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Experiences of Heat Stress Vulnerability and Climate Change among Farmers in Ghana

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Abstract
The trend over the last decade of increasing temperature associated with climate change with the impacts being felt in the poorest communities of the developing world is unequivocal. Bawku East of northern Ghana is assessed as one of the poorest communities. Being a farming community the study investigates the extent of farmers' experiences on heat and climate change. A selected number of 308 farmers from a farming population of over 15,000 were interviewed about heat stress and climate change to gauge their level of vulnerability to heat stress at the household and farm levels, as well as their general experiences of climate change. The age, gender, duration of residence, community where a farmer lives and educational level were used as predictors to elicit experiences of heat stress vulnerability and climate change using logistic regression models and empirical results. The significance of the study is to establish baseline parameters for effective adaptation of heat stress as temperature is projected to increase with and beyond this century in the study area. On the balance, farmers have significant experience on heat stress vulnerability and climate change. The farmers who have lived longer in the study area showed significant experience of heat stress and climate change. Future study on level of adaptation to heat stress and climate change at household and farm level is timely and appropriate.
Keywords: Climate change, Heat Stress, Farmers, Experiences

1. Introduction

The global economy is envisioned to lose 20% of Gross Domestic Product (GDP) by the year 2050 if a concerted effort is not devoted to tackle climate change and its consequential impact (Stern, 2007). The impact of climate change expressed as increased temperatures, changes in precipitation, more extensive flooding, and enhanced drought and heat waves, is projected to be different in each geographic location (IPCC, 2007a; May, 2008; Schellnhuber, 2008). Africa is predicted to suffer a large impact from climate change, even though its contribution to global emission is insignificant (Christensen et al., 2007). A substantial part of climate change research involves measuring and establishing the recent changes in climate, projecting future climate changes, and identifying the causality of climate and anthropogenic greenhouse gas emissions (Bolin, 2007). Studies on the implications of climate change for humankind and options for responses have often been linked with conventional investigations of anthropogenic greenhouse gases and climate change (Bolin, 2007; Dovers, 2009; Smit & Wandel, 2006; Trainor, Stuart Chapin III, Huntington, Natcher, & Kofinas, 2007).

In all sectors of human endeavors and national economies, it is prudent to identify impacts and vulnerabilities of climate change since these phenomenon can adversely affect social wellbeing and economic development (Gössling & Hall, 2006; Maoh, Kanaroglou, & Woudsma, 2008; Smith & Almaraz, 2004), whilst identifying vulnerability and locating mechanisms to confront them serves as a tool to reduce poverty in a given population (Halsnæs & Trærup, 2009).

Crop farming contributes over 75% of agricultural production in Ghana even though the system is inflicted with unsustainable methods (Diao, 2010). Agriculture is the mainstay of the Ghanaian economy (Aryeetey & McKay, 2004), and the sector is predominantly managed by small landholders for the purpose of subsistence farming. Agriculture has contributed about 40% to the GDP of Ghana, though over recent years there has been a systematic decline to about 32% (Diao, 2010). Each agro-ecological zone contributes a certain percentage of agricultural GDP, with the forest zone accounting for 43% (Diao, 2010). The northern savannah zones account for 20.5% of agricultural GDP with the farmers producing over 70% of the nation's crops such as millet, maize, cowpea, sorghum, groundnut, and soya beans (Breisinger, Diao, Thurlow, & Al-Hassan, 2008). Over 90% of income in the northern savannah zone is generated from farm proceeds of staple crops and livestock (Diao, 2010). Agriculture employs about 55% of the population and contributes 30-40% of foreign exchange earnings in Ghana (Ghana fact sheet, 2010).

Studies of climate in northern Ghana have indicated that from 1961-1975 there was an average of 2.3 months of temperature per year above 37°C which rose to 5.3 months of temperature per year above 37°C between 1998-2012 (Frimpong, Van Etten, & Oosthuizen, 2014). In the same study, it was shown that the decadal increase in

mean minimum and maximum temperature were above the national average of 0.21°C. (Frimpong et al., 2014). With meteorological evidence of change in climate and a systematic increase in temperature, it is important to elicit the experiences of rural farmers in the vicinity since the major occupation of the residents are farming and the area is considered among the poorest in Ghana (Webber, 1996; Whitehead, 2006).

Knowledge of famers perceptions and experiences of heat and climate change is a prerequisite for effective adaptation strategies (Acquah, 2011). The propensity of farmers to experience and perceive that the climate has changed would inspire them to locate and implement effective adaptation options (Maddison, 2007). Conversely, inadequate knowledge on climate change and its impacts on agriculture and farming is a disincentive to sustainable agriculture, especially in developing countries (Kotei, Seidu, Tevor, & Mahama, 2007).

In spite of the sensitivity of farming to climate change, to the authors' knowledge, there have been no published studies of the experiences and perceptions of heat stress vulnerability and climate change and how heat exposure affects the rural farming communities in northern Ghana. This has become an important issue in the wake of prediction of 2.5-3°C upsurge in temperature by the year 2020 in northern Ghana (EPA, 2007). Eliciting the experiences, perceptions and understanding of the vulnerability of farmers to heat exposure and climate change constitutes important baseline information for government-led initiatives to ensure sustainable farming in the emergence of climate change. Arguably, understanding of farmers' experiences and perceptions of climate change and strategies for adaptation is also a necessary precursor for establishing cutting-edge policies and programs for instituting successful adaptation in the agricultural sector (Bryan, Deressa, Gbetibouo, & Ringler, 2009). A further warrant for this research regards food insecurity in Bawku East of northern Ghana (Hesselberg & Yaro, 2006; Webber, 1996; Whitehead, 2006), as distinguished from the forest zone in the south of Ghana where there is relatively adequate food for the residents (Songsore, Denkabe, & utvikling, 1995). Sustainable development in the emergence of climate change makes it imperative to examine environmental, social–cultural and economic concerns that undermine food security in a zone noted for its poverty and food insecurity. In view of inadequate knowledge regarding farmers' experience and perception of climate change (Fosu-Mensah, Vlek, & MacCarthy, 2012), this study is aimed at investigating whether farmers in Bawku East are experiencing increasing heat stress and climate change and how this is impacting their lives.

2.Research Objectives

This paper reports the results of a survey administered to rural farmers in Bawku East, northern Ghana, documenting their vulnerability to climate change and heat exposure. The paper uses logistic regression to model the effects of age, gender, community of residence, educational level of farmers and duration of residence in Bawku East on farmer's experiences of increasing heat stress and climate change. The survey questionnaires were adapted and modified from a global program which explores workers' vulnerability to heat stress and climate change, called 'Hot Occupational Temperature Health and Productivity suppression' program or HOTHAPS (Kjellstrom, Gabrysch, Lemke, & Dear, 2009). The survey presents results on duration of residence of farmers and their experiences of signs of climate change, heat impacts at the farm level, and heat impacts on sleep. The research questions elicit farmers' experiences on increasing heat stress and climate change in recent years. It further probes heat stress impact on farmers' sleep patterns. The impact of heat on their day to day activities at farm level is also examined. Recent signs and symptoms that denote a changing climate were investigated. Duration of residence was largely used to determine people's experiences on climate change and heat exposure since the number of years a farmer had lived in a community is likely to increase their knowledge and experience of these issues. Age of residents of farmers was used to determine the impact of heat at the farm level since the mature and the elderly are more likely to be affected by heat exposure (Fouillet et al., 2006). The conclusion of the paper includes discussion of the survey results in the context of scientific implications of climate change and sustainable development of rural farming in Bawku East of Northern Ghana.

3. Methods

3.1 Study area

The study was conducted in Bawku East of Northern Ghana (Figure 1). The area is found between latitudes 11^{o} 11^{1} and 10^{0} 40^{1} north and longitude 0^{o} 18^{1}w and 0^{o} 6^{1} E in the north eastern part of the Upper East region (Ministry of Food and Agriculture, 2014). The three selected farming communities in Bawku East were Manga, Pusiga and Binduri which have an estimated active farming population of 15,000 (Ministry of Food and Agriculture, 2014).

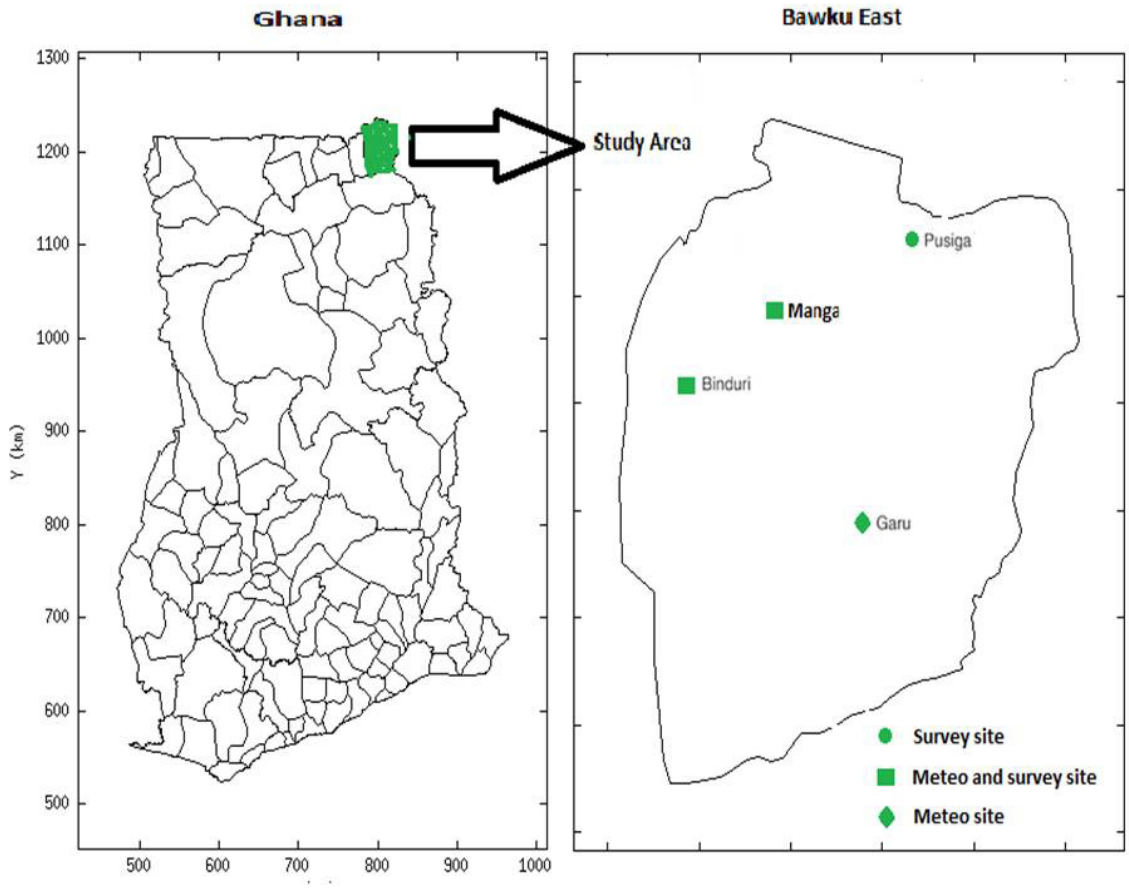

Figure 1: A map of Ghana showing the study area.

3.2 Sampling

The agricultural extension officers of the Ministry of Food and Agriculture in Bawku municipality assisted in conducting the survey in Pusiga, Manga and Binduri. Each of these communities has a lot of scattered villages, with houses surrounded by fields of cultivation of crops. Three hundred and eight farmers' households were randomly selected in these three farming communities for the survey. Interviews were conducted using structured questionnaires and focus groups discussion. Only one farmer was interviewed in each household to spread the range of responses in the event where a household has two or more farmers. The structured questionnaire focused on demographic information of the farmers, experiences on heat stress vulnerability and climate change (the focus of this paper), local adaptation strategies by various farmers (legume, cereals, and vegetables) and barriers associated with strategies to confront heat and climate change. Predominantly, face to face interviews were used to collect the data. The questionnaires were written in English, whereas the interviews were presented in their respective local languages by research assistants recruited from each locality. Both interviews and focus groups discussion questions were adapted and modified from the ongoing global program of HOTHAPS. Interviews were conducted from January 2013 to May 2013. Data were analyzed using the Statistical Package for the Social Sciences (SPSS v.21). Focus groups discussion on heat stress vulnerability and climate change were done to obtain more detailed and richer responses from farmers.

3.3 Logistic regression model approach

To establish the effects of community type, duration of residence, educational level, age and gender on the farmers' experiences, perception and vulnerability to heat exposure and climate change, a binary logistic regression model was adopted (Acquah, 2011; Apata, Samuel, & Adeola, 2009). The binary logistic regression model is a component of generalized linear model (Agresti, 2007). Binominal distribution is a prime assumption underpinning the binary dependent variable (McCulloch, 2006).The reason for utilizing this model was the dichotomous state of the dependant variable (having knowledge, experience on heat exposure and climate change, as against not having knowledge, experiences on heat exposure and climate change). This model determines the probability of estimating farmers' experiences, perception and vulnerability to climate change and heat exposure or not having experience on heat exposure and climate change based on the predictor variables (community, age, duration of residence, educational level, and gender) which are fixed into the regression

model. In this case both categorical and quantitative independent variables can be used in the regression modeling. The binary logistic regression model is represented by equation (1) below:

$$\log\left[\frac{P(Y=1)}{1-P(Y=1)}\right]=\log\left(\frac{\pi}{1-\pi}\right)=\text{logit}(\pi) \\ =\alpha+\beta_1 x_1+\beta_2 x_2+\ldots+\beta_n x_n \quad (1)$$

where $P(Y=1)=\pi$ denotes the probability of a farmer having experienced heat vulnerability and climate change in recent years, while $1-P(Y=1)$ represents the probability of a farmer not having experienced heat stress vulnerability and climate change in recent years. The $\log it(\pi)$, predicts the probability (π) of a farmer having experienced heat stress vulnerability and climate change. Such probability lies between 0 and 1 $(0\le\pi\le 1)$ with regards to all the likely independent variables.

As illustrated in equation (1), α represents the intercept and $\beta_1,\beta_2,...,\beta_n$ are the coefficients of the logistic regression model which are aligned to the set of n independent (or predictor) variables, denoted by $x_1,x_2,...,x_n$, whiles the log transformation of the odd ratio ($\log it(\pi)$) is modelled as the dependent variable. The maximum likelihood approach was used to estimate the model parameters being the intercept and coefficients. The estimated coefficients quantify the effects of the predictor variables on the dependent variable which represent the contributions of the odd ratio by each predictor for its unit change (increase or decrease). Statistically, the significant effect of each predictor variable included in the model is determined by its P-value. Thus, the odd ratio, as stated earlier in this paper, denotes the likelihood of a farmer having experienced increasing heat and climate change with regard to a change in the independent variables that have been considered in the model.

4. Results

Results

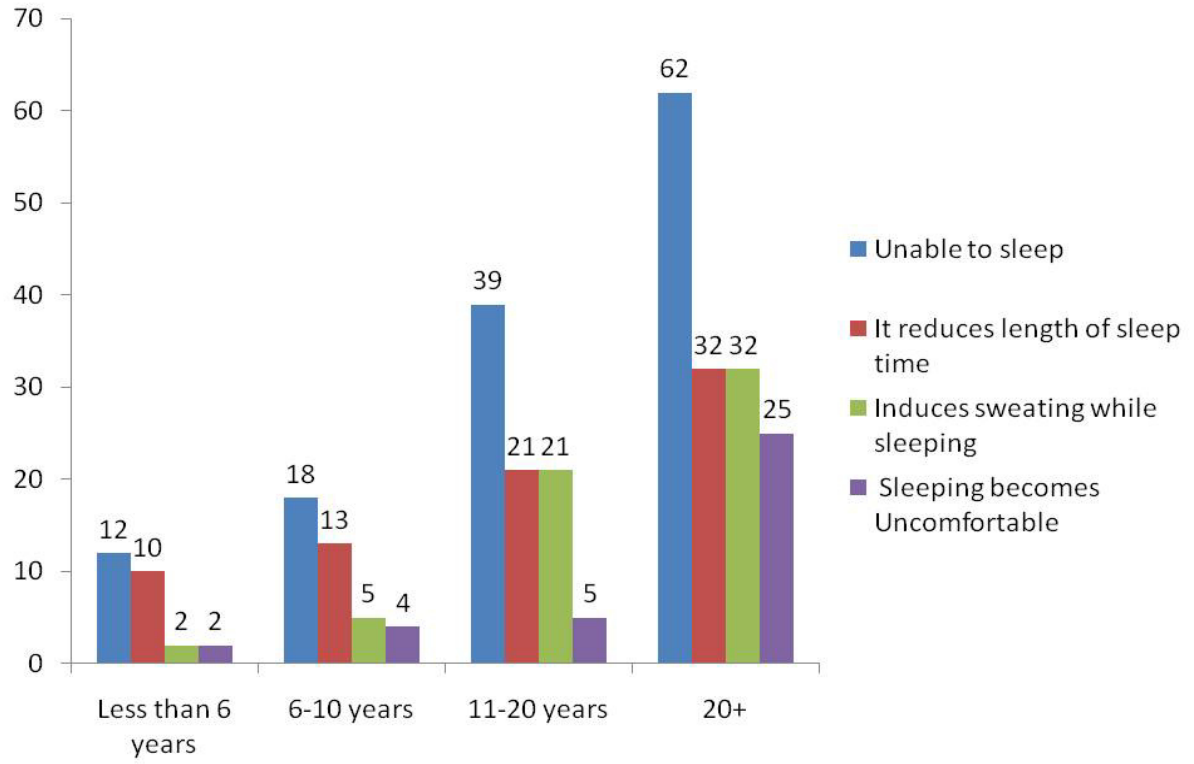

Figure 2: Farmer's responses (measured by number of responses) to heat impact on sleep and their duration of living in Bawku East (n=303 of 308, 5 non respondents).

Duration of residence of farmers in Bawku East was used to determine their responses on effects of heat on sleep (Figure 2). Out of 308 respondents, there were five non-responses to the question of how heat affects their sleep. Farmers who had lived in Bawku East for twenty years or more showed a higher response relating to 'unable to sleep'. Induced sweating and reduced length of time to sleep were the second highest response from persons who had lived longer in the communities. Those farmers who had lived 11-20 years reported a relatively higher effect of heat on sleep, with the least response emerging from those with less than 6 years of farming experience.

Fig.3.

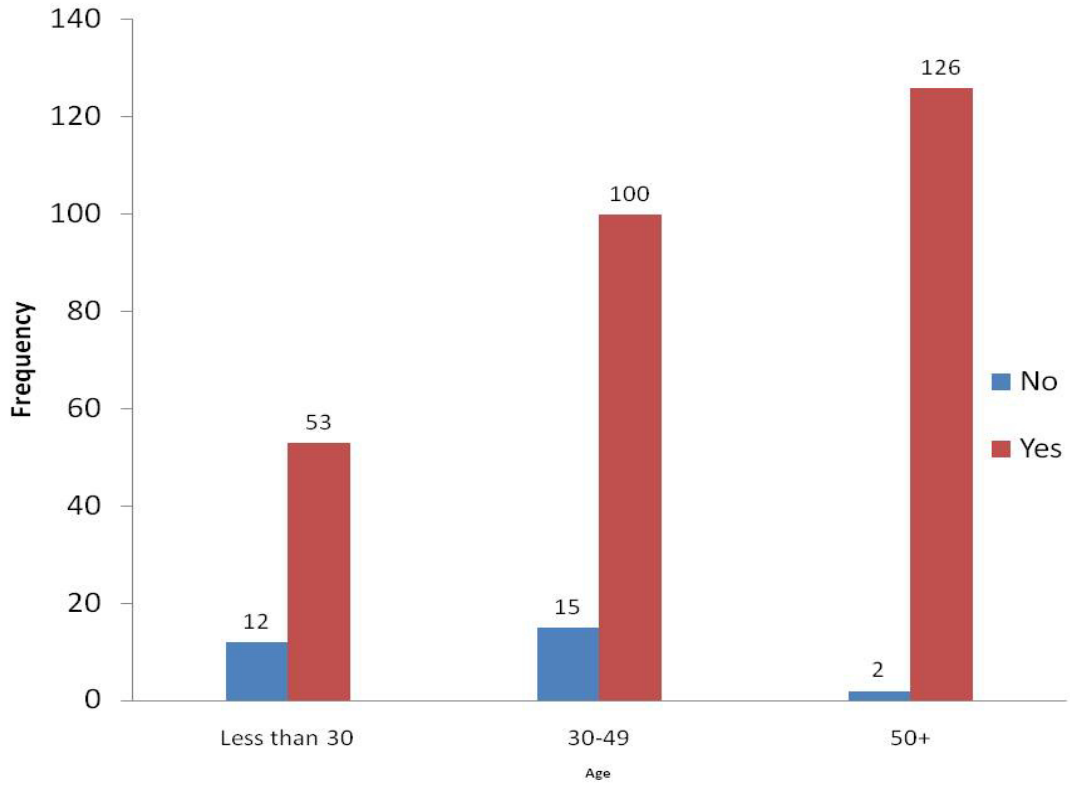

Figure 3: Experiences of farmers in Bawku East on increasing heat and climate change aggregated in age group (n=308).

Farmers' perceptions and experiences of increasing heat and climate change were determined using the age groups of less than 30, 30-49 and 50 and above. Those who were 50 years and above showed a higher response (Yes) for having experienced heat and climate change impacts. The age group of 30-49 showed the next highest response to having personal experiences of heat exposure and climate change.

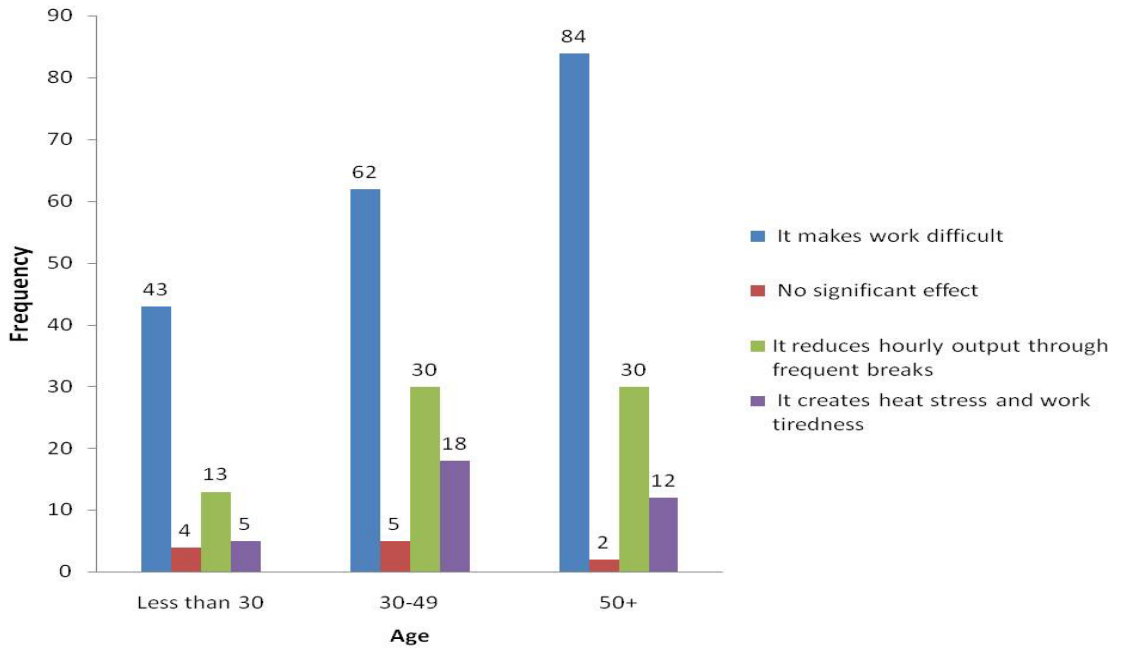

Figure 4.
Experiences of farmers on impact of heat at farm level in Bawku East (n=308)

In the context of experiences of farmers with regard to heat at their farm level, those aged 50+ showed the highest impact of heat on their day-to-day activities at the farm level, which continues the trend of those with higher age having higher concern on the impact of heat.

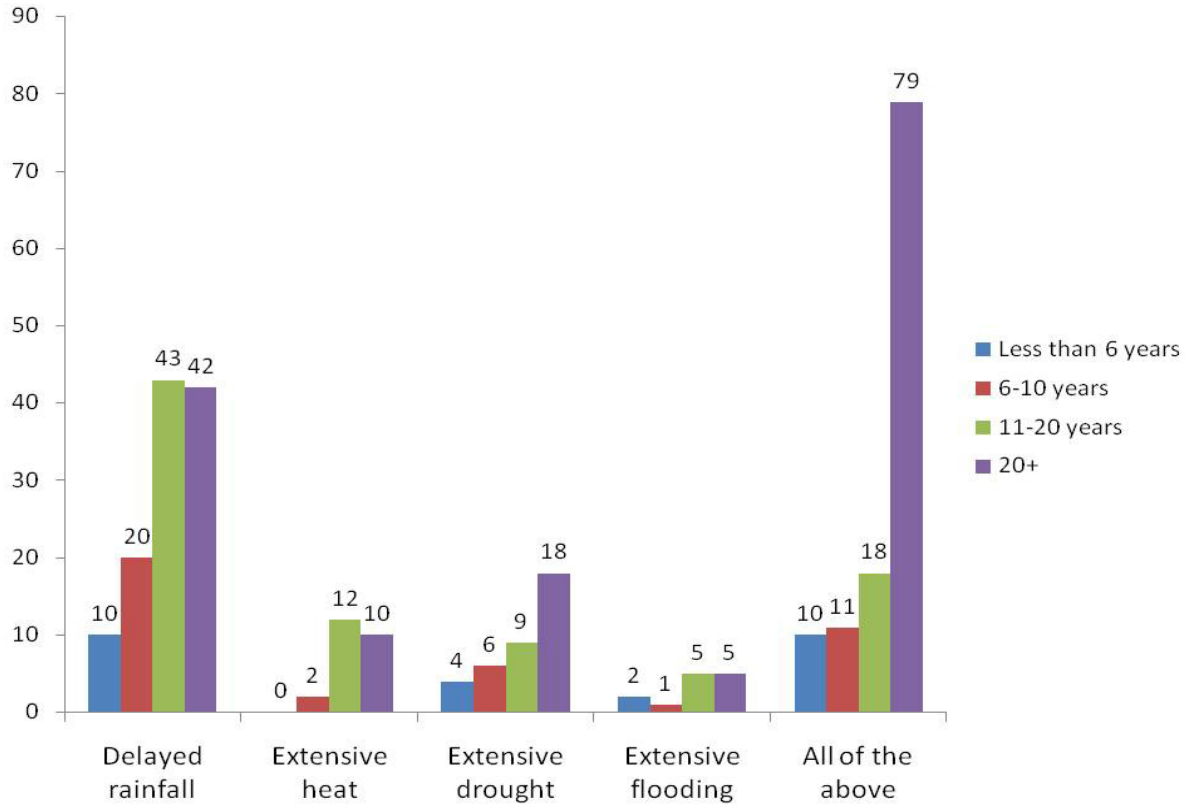

Figure 5: Farmers' experiences (signs) of climate change in recent years and duration of residence in Bawku east n=302 of 308, 6 non response)

Farmers' duration of residence was used to compare their perceptions of the signs of climate change (Figure 5) . Farmers who had resided in the region for more than 20 years more often noticed signs such as delayed rainfall, extensive heat exposure, extensive drought and extensive flooding, followed by those who had resided in the area for 11-20 years. Thus farmers who had been in the locality longer, were more concious of climate change signs.

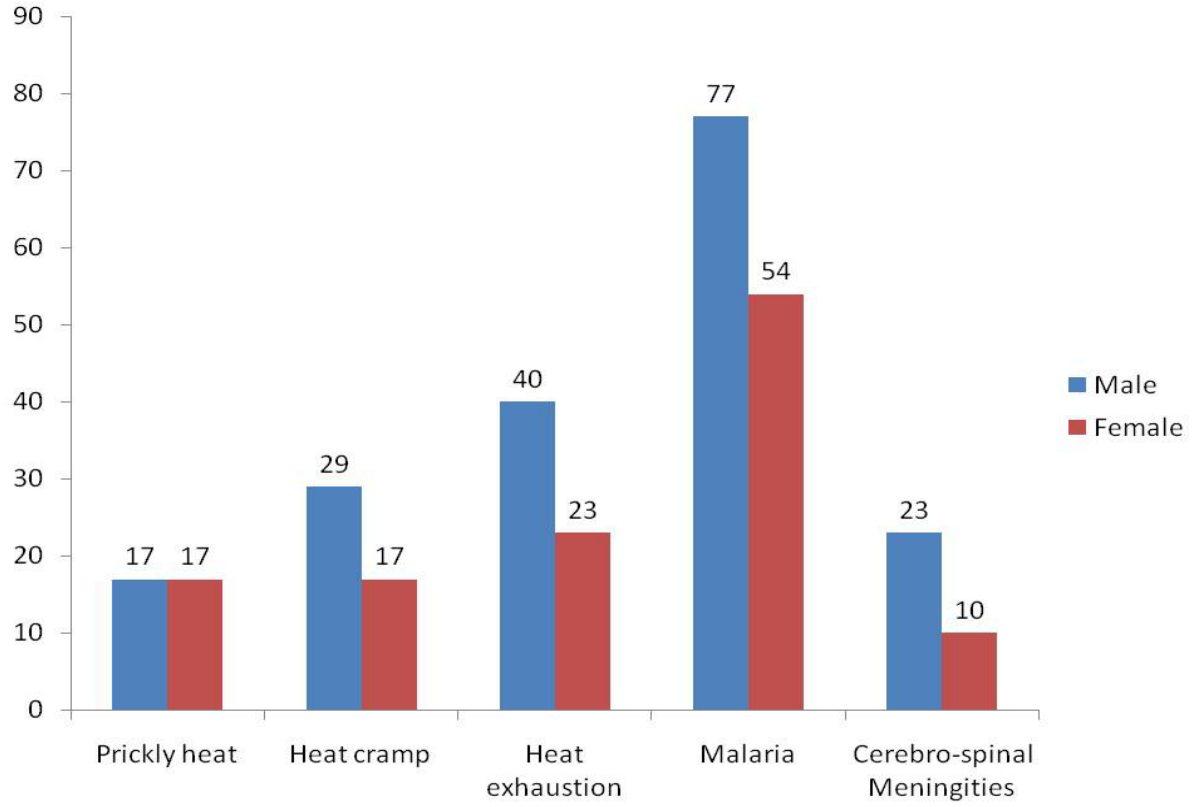

Figure 6: Experiences of farmers in Bawku East based on their gender and heat-related illness

Malaria is perceived as the most common heat related illness in Bawku East, with many males experiencing that condition. Cerebro-spinal meningitis is another illness which is enhanced by heat. It usually occurs when heat is at its high peak. Other less threatening heat-related illnesses reported by respondents were heat exhaustion, heat cramp and prickly heat

Age, gender, educational level, community of residence, and duration of residence were used as independent variables to measure farmers' responses on experiences of increasing heat exposure and climate change during recent years in Bawku East. The dependent variable was experiences of increasing heat and climate change in recent years in Bawku East

Logistic regression results

Table 1 Results of logistic regression equation modelling examing the effects of community, age, gender, education and residency time on farmer's awareness of heat stress and climate change.

Variables	Coefficient	Standard Error	P-Value	Odd Ratio
Community				
Binduri	1.565	0.674	0.020	4.783
Pusiga	0.078	0.638	0.903	1.081
Manga	Ref			
Age				
< 30	-2.275	0.804	0.005	0.103
30-49	-1.373	0.707	0.052	0.253
Above 50	Ref.			
Gender				
Male	1.575	0.369	0.000	4.831
Female	Ref.			
Education				
Primary	2.213	0.480	0.000	9.143
Secondary	2.131	0.536	0.000	8.423
Tertiary	1.909	0.664	0.004	6.746
Non formal	Ref.			
Duration of residence				
<6years	1.330	0.863	0.123	3.781
6-10 years	0.172	0.605	0.123	1.188
11-20 years	0.744	0.471	0.114	2.104
Above 20	Ref.			

Discussion

A large number of the respondents have shown that they were unable to sleep due to higher heat exposure. The farmers who had lived in Bawku East for over 20 years showed the highest level of responses to heat impact on sleep. Apart from the area being a poverty prone environment, farmers' livelihood are exacerbated by harsh climatic conditions, and poor socioeconomic infrastructure (Laube, Schraven, & Awo, 2012). Over 88% of the rural population live below the national poverty line (Ghana Statistical Service, 2000). The entire region did not receive any development under the past colonial administration and such trend was replicated by succeeding governments after independence (Laube et al., 2012). Previous studies indicated that rainfall commencement has shifted from April to May increasing a long dry season (Laux, Kunstmann, & Bárdossy, 2008).Climate analyses have predicted increasing occurrence of extreme weather event such as heat, drought which is likely to worsen already food insecurity issues in the area (Van de Giesen, Liebe, & Jung, 2010). This corresponds to studies that stipulate that heat waves globally are projected to increase in intensity and frequency especially in the tropics (IPCC, 2007b). Therefore the entire evaluation of farmers' experiences of heat stress vulnerability and climate change is crucial and timely. Moreover, poor people are projected to have significant impacts related to changing climate as a result of low adaptive capacity (Parry, 2007). Bawku East being a poverty prone area (Webber, 1996; Whitehead, 2006), the incidence of high responses by farmers to high heat during sleep are likely due to poverty and low adaptive capacity to confront heat stress in their home and working places. Studies done by Frimpong et al. (2014) indicate a consistent increase in temperature in Bawku East, especially in Garu from 1961 to 2012. Those aged 50 and above showed the highest response rate of having experienced increasing heat and climate change during recent years. This was in agreement with the perceptions expressed by farmers in other part of northern Ghana on changes that have occurred in climate (Dietz, Millar, Dittoh, Obeng, & Ofori-Sarpong, 2004). A study conducted in Asekyedumase of Ghana indicates that farmers have a clear perception that the climate has changed (Fosu-Mensah et al., 2012).

Farmers who were above the age of 50 showed high concerns on impact of heat on farm activities. This may be due to their feeble physiological capabilities to cope with heavy and very heavy tasks associated with farming, such as digging holes and drawing of water to irrigate crops in full exposure of heat. Exposure to high temperatures and humidity can cause heat-related illness like heat cramps, heat exhaustion, heat syncope especially in a given population that have respiratory diseases (McGeehin & Mirabelli, 2001) and such illnesses were commonly reported across all age groups in this study. Many diseases related to old age are likely to increase in heat prone environments.

With regard to changes in climate, the farmers who have lived for more than 20 years in Bawku East were more aware of the delay in wet-season rainfall, extensive heat, extensive drought, and extensive flooding. In 2007, there was extensive rainfall that caused damage to human and properties in the vicinity. Farmers who have lived longer in the area affirmed in focus group discussions that a lot of changes had occurred in the past 20 years. They intimated that there is a delayed rainfall, which has shifted their planting season from April to May and sometimes June. These experiences of the farmers of shift of rainy season to May in many parts of northern Ghana were attributed to climate change (Dietz et al., 2004). The same concern about changes were expressed by farmers in Asekyedumase located in the Ashanti region of Ghana (Fosu-Mensah et al., 2012). Farmers stated that traditional symptoms they used to gauge the commencement of rainfall were not reliable any more (Dietz et al., 2004).

Farmers' experiences of heat-related illness indicated that more farmers were prone to acquiring malaria than any other heat-related illness, particularly so for males. This conforms to the study of malaria epidemics in Ghana, where Bawku East was noted as one of the high prevalence zones (Appiah, 2014). The spread and distribution of malaria are associated with the upsurge of mosquito populations which in turn is linked to climatic factors and geographical locations (Habib, El Zein, & Ghanawi, 2010). The impact of climate change resulting in changing trend of temperature, humidity, and rainfall is likely to affect the local distribution and severity of the spread of malaria disease (IPCC, 2007b; Sachs & Malaney, 2002). A copious amount of research in the Eastern Mediterranean have indicated an association between incidence of malaria due to increased temperature, humidity and rainfall changes (Habib et al., 2010). Since there is a systematic increase in temperature in Bawku East of northern Ghana (Frimpong et al 2014), the high incidence of reported malaria cases by farmers (as shown in Fig. 6) is warranted.

The key independent variables (community, age, gender, education, and duration of residence) were used in a logistic regression to model their effects on the dependent variable, which is whether or not the farmers' were experiencing increasing heat stress and climate change in recent years. This was shown to be significantly higher in all the independent variables except duration of residence (Table 1). The selected farming communities within Bawku East showed significant differences in their experiences of increasing heat stress and climate change (Table 1).

The selected farming communities within Bawku East showed significant differences in their experiences of increasing heat stress and climate change with those from Binduri being most affected. This is likely attributable to ethnic differences and perhaps the architectectural style of housing. Age was significantly associated with experience of farmers to increasing heat stress and climate change. In empirical results derived from the survey, farmers over 50 years of age were more concern about increasing heat stress and climate change than younger farmers. Education was associated with farmers' experiences of increasing heat stress and climate change and this indicates that education enhances peoples' understanding of the changing climate. The most important aspect of education is likely to stem from variation in behavioral responses to thermoregulation(Brager & de Dear, 1998) Duration of residence in the community was not significantly associated with concerns over climate change. However, in the empirical results (as presented in Fig. 2 and 4), duration of residence in the community showed that the longer a farmer had lived in the community the greater their concerns were regarding increasing heat stress and climate change.

Conclusions

In determining farmers' experiences to increasing heat and climate change, the age of farmers is cardinal since their age allows them to establish a frame of reference for assessing climate change and increasing heat exposure. Moreover, farmers' educational level is a factor to consider as it relates to their ability to understand and express the changes in climate they perceive in the sphere of scientific contexts. In a Bolivian farming community, the frequent occurrence of hailstorms was largely attributed to the curses the gods had meted out on the residents due to high incidence of teenage abortion and refusal to perform customs and rituals to honour gods and ancestral spirits (Chaplin, 2007). Such perceptions have no scientific relevance, hence the importance of education in shaping the thinking of rural farmers on the trends and changes in climate.

Duration of residence, even though it did not prove significant in the logistic model, is an important aspect in eliciting peoples' experiences of climate change and heat vulnerability. The longer a farmer had lived in an area, the greater their awareness of climate change and their experiences can be well presented. Malaria is a heat-related illness that is triggered by an environment conducive for mosquitoes breeding and this related to higher temperatures.

It is imperative for government-led adaptation initiatives to be intensified in poor communities of developing countries to provide residents in heat-prone environments with well-ventilated accommodation and to reduce heat stress in the wake of global warming. Farmers who depend solely on the dictates of the weather need to be supported by government to enhance their resilience and increase food production to reduce poverty and food insecurity. Future studies on climate change and heat impact in a community, should consider using age, duration of residence in the community, and education level of residents when eliciting respondents' experiences on a particular experiences of climate change, since such variables have proven to be effective in eliciting farmers experiences to heat vulnerability and climate change in Bawku East of northern Ghana. To curb rural urban migration from Bawku East to the southern part of Ghana, it is imperative for the Government to focus on sustainable measures, such as providing or encouraging well-ventilated accommodation in farming communities and developing programs of mechanized farming to reduce human physical outlay of labor in hot temperatures.

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