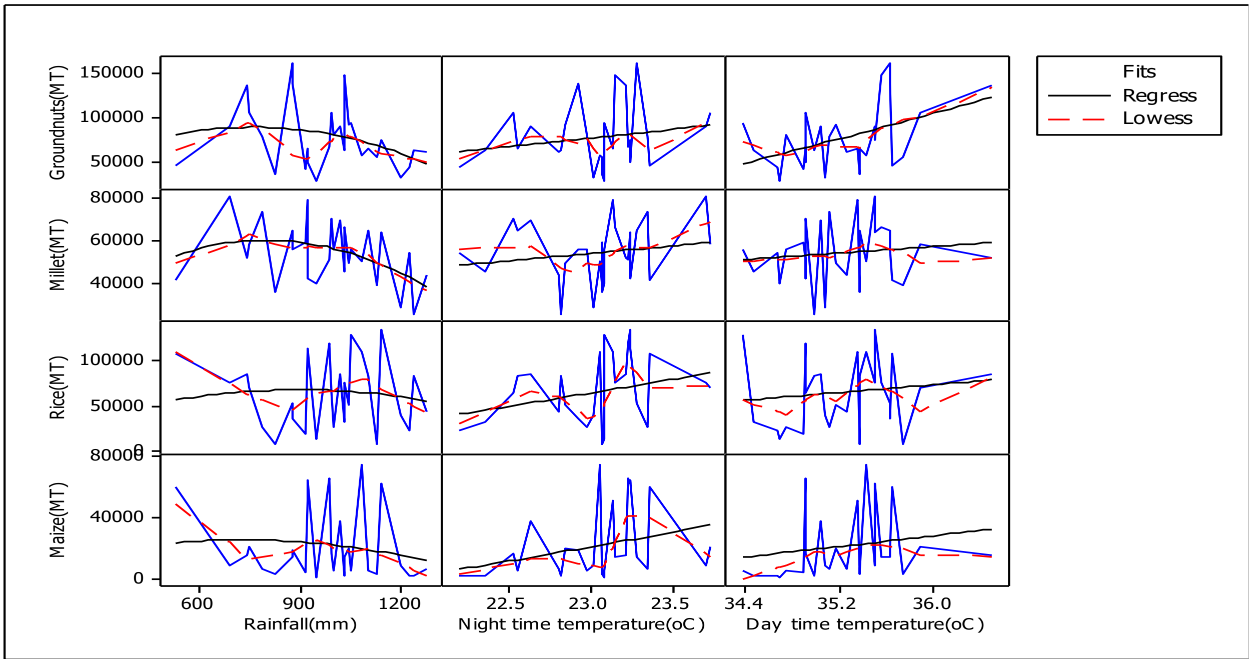

Figure 6: Matrix plot of food crops production in metric tons verses climatic variables

The blue lines indicate the variability in the production of the food crops, while the red lines indicate the LoWeSS. The LoWeSS makes the variations easily seen and shows that the relationships between the variables were not linear but rather polynomial in nature (Figure 6). The polynomial nature of the graphs suggests that production of food crops was not uniform but varied depending on rainfall and temperature. The variations were clear with rainfall and daytime temperature as compared with night temperature. This implied that rainfall and temperature negatively impacted crop production. While rice production was linearly related to rainfall, groundnut production was linearly related to daytime temperature. Millet and rainfall had a quadratic relationship, while maize and rainfall had a cubic relationship.

The findings underline the importance of understanding how each climate variable influences specific food crop production in the developing country context. Though a number of studies in Ghana (Yaro, 2013) have examined climate variability and its relationship with food production, most were undertaken using a specific crop and at a single geo-spatial setting. Such studies were also usually conducted using a single methodological strand. Combining in-depth interviews with quantitative analysis of climate and crop output over a period of not less than 30 years, the present study exposes the real risk of amplification of negative impacts resulting from unreliable climate. The Upper East Region of Ghana was used as a test bed and was chosen due to its location (in a savannah zone) where the dry season is more pronounced.

From all indications, the most significant climatic element with the potential to affect food crop production is rainfall. The impact of rainfall on agricultural production is recognized worldwide because of its implications for food security, and it raises a number of issues. First, issues of food security feature prominently in the list of human activities and ecosystem services under threat of dangerous anthropogenic interference with the earth's climate (Watson et al., 2000; IPCC, 2001). Second, countries are naturally concerned about the potential damage that may arise over the coming decades from climate variability impacts, since these have the potential to affect domestic and international policies, trading patterns, resource use, regional planning, and ultimately the welfare of people (Fischer et al., 2005).

The findings of the study also resonate with a study conducted by Adger (1999). He observed that extreme weather activities such as floods and drought threatened the existence and livelihood of farmers who were in the business of crop production. In a similar study, the Food and Agricultural Organization (FAO, 2009) observed that any minor deviations of food production patterns created by unstable climatic conditions could harm millions of people, because agricultural production is such a significant contributor to providing a means of survival through the production of food for consumption, in addition to the fact that it employs 36% of the world's workforce and 40–50% of the workforce in agriculturally dependent Sub-Saharan countries. Available scholarly works (Devereux & Edwards, 2004; Yaro, 2013) indicate that food production has steadily decreased by 10% in the last 20 years in the Horn of Africa, while acute famine has increased as a result of climate variability, especially unreliable rainfall patterns. While the situation might not be so acute in Ghana, there is every indication that climate variability is already having a negative impact on food crop production (Yaro, 2013).

As observed, climate variability has increased uncertainty and risk among food crop farmers. The risk exists because there is uncertainty about the future outcomes of on-going processes (farming activities) and about the occurrence of future events (climate-related activities). Once these uncertainties exist, farmers in the selected communities are unable to make decisive preparations to deal with an unknown future. Beyond its impact on food crop production, our results from the in-depth interviews also revealed that the phenomenon involves complex interactions between demographic, climatic, environmental, economic, health, political, institutional, social, and technological processes. There are therefore significant intergenerational implications in the context of equity and sustainable development (Fischer et al., 2005). In this regard, we appreciate the concerns of Devereux and Edwards (2004) and Yaro (2013) that unpredictable climate will impact social, economic, and environmental systems and will shape prospects for food, water, and health security in the coming years.

Conclusion and recommendation

This paper has examined the nexus between climate variability and food crop production in north-eastern Ghana. The results showed a real risk of climate variability impact on food crop production. However, the effects were not homogenous across all crops. This suggests that the interpretation of the impact that climate variability can have on food crop production should not be generalized. Again, climate variables (particularly rainfall and temperature) did not all exert the same effect on agriculture, and therefore each variable must be examined on its own merit. This notwithstanding, there is a general consensuses that in the tropical and sub-tropical regions of the world, regions that coincide with the location of north-eastern Ghana, climate variability is having a generally negative impact on food crop production, a situation that must be addressed if SADA is to record meaningful gains in poverty reduction in north-eastern Ghana. Against the backdrop that food crop farming is an important sector of the rural economy of the study location, as it provides employment, income, and food, any negative change in the production and distribution of food will be critical to food security. For this reason, understanding how the most cultivated food crops respond to climate variability is crucial.

In moving forward, we tend to concur with the idea of ONCTAD (2010) that, given the clear indications of the effects climate variability can have on food crop production and the fact that the future of the human race may be at risk from food insecurity, a fundamental transformation is required rather than simply ‘tweaking’ existing agricultural systems. There should rather be a ‘regenerative’ agricultural system, one which consists of a mosaic of sustainable production methods that continuously recreate the resources they use and achieve higher productivity. Such a system will have to marry local knowledge with modern agricultural techniques. This regenerative agricultural system must be packaged as a new and innovative system of farming and land management; and it should be central to future undertakings to improve not only agricultural systems but also the living conditions of peasant farmers while keeping them competitive in the global market. Evidence from other developing countries (Boko et al., 2007; FAO, 2012) shows that innovative solutions are the key, rather than craving for irrelevant mitigation or adopting foreign policies which do not hold the key to sustainable food production.

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