



Research article

Evaluation of heat stress impacts and adaptations: perspectives from smallholder rural farmers in Bawku East of Northern Ghana

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ARTICLE INFO

Keywords:

Risk
Climate
Exposure
Farmers. heat
Livelihood
Bawku east
Climate change
Heat stress
Agricultural science
Environmental science
Health sciences

ABSTRACT

Across the tropical developing countries, smallholder farmers are confronted with various climate related risks that hinge on agricultural activities. Climate change is predicted to impact smallholder farmers and their livelihood, especially within and beyond this century. Several studies have examined the impact of drought and rainfall on smallholder farmers as climate change impact assessment. However, there is limited information on impacts and coping strategies of poor farmers to heat exposure at household and farm level in tropical developing countries. As global temperature is predicted to increase with robust impacts on farmers in African region due to poverty and low adaptive capacity, this study evaluates how farmers in Bawku East of Northern Ghana experience the impacts of heat stress and how they cope with it both at the household level and on the field of cultivation. Using household survey and focus group discussion, the authors elicited impacts and responses of heat exposure from 308 resident farmers in three selected farming communities in Bawku East to gauge their vulnerability to heat exposure. Even though farmers have various impacts and coping strategies to heat exposure, these are ineffective to prevent them from heat related morbidity and mortality at both household and farm level. The study recommends the need for government led intervention to assist farmers in their effort to cope with heat stress as global temperatures will exacerbate heat stress impacts on small holder farmers especially in African region.

1. Introduction

Smallholder farmers form a big fraction of the global population ranging from 450-500 million persons worldwide and constitute 85% of global farmers (Graeub et al., 2016; Lowder et al., 2016; Nagayet O, 2005). About half of the global hungry persons are projected to be smallholder farmers with three quarters expected to be in African region (Graeub et al., 2016; Sanchez PA & Swaminathan MS, 2005). Achieving the target of sustainable development goals is contingent on renovating the livelihood of smallholder farmers. In the tropical developing world, series of studies have examined drought, erratic rainfall and other weather impacts on smallholder farmers. However, little studies have been accomplished on heat stress as a growing occupational health issue in the developing world (Kjellstrom, 2012; Kjellstrom et al., 2014). Apart from negative impact of temperature on farmers crops like cereals (Kumar et al., 2011; Morton, 2007), increase in temperature as a result of global climate change has various socioeconomic and health impacts

worldwide (Djurfeldt, 2015; Martin Lewis Parry, 2007), especially on the health and productivity of smallholder farmers in the tropical developing world (Costello et al., 2009; Easterling et al., 1997; nullQ; M.L. Parry, 2007; Zander et al., 2015). In the sphere of health impacts, it is identified that excessive heat stress can give some health effects such as cardio respiratory diseases, diarrheal diseases, as extreme weather events occur with climate change (McMichael, 2003; Sahu et al., 2013; Zander et al., 2015). Moreover, there is a confirmation that extreme temperatures will increase heat related morbidity and mortality (Field et al., 2014; IPCC, 2007). With the upsurge of mean temperatures associated with global warming, its concomitant rise in extreme temperature and heat episode is imminent (Fischer and Schär, 2010; S. Hales, Edwards and Kovats, 2003; Pachauri et al., 2014). Areas of the world where significant record of heat stress is rife, there is the possibility of such events being frequently experienced (McMichael et al., 2008; K. Smith, Woodward and Campell-Lendrum, 2014), especially in tropical developing countries with poverty and low adaptive capacity (Christensen et al., 2007).

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Table 1. Impacts of heat at household level.

Impact of heat	Frequency	Percentage
Impact on Household activities		
No effect	11	3.6
Makes domestic chores difficult	189	61.4
Increase work hour	73	23.7
Creates stress and work tiredness	35	11.4
Impact on sleep		
Unable to sleep	132	43
Reduces length of sleep	79	25.7
Induces sweating while sleeping	60	19.5
Makes sleeping boring	36	11.7
Level of impact of time to cope with heat at household level		
Moderately	47	15.3
Highly	151	49.2
Extremely	98	31.9
No impact	11	3.6

Source: Authors Compilation of Household Survey, in Bawku East (2013) in % and frequencies.

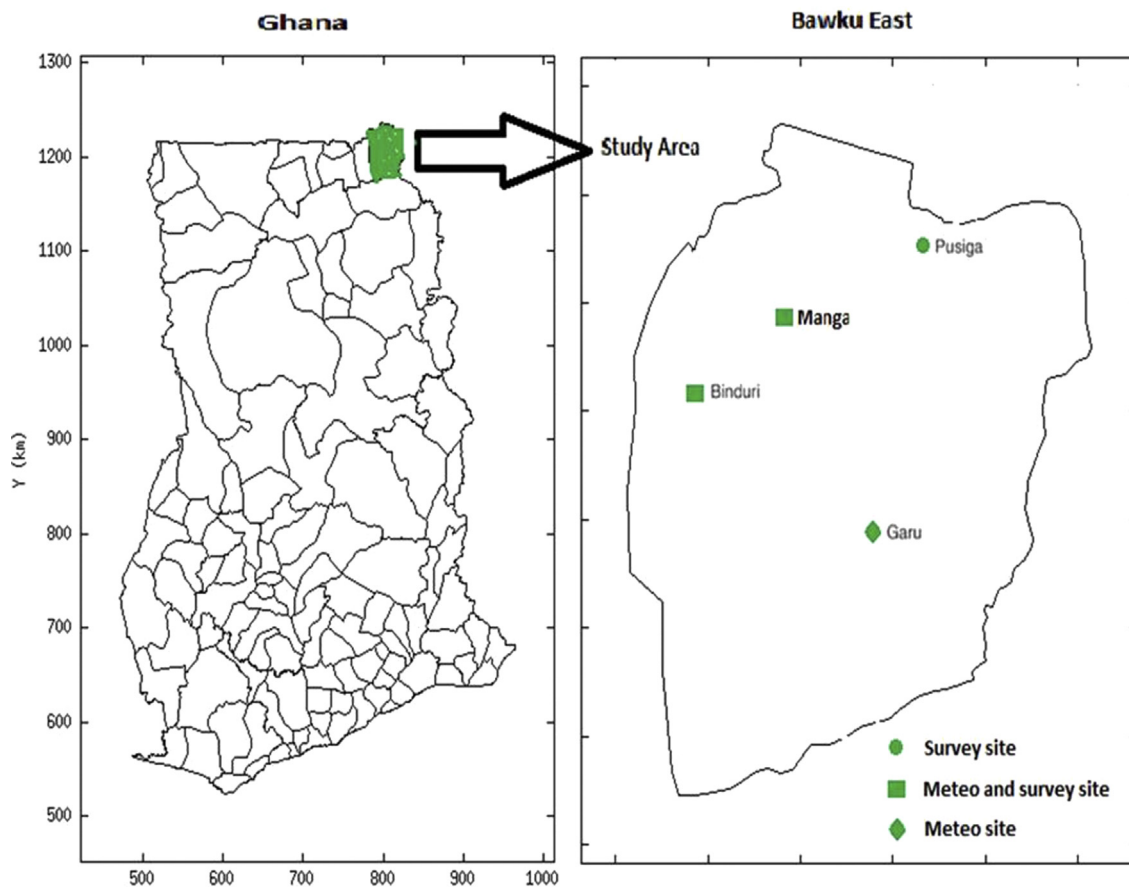


Figure 1. A map of Ghana showing Bawku East and the selected villages for the study. Adapted from (Frimpong et al., 2014a, b).

Among weather related hazards heat exposure has resulted in many fatalities as compared to other climate change variables such as drought, rainfall vagaries, and temperature among others (National Climate Data Center, 2006). It is rare to find studies that examine peoples vulnerability and how they respond to heat in many places (Sheridan, 2007), and in African region there is inadequate published study evaluating outdoor peoples exposure, self-reported impacts and response to heat stress (Costello et al., 2009). In view of that, it is imperative to constantly

investigate how the most vulnerable group could be exonerated from heat stress impacts (Ebi et al., 2006). Certain sectors of human endeavors are at the peril of the harsh impact of climate change and heat stress. These include farming, fisheries, forestry and construction, which are the predominant occupation usually carried out in an outdoor environment under the exposure of heat in Asian and African regions where climate change and heat exposure is predicted to be worse within and beyond this century (IPCC, 2007; Tord Kjellstrom, Butler, Lucas and Bonita,

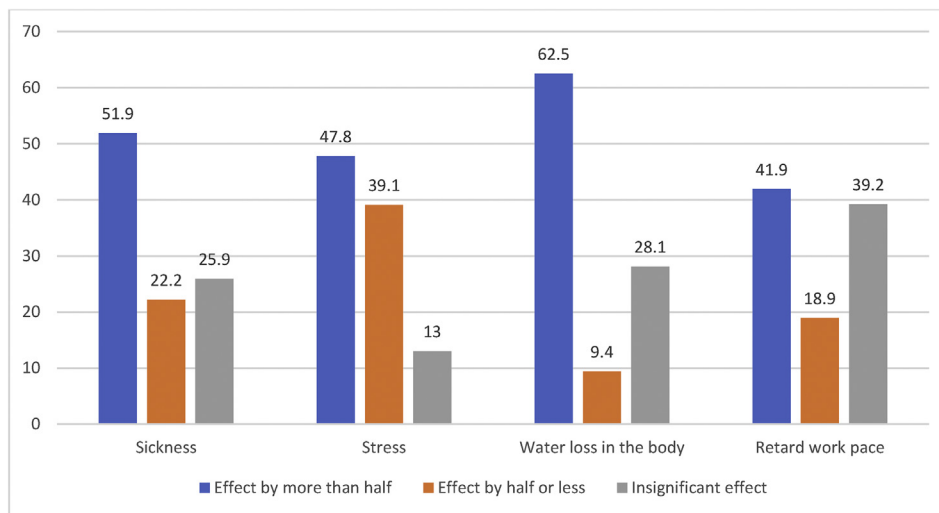


Figure 2. Effects of Heat on income and productivity of farmers.

Table 2. Adaptation strategies at the household level.

Adaptation strategies at household Level		
Adaptation strategies	Number	Percentage
Minimization of heat in room during the day		
Opening doors and windows	179	58.3
Usually not hot in room (do nothing to adapt)	12	3.9
Providing room standing fan	116	37.8
Minimization of heat in room at night		
Sleeping outside the room	74	24.2
Opening doors and windows	134	43.8
Taking very cool shower before sleeping	98	32.0
Hotness of room during hot season		
YES	298	97.1
NO	98	32.0
Information from government about heat and temperature		
Yes	268	87.3
No	38	12.4

2010). As heat stress will be an occupational issue in poor and small-holder farming communities in low and middle income countries in the emergence of climate change (Kjellstrom, 2012), it is imperative for the global community to assess the current impacts and coping strategies of poor farmers who work in hot outdoor environment under the exposure of full sun shine and heat.

In Ghana, a large number of the population are engaged in agriculture (Agyeman-Bonsu W, Dougherty B, Amanda F, & Kemp-benedict, 2008), which is predominantly undertaken under the exposure of full sunshine, with human physical labor and primitive equipment, a feature characterized by third world method of agriculture (Food and Agriculture Organization, 1987; Kjellstrom, 2000; Kjellstrom, 2009). These people are known to be poor (Laube et al., 2011; Morton, 2007), but constitute the bulk of agricultural labor force for Ghana's socioeconomic development (Aryeetey and McKay, 2004). Over the past fifty years there has been a record of an upsurge of one degrees rise in temperature (Agyeman-Bonsu et al., 2008) with its corresponding increase in hot days and nights (McSweeney, 2012). In Bawku East of Upper East part of Northern Ghana, an aggregate of 2.3 months of day time temperature was assessed to be above 37 degrees Celsius from 1961-1975. This rose to 5.3 months per year for day time temperature above 37° from 1998–12 (K Frimpong, J Oosthuizen, & EJ Van Etten, 2014b). Investigating the impacts and

responses of farmers in northern Ghana to heat exposure is timely and appropriate to aid policy.

When there is excess heat generated by the body or decrease in the dissipation of heat to the environment, it can result in heat related morbidity. Over production of heat can lead to the body temperature to rise above the limit capable of maintaining a thermal balance, which usually can be injurious to the cells leading to heat morbidity and mortality. When the body temperature is above the threshold of 37–39° heat stroke, heat exhaustion, heat syncope and heat cramp are likely to occur (Kilbourne, 1997; Leithead and Lind, 1964). The impact of air temperature, humidity, mean temperature in an area, and air movement are the key determinants of heat stress (Srivastava et al., 2000). In executing a task of high level of physical demand (predominantly known in farming communities) in a hot area, there is the risk that the core body temperature will rise above the normal limit, which can lead to reduced physical work capacity (Bridger, 2003; Kerslake, 1972) undermine ability to undertake mental task (Ramsey, 1995) and expose a worker to rapid accidents (Ramsey et al., 1983) and can lead to heat stroke (Hales and Richards, 1987). People living in each environment are certainly acclimatized to their local climate with regard to physiological, cultural and behavioral stature (Kovats and Hajat, 2008). However, these potential are dictated by clear limit that the body can tolerate. As global

Table 3. Descriptive Statistics of variable (using percentages) of limiting heat exposure at farm level.

Variable	Number	Percentage
Methods of limiting heat exposure at farm level		
Get away to a shade for a while	82	26.6
Clothing removal for free air	13	4.2
Regular intake of water	61	19.8
Wearing a hat	52	16.9
Wearing of airy dress	100	32.5
Intake of water		
Yes	295	95.8
No	13	4.2
Availability of sufficient water		
Yes	174	56.5
No	134	43.5
Intake of traditional diet to cope with heat		
Yes	175	56.8
No	133	43.2
Traditional or other method to cope with heat		
Cover head with traditional scarf	10	3.2
Wearing traditional cloth which is airy	32	10.4
Eating traditional food which induces regular intake of water	142	46.1
No traditional food	124	40.3
Have financial investment to cope with heat		
Yes	69	22.4
No	239	77.6
Conflict of social life time and time to cope with heat		
Yes	286	93.5
No	20	6.5
Adaptation strategies for crops		
Mulching	175	57
Irrigation	46	15
Applying manure	70	22.8
Erecting shade cover crops for sunshine and heat	16	5.2

climate change is presumed to exacerbate heat events (McMichael et al., 2008), there is the need to assess the impacts and level of response of a given population to current heat exposure. Using a poverty prone farming environment normally associated with low adaptive capacity (Kjellstrom et al., 2009b; Morton, 2007; Nti and Barkley, 2013) is a key step in evaluating their current impacts and adaptation, which can assist identifying their tolerance range to temperature and increased heat as basis for postulating future impacts as global mean temperature is expected to increase. Therefore, the aim of this article is to examine the impacts and responses to heat exposure at both household level and on the field of cultivation on farmers in Bawku East of Northern Ghana, where significant number of the residents are poor (Webber, 1996) and have low adaptive capacity to predictors of climate change (Laube et al., 2011) and are highly prone to heat exposure (Frimpong et al., 2014b). To achieve the outlined objective a survey was conducted to obtain self reported impacts and responses of heat exposure in the farming community of Bawku East encompassing Pusiga, Binduri and Manga.

2. Methods

The study assessed farmers' vulnerability to heat exposure in Bawku East of Ghana. Ethical Clearance reference number KC-5/287/02 was given by the Ghanaian Ministry of Food and Agriculture, for the study to commence. Human Ethics committee of Edith Cowan University, Western Australian further approved the study under ethical clearance number 8483. The study has been informed by the concept of vulnerability, which denote that the methods of reducing the impacts of hazards on humans are the key base of adaptation (Adger et al., 2004) and the

ability to utilize the current state of reduction of impacts towards enhancing livelihood is important feature in successful adaptation (TERI, 2007). The study revolves on exposure, sensitivity and adaptive capacity in the sphere of individuals and communities (Smith et al., 2000). Previous studies have applied this concept to ecology and forest management in assessing exposure, sensitivity and adaptive capacity of vulnerability of ecology and forest sector (Ford and Smit, 2004; Johnston and Williamson, 2007; Smit and Pilifosova, 2001; Turner et al., 2003). The level of heat exposure in the sampled communities denotes their vulnerability. The methods of living and working largely limit or intensify farmers' exposure to heat stress vulnerability. The effects of heat exposure in the study area on the sampled communities are represented as their sensitivity. This varies from individuals to individuals base on their physiological and socioeconomic capabilities. Exposure and sensitivity are contingent on both architectural style and methods of farming in this study. Adaptive capacity, is an integral part of the tripartite (Exposure, Sensitivity and Adaptive capacity) concept of vulnerability (B. Smith, Burton, Klein and Wandel, 2000), which forms the fulcrum of this study. The ability of farmers to overcome the impact of climate change is reliant on their adaptive capacity (Ziervogel et al., 2008). Farmers socioeconomic status dictates their adaptation to heat exposure.

The methodological fulcrum of the study hinges on mixed method, exploratory study design encompassing quantitative and qualitative methods used for achieving triangulation and further strengthening the research. Triangulation uses quantitative and qualitative data by collecting, analyzing, and seeking to confirm the worth of information rendered by the approaches (Creswell, 2003). The use of two or more sources of evidence in a study opens a space for clearer comprehension of

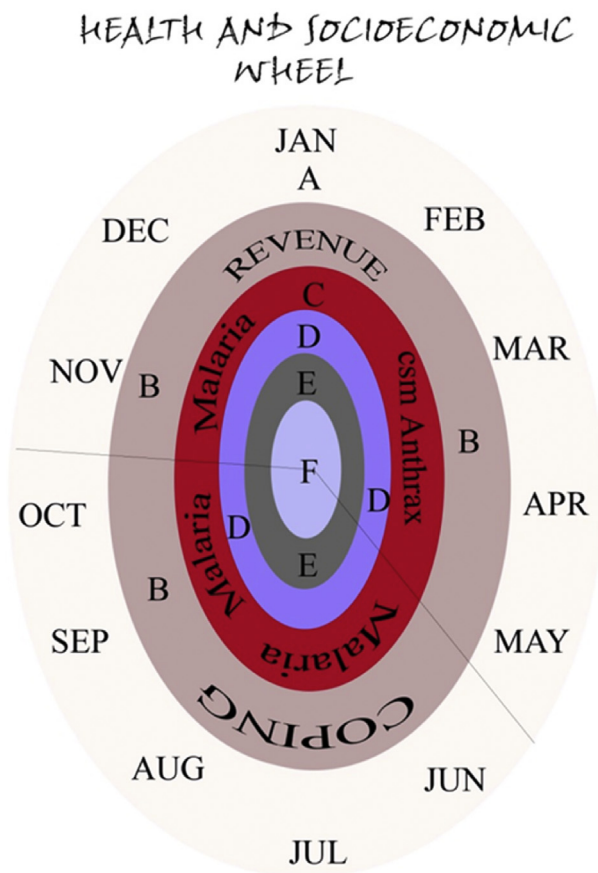


Figure 3. Represents results of Focus Group Discussion from the three communities (Binduti, Manga, and Pusiga).

the research problem by integrating numeric pattern from quantitative data and direct details from qualitative source (Marten, 2003). The study population was farmers from three farming communities (Binduri, Pusiga, Manga) in Bawku East who are constantly exposed to heat especially in the field of cultivation due to the method and nature of which farming activities are carried out and at residential level because of the nature of architecture. Sampling involved purposive, simple random and systematic sampling used in selecting 378 farmers for the study which was consistent to sample size determination of (Krejcie and Morgan, 1970) from an estimated farming population of fifteen thousand. Only 308 returned their questionnaire and as such 308 was used to performed the analysis. Purposive sampling was used in selecting four participants for the focus group discussion. These include chief farmers, village heads and agricultural extension representative to join fifteen farmers who voluntarily expressed interest and signed a consent form to join the Focus Group to further discuss the impacts and response of heat stress with regard to farmers’ yearly pattern of socioeconomic activities(What is your yearly pattern socioeconomic activities especially produce and revenue from farm work: Which months do you generate a lot of trvenue?) The justification of the FGD was to elicit from experience farmers, heads of the farming groups and government trained personnel who assisted farmers in their crop cultivation to present the extent of socioeconomic activities that farmers embraced throughout the year. Such persons were selected because of their good standing and experience in farm work The household survey encompassed farmers livelihood coping strategies, coping strategies against heat exposure, experiences of climate change, among others. Before administering the survey questions, ten farmers were randomly selected and tested with survey questionnaire. Moreover a large number of questionnaires were extracted from a global program on heat stress termed “HOTHAPS” The study area was selected in that it is one of the poorest areas in Ghana (Webber, 1996) with much exposure to temperature over the recent years (Frimpong et al., 2014b). Farming is the predominant occupation where over 65 percent of the inhabitants are engaged. Instruments such as

Table 4. Architectural style to reduce heat stress at household level.

Characteristics	Bricks & roofed with thatch with trees surrounding the house to create shade	Bricks & roofed with thatch	Bricks & roofed with iron sheets with a lot of windows	Mud and roofed with thatch	Chi-Square Value	P-Value
Level of education						
Primary	30.3	25.7	37.6	6.4	26.541	0.002
Secondary	34.6	32.1	30.9	2.5		
Tertiary	46.3	19.5	24.4	9.8		
Non formal	25.8	28.8	22.7	22.7		
Duration of knowledge of climate change						
Less than 1 year	22.2	11.1	44.4	22.2	31.789	0.001
1–5 years	26	40	30	4		
6–10 years	44.4	19.8	30.9	4.9		
11–15 years	30.7	20	29.3	20		
16+	32.4	33.8	29.4	4.4		
Effects of heat on sleep						
Inability to sleep	36.2	33.9	26	3.9	39.924	0.001
Reduced length of sleep time	26.3	22.4	43.4	7.9		
Induce sweating while sleeping	49.2	16.9	20.3	13.6		
It makes sleeping boring	8.3	30.6	36.1	25		
Experience of heat illness						
Prickly heat	32.3	25.8	29	12.9	25.935	0.011
Heat cramp	39.1	43.5	10.9	6.5		
Heat exhaustion	44.3	29.5	19.7	6.6		
Malaria	26.9	22.3	39.2	11.5		
Cerebro spinal meningitis	26.7	23.3	43.3	6.7		

Table 5. Methods of limiting heat exposure at farm level.

Variables	Methods of limiting heat exposure (%) and Chi-square					Chi-square value	P-Value
	Get away to a shade for a while	Remove clothing for free air	Regular intake of water	Wearing a hat	Wearing of airy dress		
Knowledge of impact of clothing on heat exposure							
Yes	25.9	2.9	20.5	17.6	33.1	14.7	0.005
No	33.3	16.7	13.3	10.0	26.7		
Experience of heat related illness							
Prickly heat	47.1	5.9	23.5	5.9	17.6	48.1	0.000
Heat cramp	23.9	0.0	23.9	6.5	45.7		
Heat Exhaustion	33.3	11.1	15.9	17.5	22.2		
Malaria	16.0	1.5	19.8	21.4	41.2		
Cere bro spinal meningitis	39.4	6.1	15.2	24.2	15.2		
Age Group							
less than 30	40.0	6.2	12.3	13.8	27.7	15.4	0.052
30–49	22.6	6.1	18.3	15.7	37.4		
50+	23.4	1.6	25.0	19.5	30.5		
Level of education							
Primary	33.0	1.8	23.2	14.3	27.7	29.8	0.003
Secondary	26.5	7.2	9.6	18.1	38.6		
Tertiary	34.1	6.8	13.6	9.1	36.4		
Non formal	10.4	3.0	29.9	24.4	31.3		
Classification of task at farm level							
Light	45.5	9.1	18.2	18.2	9.1	13.3	0.348
Moderate	25.0	6.2	17.2	10.9	40.6		
Heavy	25.7	3.4	21.1	17.7	32.0		
Very heavy	23.4	2.1	19.1	21.3	34.0		
Day to day clothing for farming work							
Breathable cotton	22.1	5.7	13.9	25.4	32.8	15.5	0.051
Thick cotton overall	26.8	3.0	24.4	11.3	34.5		
Rayon/nylon	42.9	0.0	14.3	14.3	28.6		
Health status							
Poor	19.4	0.0	20.1	20.9	39.6	59.5	0.000
Good	30.5	5.7	20.6	14.2	29.1		
Very good	44.4	5.6	22.2	16.7	11.1		
Excellent	44.4	44.4	0.0	0.0	11.1		

questionnaire, interview guide and focus group discussion were used in acquiring primary data (Sarantakos, 1998) for the study. Both descriptive and inferential statistics were used in analyzing the data. The data was processed employing statistical product and service solutions (SPSS) version 16. The results covered the respective heat events categorized as impacts and responses which are presented in charts, and tables.

The study was conducted from January to June, 2013. In the sphere of impact assessment of heat on farmers, questions revolving impacts on domestic chores, impacts on time to cope with heat, age and its association with general health status, various level of crop growers, and their concern to heat, assessment of heat related sicknesses, effects of heat on income and productivity, and association of work classification and health status.

In the sphere of adaptation assessment, coping strategy to minimize heat stress during the day and night, coping strategy at the farm level, with regard to human and crops were assessed. Water availability and farmers intake were examined. Selected variables such as impacts of heat on day to day activities, effects of heat on sleep, educational level of farmers, duration of farmers knowledge on climate change, and peoples experiences of heat related illnesses were used to model their association to architectural style to reduce heat at household level. In the same vein, knowledge of impact of clothing on heat, experiences of heat related illnesses, age, educational level, classification of task at the farm level, knowledge of climate change and general health status of farmers were used to model their association on methods to reduce heat stress at the farm level.

3. Results

3.1. Demographic information

In the survey, 21.1% of the respondents were less than 30 years. Farmers who had the age of 50 and above were 41.6%, while 37.3% were in the age range of 30–49. Farmers who were married formed the largest part of the survey with 75%. Persons who were divorced were 12.7% of the studied population. Males formed 60.4% of the population, followed by female with 39.6%. Over 36% had primary education followed by 26.9% with secondary education and 14.4% had tertiary education.

3.2. Impacts of heat at household level

Table 1: A pictorial stature of impacts of heat on household with regard to domestic chores, comfort of sleep and degree of time to cope with heat are presented. Large number of respondents (61.4%) stated that domestic chores become difficult during high heat exposure. Increase of time for work hour was noted with second highest number of respondents (23.7%). Almost half of the respondents 43% indicated that heat disrupt their sleeping pattern. With impact on time to cope with heat 49.25% expressed high impact of time to cope with heat.

There is a gap in literature with regards to how heat can affect domestic activities in developing countries (Frimpong et al., 2017). In the same vein 43 percent expressed the impact of heat as impairing their sleeping pattern. This demands that there is the need to improve their dwelling conditions to enable them live and sleep comfortably. As high as

49.2 percent of the respondents aggregated the impact of heat on their time to cope as highly. This denotes that as temperature is projected to increase a lot of time might be needed to cope with heat if adaptive capacity is not improved. (see Figure 1)

From Figure 2 it can be observed that Farmers' major concern on heat was used to model their relationship with its effects on income and productivity, at the chi-square value of 15.215, with 0.055 P-value.

3.3. Adaptation strategies at the household level

Table 2 illustrates self-reported methods that farmers used to adapt to heat exposure at household level at day and night, their perception of hotness of their room, their responses on guidance from government to provide information on impending heat and temperature rises as adaptation information.

3.4. Methods of limiting heat exposure at farm level

Table 3 shows series of questions to elicit farmers adaptation to heat exposure at farm level both on their crop and human coping strategies.

The association of architectural style of limiting heat at household level, and impacts of heat on day to day activities, effects of heat on sleep and its relationship with methods of limiting heat exposure, educational level and its relationship with architectural style of limiting heat exposure, duration of knowledge on climate change and its relationship with architectural style of limiting heat exposure and experiences of heat related illnesses and architectural style of limiting heat exposure. These variables were modeled with architectural style of limiting heat exposure at household level. The results showed statistical significance with the architectural style of limiting heat exposure at household level.

The association of knowledge of impact of clothing on heat exposure and its relationship with methods of limiting heat exposure at the farm level was identified (Table 5). Experiences of heat related illnesses, age, education, level of task at the farm level, knowledge of climate change, day to day clothing at the farm level and health status are individually used to established its relationship with methods of limiting heat exposure at the farm level. Large number of the variables showed statistical significance with the with the methods of limiting heat exposure at the farm level.

The study through Focus Group Discussion (FGD) sought to elicit how farmers conduct their socioeconomic activities through out the year. The FGD presented Socioeconomic life pattern of the farmers in the studied communities which lay bear key information that revolved on their yearly activities. In their day to day experiences regarding impacts and responses to heat and climate change grouped the year in two patterns. These include November, December, January, February, March, April and May (7 months) as part one of the year. These are the summer months (dry season). There is little or no rains to aid their farming activities. The farmers stated that such months are associated with intense heat that undermine household and farming activities. As a result, farmers who are able to work harder get the highest yearly revenue from this season. Water from hand dug borehole on the surface of dried up rivers are mostly used to irrigate farm crops. Farmers who showed the resilience of undertaking farm activities get a lot of revenue than during the rainy season where all the farmers participated in the farm activities which result in a lot of farm produce in each household. Part two of the year starts from June., July, August, September, and October. During this time every farmer gets food from farm produce thereby leading to bumper harvest, low revenue and inadequate income even though there are food at each household. These months in the rainy season are denoted as coping months in terms of financial revenue while months in the dry season as revenue period for hard working farmers. The major diseases reported to be associated with the dry season include Malaria, Anthrax, and Cerebrospinal meningitis.

4. Discussion

The study through Focus Group Discussion (FGD) revealed Health and Socioeconomic life pattern of the farmers in the examined communities which presented some key details that hinged on their day to day activities through out the year. The farmers through their experiences, impacts and responses to heat and climate change aggregated the year in two patterns. These include November, December, January, February, March, April and May (7 months). These months are noted as dry season (summer) with no rains to aid their farming activities. The farmers stated that such months are characterised by intense heat, which make household and farm activities very difficult. However, since these are difficult months, farmers who are able to work harder get the highest yearly revenue from this season. Irrigation from hand dug borehole on the surface of dried up rivers are mostly used in their farm activities. Farmers who will show the resilience of undertaking farm activities get a lot of revenue than during the rainy season where all the farmers participated in the farm activities which result in a lot of farm produce in each household. Similar activities occur in peer communities in China and part of Nigeria where irrigation is utilised to enhance income generation (Huang et al., 2006; Tefera, 2012; Zhu et al., 2013).

The rainy season include June., July, August, September, and October. During this time every farmer gets food from farm produce. This invariably leads to bumper harvest and low revenue. and leading to inadequate income even though there are food at each household. These months in the rainy season are denoted as coping months in terms of financial revenue while months in the dry season as revenue period for hard working farmers. The major diseases associated with the dry season include Malaria, Anthrax, and Cerebrospinal meningitis.

In the dry season the most grown crops include onion, pepper, and tomatoes. While during the rainy season farmers grow Maize cowpea, and sorgum. Goats, sheeps, and cattle are reared during the year round as source of income to augment what farmers get from farm produce. The study highlights three significant facets that hinge on health, socioeconomic and productivity pattern of the farmers expressed as impacts and responses. In the study, it is evident that there is heat impact at the household level (Table 1) manifesting in various degree such as stifling domestic chores. As there are a lot of health issues aligned to heat exposure at both household and outdoor level (Kovats and Hajat, 2008), there is the need for proper management of heat linking government and the grass root members of the community to workout concrete modalities to offset such level of impact to make rural livelihood congenial. Productivity is affected where there is intense heat exposure. Responses from farmers (Figure 2) indicated that their productivity at farm level is impacted by more than half of what they use to get in recent years. Only few farmers reported that heat has no significant effect on their productivity. Such assertion by the farmers commensurate with the study of (Sahu et al., 2013) that agriculture workers productivity decline as heat exposure is increased. Previous assessment of heat exposure in this study area affirmed a range of 27–34 wet bulb globe temperature (WBGT) during working hours of the day (Frimpong, Jacque Oosthuizen, & Eddie Van Etten, 2014a). This means that farmers need to slow down the degree of work intensity to minimise bodily heat production to avoid cardiac strain and heat exhaustion (Parsons, 2003). When farmers slow down work pattern to rest in shade or cool down, it also affect productivity (Kjellstrom et al., 2009a). The study found that the adaptation mechanism of farmers at both household and farm levels are weak and could not be termed as adaptation. Since these mechanism are short term measures they are rather coping strategies. This implies that to avert food insecurity known in this part of Ghana, key measures need to be put in place to augment farmers coping mechanisms to heat, an area that has not been looked by the researchers and the government of Ghana. The relationship of work classification at the farm level and its relationship with heat impact on health (Figure 3) showed that there is impact of heat on health at all level of work classification with very high task at the farm level receiving 100% impacts. The variables in Tables 4 and 5 showed

statistically significant relationship with methods of limiting heat exposure at the farm level and architectural style to reduce heat stress at the household level. The results of the survey are mostly replicated by farmers responses of themes emanated from the FGD.

Farmers have confirmed that they are impacted by heat at household and farm level. Their home environment are mostly hot during the dry season and doing farm work are mostly done early in the mornings. A large number of the participants in the FGD agreed that heat stress makes household work very difficult. There are a lot of perspiration as a result of carrying any task at household level. Many of the farmers expressed concerned that they are not able to sleep at all because the room are extremely warm. However, there are a lot of mosquitoes that intrude comfort of sleeping when windows and doors are opened. In effect there is high impact of time used to manage heat which should have been used in other activities. Most of the farmers expressed that opening doors and windows are the key coping methods to offset the impact of heat. On the farm level, many of the farm stated that they rest under the shade, and usually wear traditional airy dress, and indulged in high intake of water., eating traditional food that aid in frequent consumption of water to cool their body down during the day.

5. Conclusion and implication for policy purposes

From the above results the following conclusion and recommendation are adduced. Heat stress has significant impact on farmers in their household level. This implies that there is the need for some measures to be put in place to improve the existing measures of combating heat exposure at the household level. Heat related illnesses are visible in the communities where the study was conducted. Malaria and heat cramp was identified as one of the prominent recurring diseases that need attention. There is the need for hospital record to be commenced to track heat related illness since researchers could not lay hands on heat related illness from the health post in the communities apart from perceived self reported cases that the farmers stated in their responses to the survey and FGD.

The type of work intensity that farmers undertake. was identified to expose them to heat and their health is adversely affected. There is the need for the nature of farming to be modernized to incorporate mechanization instead of labor-intensive method which exposes them to long hours in full sun shine. This could be very dangerous as temperature is predicted to increase in such areas. The coping mechanism that farmers undertake to reduce the impact of heat at the farm, level is viewed to be unsustainable. Opening doors and windows which is the predominant norm of cooling rooms is not effective as temperature will continue to rise. The architectural style of rural houses needs to be improved and modernized to suit climate change and heat exposure. Wearing airy dress and cooling under a shade are some of the mechanisms used by farmers to cool down during farming hours. These are crude methods which cannot stand the test of climate variability and change especially in the context of working productively to achieve food security. Education and farmers knowledge of climate change need to be intensified as well as provision of mechanized equipment from the government to farmers that can reduce their exposure to heat stress while working in the day. Expanding acreage of farming and provision of storage facilities during the rainy season is imperative to reduce waste of food produce during bumper harvest. This can go a long way to improve farmers standard of living.

Declarations

Author contribution statement

Kwasi Frimpong, Stephen T. Odonkor, Francis A. Kuranchie, Victor Fannam Nunfam: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Funding statement

The authors received no funding from an external source.

Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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