RESEARCH ARTICLE

Smallholder farmers' perception of climatic and socio-economic factors influencing livelihoods in the transition zone of Ghana [version 1; peer review: 1 approved with reservations]

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Abstract

Background: The study analyzed smallholder farmers' perception with regards to climatic and socio-economic changes influencing their agriculture livelihoods and coping strategies thereof in the transition zone of Ghana.
Methods: We used semi-structured questionnaires for household survey involving 59 households and focus group discussions (n=60) for data collection in three communities.
Results: Farming systems are influenced by high and extreme temperatures, delayed onsets of rain, short raining season as well as unpredictable raining seasons. Similarly, socioeconomic factors affecting the communities and their households' livelihood included i) bad road network; ii) high prices of farm inputs; iii) prevalent crop pests and diseases and iv) absence of irrigation facilities. It was ascertained that though most farmers have not made conscious efforts to adapt strategies in their farming system to climate change and the social stressors, as expressed in 'doing nothing or bearing losses' and we are at the 'mercy' of the weather, there are hidden resilience mechanisms that can be harnessed to strengthen their adaptation capabilities. Women in the study area have adapted to the changes in the weather and safeguarded against post-harvest loss of cassava more effectively as compared to their male counterparts. Similarly, the prevailing group farming and maintenance structure (*locally known as 'Noboa'*) strengthen the shared responsibility and reciprocity among migrant' farmers.
Conclusions: Though these agrarian communities have some coping strategies to overcome some climatic and socioeconomic challenges, their general adaptive capacity in terms of physical, financial and human assets are limited. This, therefore, calls for the capacity building of both men and women on best farming practices, adaptation strategies and piloting of irrigation systems to enhance their major livelihood but these must be complemented with good road network for ease of access to the market centres.

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Any reports and responses or comments on the article can be found at the end of the article.

Keywords
Smallholder farmers, transition zone, livelihoods, climatic change, socio-economic change, coping strategies, rain-fed agriculture, gendered analysis

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Introduction

Most farm households and communities, especially in sub-Saharan Africa, have long been and continue to battle with socio-economic challenges in their forest and agriculture livelihoods before issues of climate change and variability became a paramount concern. African's livelihood vulnerability is often attributed to widespread poverty, inadequate and untapped economic and technological resources, insufficient safety nets and educational progress (Cooper *et al.*, 2008; IPCC, 2007; Reid & Vogel, 2006). With the issue of climate variability and change pertaining to changes in rainfall patterns, temperature and extreme weather events, becoming a major concern, the region is now at a crossroad with possible severe consequences for food production and security due to its high dependence on rain-fed agriculture (Codjoe *et al.*, 2012; Cooper *et al.*, 2008; Mawunya & Adiku, 2013; Sissiko *et al.*, 2011). Rain-fed agriculture often managed by smallholder or peasant farmers contributes about 60% of global food production and supports about 90% of staple food production in sub-Saharan Africa (Altieri *et al.*, 2012; Rosegrant *et al.*, 2002). In Ghana, crop farming is the lead contributor to the agriculture GDP by 66.2% as of 2010. The sector is dominated by smallholder farmers, with about 90% of their farm holdings being less than 2 hectares (ha) in size (MOFA-SRID, 2011).

Though manifestations and effects of climate change and variability have existed for many years, the impacts have now reached proportions that require more conscious efforts to deal with than hitherto. Several studies have confirmed that rural communities and the rural poor have been already experiencing the impacts of climate change because of rising temperatures, erratic rainfall and increased frequency of droughts and floods (Codjoe *et al.*, 2012; Sissiko *et al.*, 2011). Data from the Ghana Meteorological Agency showed a 1°C rise in temperature over the past 60 years (Agyemang-Bonsu *et al.*, 2008). In addition, rainfall patterns have shifted somewhat, with an increase in the variability of the onset. These have negative implications on the national economy in view of dependence on climate-sensitive sectors such as agriculture, energy, and forestry (Agyemang-Bonsu *et al.*, 2008). Conceivably, the impacts of climate change and variability, as well as responses, will not be uniformly felt amongst individuals, households, communities or even nations. Based on their roles and responsibilities, men and women who are actively involved in agricultural activities have differentiated vulnerabilities to climate change and consequently develop differentiated coping and adaptation strategies (Codjoe *et al.*, 2012; FAO, 2012; Swai *et al.*, 2012).

There is limited empirical evidence to ascertain whether this assertion holds, especially for smallholder male and female farmers whose livelihoods are dependent on the forest and agriculture landscape in Ghana. Unlike research on the vulnerability of local communities to climate change, little attention has been paid to gendered perspectives in respect of climate variability and change effects as well as impacts on livelihoods and adaptation strategies of rural communities (Fosu-Mensah *et al.*, 2010; Yaro, 2013). It is noted that to ensure effective and successful adaptation strategies, the needs of men and women should be integrated into adaptation plans and policies (Least Developed Countries Expert Group, 2015).

Given the gap in knowledge, this paper explores how smallholder male and female farmers perceive and cope with climatic and socio-economic changes influencing their agriculture livelihoods in the Offinso North and Nkoranza South Districts. In order to appreciate these changes, there was the need to understand the livelihood trajectories of farmers. Thus, the specific questions we asked were in four folds: i) What livelihood trajectories are available to the men and women in the study communities? 2) How do men and women in these transition communities perceive climatic and socio-economic changes in their livelihoods? ; 3) How do these changes affect their livelihoods? and 4) How do the communities respond to the perceived climatic changes, and what are their aspired coping strategies?

Methods

Study area

Mantukwa, Meta and Amponsakrom No. 2 located on the fringe of the Afrensu Brohuma Forest Reserve in the transition zone were randomly chosen for the study (see Figure 1). The transition zone is between the savannah woodland of Northern Ghana and the forest belt of the South. It is a zone covering an area of 6,630 ha with an annual rainfall of 1,300 mm of the bi-modal growing season characterised by annual food and cash crops such as maize, cassava, yam, cocoyam and plantain (MOFA-SRID, 2011). The soil resource is classified as Offinso-Ejura series with a pH range of 5.3–7.8, organic matter and nitrogen percentage range of 1.5–3% and 0.2–0.3%, respectively and available phosphorus and calcium of 0.12–12 mg/kg soil and 50–100 mg/kg soil respectively (ibid). Soils with such properties may be considered to be of good fertility so long as proper management protects them. However, as a zone lying between the forest and savannah zones, land degradation continues to intensify, shifting the zone more to the savanna as a result of charcoal burning, overgrazing by nomadic *Fulani* herdsmen and annual bush-burning. Climate change scenarios based on a forty-year data projection indicated an average annual temperatures increase of about 0.6°C, 2.0°C and 3.9°C for the years 2020, 2050 and 2080 respectively (EPA, 2007). For forest-savannah transition an annual temperature of 0.80°C, 2.5°C and 5.4°C are predicted for the years - 2020, 2050 and 2080 respectively (Minia, 2004). Within the same period, average annual rainfall total is estimated to decline by 2.8%, 10.9% and 18.6% (EPA, 2007) and specifically for the transition zone it will decline by 2.2%, 8.8% and 14.6% (Minia, 2004). Historical analysis indicated that in this zone, rainfall variability may be the single largest component of rainfall changes affecting all agro-ecological zones in Ghana. In the transition zone, for instance, the short dry spell (July and August) which is crucial for preparing the land for the second crop is increasingly becoming wetter and the short rainy season terminating early. There is a progression toward a uni-modal regime for the transition zone with serious consequences for rain-fed agriculture (Minia 2004; Owusu & Waylen, 2009).

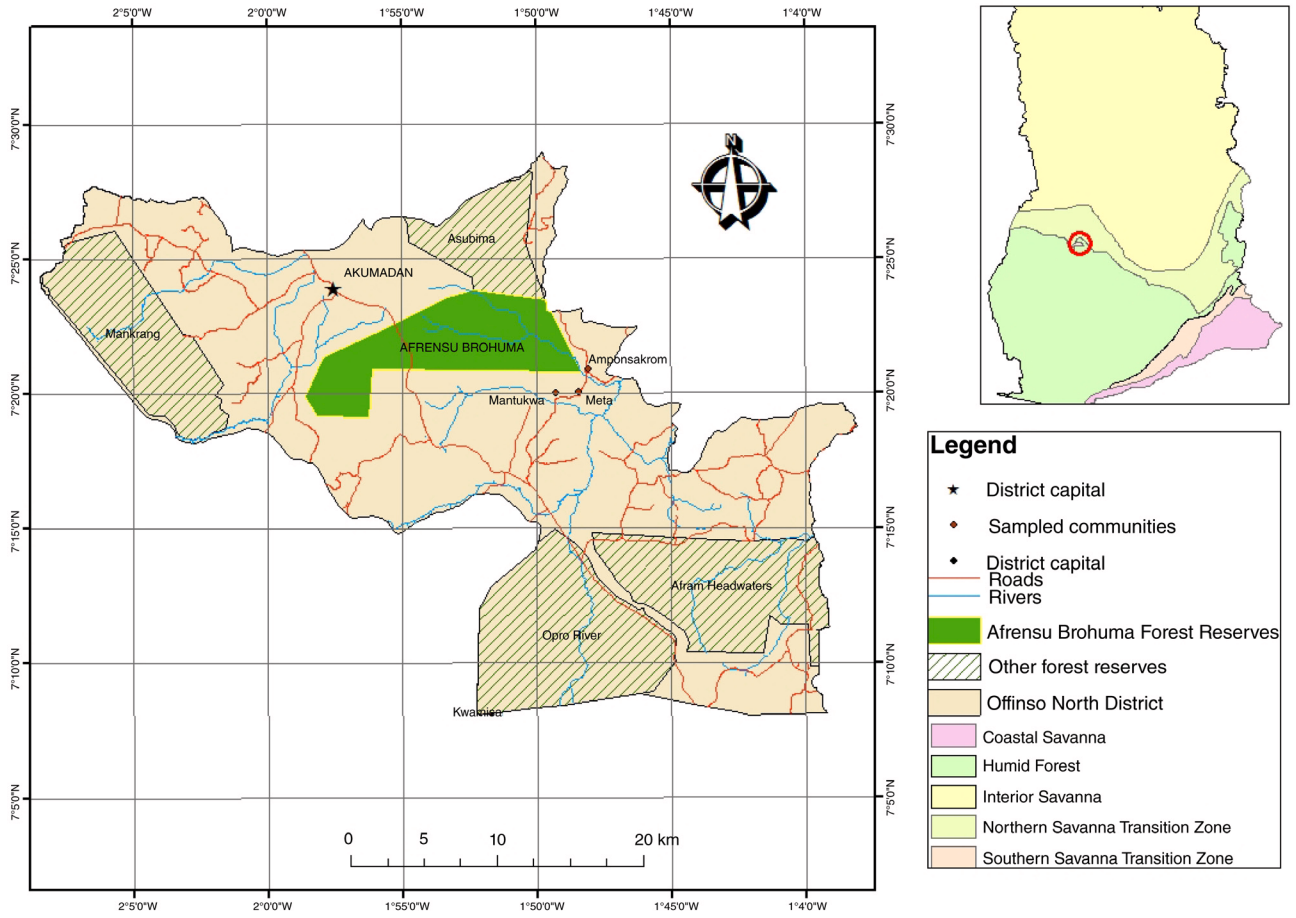

Figure 1. Map of study area.

Ethics and consent

The study ensured ethical consideration and consent in data collection and analysis. Three key ethical issues considered were: voluntary participation, which was clearly stated in the preamble in the survey questionnaire (Supplementary File 1) (completion of the questionnaire was considered consent); anonymity and confidentiality with respect to data analysis in collective manner were ensured. Furthermore during a community meeting, the people were openly told of the purpose of the study and consent was sought verbally.

The researcher (MD) presented the study proposal to the Regional Institute of Population Studies at the University of Ghana. Since this research was not biologically related and therefore low risk, the consent of the respondents, review of the protocol by supervisors at the University of Ghana, and feedback from the University community provided the study approval.

Research design and data collection methods

The study employed focus group discussions and household survey in the study communities as shown in Table 1. The study adapted some of the key guiding questions (see Supplementary File 1) in the vulnerability and capacity assessment (VCAs) framework designed by International Centre for Integrated Mountain Development (ICIMOD) (Macchi, 2011). The primary data was through focus group discussions (FGDs) among men and women and a household survey. The field data collection began in June 2015 with reconnaissance to enable the researcher and team to familiarize themselves with the biophysical features of the communities and also make arrangements for the actual data collection. The actual data gathering began in June to August 2015. As a guide to the use of the VCA, caution was taken not to mention the term "climate change and variability" during the data collection but to explore among the male and female smallholder farmers the different livelihoods prevailing, the benefits and the challenges confronting them. Furthermore, the community meetings made up of male and female farmers of different age categories were engaged in the discussion during the focus group. Problems confronting the communities and their livelihoods were listed. In each community, two groups made up of 10 men and 10 women were nominated by their people to represent them. Thus, a total of 60 respondents (30 men and 30 women) in all the three communities were asked to rank the problems in terms of their severity and urgency of intervention using a number of maize

grains (where 5 represents most severe and 1 least severe) from a gender perspective (see Table 1).

The household population size data for the survey in Meta and Mantukwa were accessed from the Planning Officer of the Offinso North District Assembly confirmed by newly gathered population data and the household data from students from the University of Development Studies having their community trimester in Mantukwa community at the time of data collection. For Amponsakrom No. 2, the elders of the town provided the household data during the reconnaissance visit and this was confirmed during the focus group meeting. In the survey data collection, a sampled percentage of 20 percent were selected as shown in Table 1.

Data analysis

The survey data was on demographic characteristics, livelihood trajectories, and perception of environmental and socio-economic changes in livelihoods and coping strategies thereof available to the farmers to enhance their livelihoods. This data was entered manually and analyzed using SPSS version 21, and Microsoft Excel 2010 where frequency and contingency tables and graphs were drawn. The focus groups discussions on the livelihood challenges in the communities and farming systems were analysed using rader charts to project the severity of challenges as perceived by men and women in the three communities.

Results and discussion

Demographic characteristics of the respondents

Respondents' age and gender characteristics in the study communities. Table 2 indicates the gender and age categories of the respondents in the three study communities (i.e. Mantukwa, Meta and Amponsakrom No. 2).

In respect to gender, 26 male farmers constituting 44% and 33 female farmers (56%) were involved in the survey. In terms of age categorization, most of the respondents (53%) were middle aged range of 36–54 with the least (10%) being 55 and above. The middle age group, active in farming, is a good indication for the sustainability of natural resource-based sectors like agriculture, forestry and fishery in the district which is the lead occupation (75.4%) for the populace from 15 years and above (GSS, 2013). The educational levels of these smallholder farmers range from tertiary to no formal education. It was observed that majority of the men (65%) have a more formal education than the women (35%). The low formal education observed among the women could be seen as a general trend for females in the district compared to the males (GSS, 2012). The variation in education was not seen as a hindrance to the effects of climate change on the gender category. Both men and women farmers felt and experience the effects of changes in rainfall pattern, high temperature as well as long drought on their farming systems. However, regarding knowledge and education on climate change

Table 1. Study sites and number of sampled households and respondents.

District	Forest Reserve	Community	No of households	Sampled Number for the survey (20%)	Total number of men and women per community for focus group discussion
Offinso North	Afrensu Brohuma Forest Reserve	Meta	70	16	20
		Mantukwa	179	35	20
Nkoranza South		Amponsankrom	40	8	20

Table 2. Respondents' communities against age range and gender (n=59).

Variables	Name of Community							
	Mantukwa		Meta		Amponsakrom No.2		Total	
	Count	%	Count	%	Count	%	Count	%
Gender								
Male	17	48.6	5	31.2	4	50	26	44
Female	18	51.4	11	68.8	4	50	33	56
Total	35	100	16	100	8	100	59	100
Age range								
18–35	12	34.3	6	37.5	4	50	22	37
36–54	18	51.4	9	56.2	4	50	31	53
55 and above	5	14.3	1	6.2	0		6	10
Total	35	100.0	16	100	8	100	59	100

Field data (2015)

and best farming practices, Amponsakrom No. 2 inhabitants during the community meeting revealed that their first awareness of climate change had been as a result of discussions with the Climate Impact Research Capacity and Leadership Enhancement (CIRCLE)[1] research team.

Livelihood trajectories

Livelihood types and land acquisition systems. As agrarian communities, the majority of the farmers (i.e. both men and women) are engaged in full-time food and cash crops. In this respect, more men (73%) participate in full and part-time farming than women (69%). With respect to non-farm activities more women (31%) are engaged in such venture than men (27%) as shown in Figure 2 and Figure 3.

Some of the common non-farming activities engaged by women rather than men are gari (milled and roasted cassava), konkote (diced and dried cassava) and oil palm processing combined with petty trading. The off-farm activities such as tailoring, driving, corn milling and working in cocoa buying companies are engaged in by the men. From the data, it is deduced that the distribution is highly polarized for men: either full-time farming or off-farm activities. For women, the spread is somewhat more gradual. This observation could be linked to the coping strategies where it was ascertained that women in the three communities have diverse off-farm coping strategies compared to their male counterpart. This, therefore, implies that any intervention for these study communities needs to be gender sensitive. Unfortunately, most international policies and practices designed to reduce the greenhouse gas emissions place little focus on gender differences (FAO, 2012). Not recognizing these gender differences in research or policy has the potential for prescribing interventions which are often not beneficial to a particular gender category.

Diversification of crops prevails in the study communities. This is a good indicator of coping strategies for food security for the households. Diversification of cropping systems is a traditional farming practice in Ghana. Among the Sahelian Region, it helps reduce and spread risks (MOFA-SRID, 2011; Sissiko *et al*., 2011). The common cropping configurations are combinations of maize, yam, vegetables, cassava, beans, groundnuts and plantain, mostly under different land acquisition systems. Land acquisition modes in the three communities are diverse but are categorized under two key major types, namely: the agricultural lands and forest reserves with different tenure arrangements. The majority of the respondents (89.5%) access their farmlands through rented and share-cropping tenure systems which prohibit tenant farmers to engage in tree crops that can withstand climate change compared to annuals crops. It was, therefore, a relief when from 2002 to 2010, the degraded portion of the forest reserve lands were allocated to migrants, as well as natives with or without land under the modified taungya system (MTS)[2] by the Forest Services Division of Offinso Forest District. The rationale was to help farmers support in the reforestation programme and ensure food security. According to the respondents during community meetings, engaging in the MTS was a huge support to the migrant and landless farmers. The arrangement was partially continued when FORM Ghana[3] took over in 2010 and 2011 but as at the time of data collection in 2015, it was not functioning. With the discontinuity

[1]The CIRCLE programme sponsored the research with funding from the Department for International Development (DFID).

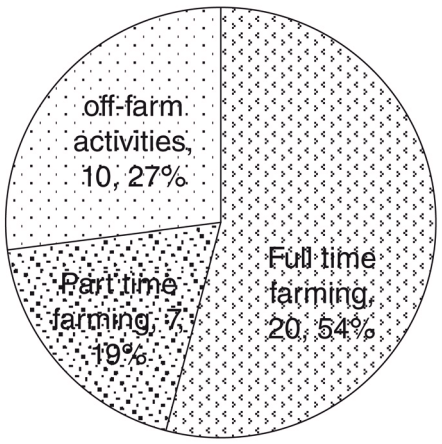

Figure 2. Men' livelihood trajectories.

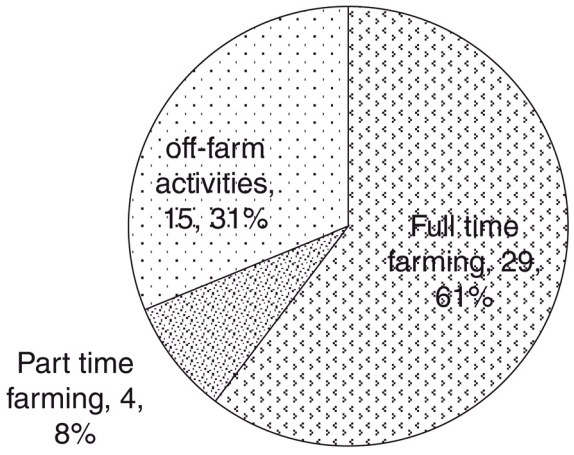

Figure 3. Women' livelihood trajectories.

[2]The MTS was co-management approach adopted in 2002 by the Forestry Commission (FC) of Ghana. It was a partnership between the Forest Services Division of the FC and the forest fringe communities to establish forest plantations in degraded forest reserves for shared benefits. Benefits of MTS included restoring the forest cover and creating livelihood opportunities for forest fringe communities through access to forest land for cultivation of timber trees and food crops in return for which farmers share in the harvestable timber. The MTS is an improvements to the old taungya system as a result of land tenure security and benefit-sharing arrangements for the timber revenues that were absent in the old taungya system and farmers owe 40% of the cultivated trees when harvested. (Derkyi, 2012).

[3]Form Ghana is a reforestation company established in Ghana in 2007, which aims at large-scale reforestation of degraded forest reserves in Ghana while conserving and restoring natural, riparian forest (http://www.formghana.com/ accessed on 1/10/2015).

of the programme, the farmers currently farming in the reserves do so unofficially.

Despite the small land holdings, these smallholder farmers play a significant role in this terrain either in terms of resource use or restoration. According to Altieri *et al*. (2012), Africa has approximately 33 million small farms, representing 80% of all farms in the region which are managed by the majority of smallholders farmers (many of them are women), with two-thirds of all farms below 2 ha and 90% of farms below 10 ha. Similarly, in Ghana, there is an indication that the foundation of agriculture is predominantly on a smallholder basis, of which 90% of farm holdings are less than 2 ha mostly using a diversified food crop system (MOFA-SRID, 2011).

Animal husbandry. Livestock (e.g. goats, sheep and local fowls) were observed to play key roles in household livelihoods in the study communities. They are sources of protein according to the respondents and also income safety nets, especially during long dry spell period where food crops do not thrive well resulting in low household income. This assertion was confirmed by FAO (2009) that livestock is a key asset in rural areas, thus are a source of income, wealth accumulation and source of resistance to shocks. In terms of decision making regarding household use, sales, feeding and providing medications in case of diseases of animals, both men and women have equal roles. The distinction is made with respect to sales and vaccination of livestock where men have more say than women.

Respondents main sources of income. The smallholder farmers in the communities sustain themselves mainly from rain-fed agriculture. The respondents' dependence on rain-fed agriculture is a typical practice. Nevertheless, the rain-fed environment of the smallholder farmer is not static; it is constantly changing over time with driving forces such as population increase and dynamics, global market forces, advances in science and technology, climatic change and variability, consumer demands, agricultural subsidies, and pressures from social movements demanding food sovereignty, land reform, and poverty reduction (Altieri *et al*., 2012). The question that remains is whether the smallholder farmers in sub-Saharan Africa are also changing their practices in accordance with environmental and socio-economic changes. This brings to the fore what coping strategies farmers have evolved over time to sustain their livelihoods which will be discussed in the ensuing sections.

Perception of changes in livelihoods

Climatic changes. 58 of the respondents made up of 26 males and 32 females indicated that they have noticed differences in temperature over the past 10–20 years. Of these, 65% males and 66% females said the changes in temperature were high whilst 35% males and 34% females reported of extremely high temperatures, observed especially in the 2015 planting season (Table 3).

Table 3. Perceived changes in temperature in the past 10–20 years by respondents.

Perceived changes in Temperature	Gender of Respondent		Total
	Male(n=26)	Female(n=32)	
High Temperature	17(65%)	21(66%)	38 (66%)
Extreme High temperature	9(35%)	11(34%)	20 (34%)
Total	26(100%)	32(100%)	58(100%)

Field data (2015)

The observations made by the smallholder farmers are in line with the projected average annual temperature increase in all agro-ecological zones by EPA (2007) and specifically to forest-savannah transition by Minia (2004). These variations in temperature, which have negative effects on crops according to the respondents, could be attributed to several factors of which deforestation was noted as the lead, followed by erratic rainfall and other factors such as drought and annual bushfires. Adjei-Nsiah & Kermah (2012) asserted that the predicted changes in both temperature and rainfall can have an impact on patterns of agriculture production in Ghana especially in areas where the agro-ecological systems are in transition. With respect to changes in rainfall pattern over the past 10–20 years, 36 respondents answered this question represented by 17 males and 19 females. Generally, all the respondents indicated less, erratic, delayed onset and unpredicted timing of rainfall as the observed changes and attributed them to deforestation, past wildfire incidences and prolonged drought. It is ascertained that the arid and semi-arid terrains in the regions are among the most harsh and vulnerable production environments where less and or more variable rainfall, higher temperatures complemented with higher evaporative demand and drought threaten crop production and yield thus leading to a decrease in food availability (Codjoe *et al.*, 2012; Cooper *et al*., 2008; Sissiko *et al*., 2011).

Socio-economic changes. Besides climatic factors, farmers' agriculture livelihoods are also influenced by socio-economic factors. These factors do affect the communities and the households' livelihoods. Factors serving as barriers to the development of the communities included: i) poor road network to enhance access to healthcare and market in the nearby towns; ii) no electricity; iii) absence of health post; iv) inadequate potable drinking water. The household livelihood challenges included: i) high prices of farm inputs especially agrochemicals; ii) absence of loan facility; iii) prevalent crop pests and diseases; iv) poor pricing of food crops and limited buyers in view of poor road network v) absence of irrigation system and iv) hunger and starvation. These challenges being felt and experienced by the farmers are common characteristics confronting smallholder farmers in most Sub-Saharan Africa as attested by most studies. The working environment of the smallholder farmers is also influenced by biophysical (e.g. soil

characteristics, both physical and chemical, incidences of pests and diseases), socio-economic (population growth rate, migration, low education level, inadequate extension and research services, market conditions, use of chemical fertilizers) and low adaptive capacity factors to enable farmers to realize the actual level of agricultural production (Cooper *et al.*, 2008; Sissiko *et al.*, 2011). This region of Africa is also characterized by limited social, political, technical and other resources to draw upon to combat problems of scarcity and poverty, constraining the ability to adapt to changing conditions (UNFCC, 2007; Westerhoff & Smit, 2008).

Prioritized communities' challenges. These changing climatic and socio-economic factors observed by the survey respondents were not totally different from that of focus groups discussions held with men and women in the three study communities. The objective was to rank the first five challenges confronting the communities in line with severities and urgency. This is shown using the rader chart (see Figure 4–Figure 9) for men and women in Mentukwa, Meta and Amponsakrom No. 2 communities respectively.

The most severe factor affecting the livelihoods in all the three communities was bad road networks with the exception of men in Amponsakrom No.2 who prioritised lack of potable water as the most severe factor. With regards to climatic factor, only men in Meta and Mentukwa communities prioritise erratic rainfall as 2 and 1 respectively. The women in Meta and Mantukwa as well as respondents in Ampnsakrom No.2 though mentioned erratic or low rainfall as a factor affecting their farming activities but did not prioritise it among the first five challenges. The reason given was that though low or erratic rainfall affects crop yield but they have no absolute control over the changes in the rainfall pattern. This rationale resulted in debate among the participants resulting in supporting and dissenting views of the assertion. For those with the dissenting view they indicated that farmers' unsustainable activities such as indiscriminate felling of trees, excessive use

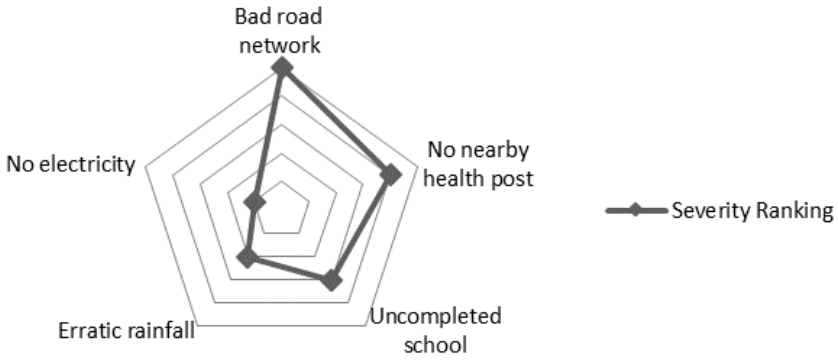

Figure 4. Severity ranking of socio-economic and climatic changes by men in Meta community.

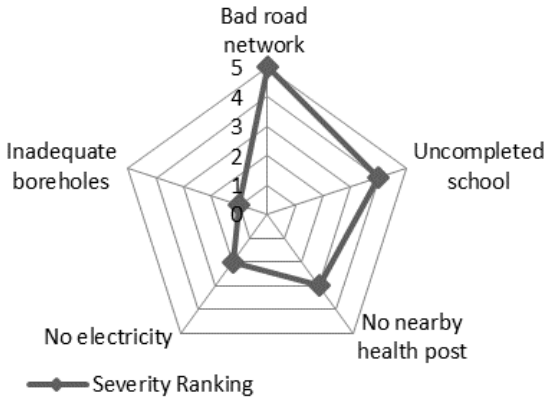

Figure 5. Severity ranking of socio-economic changes by women in Meta community.

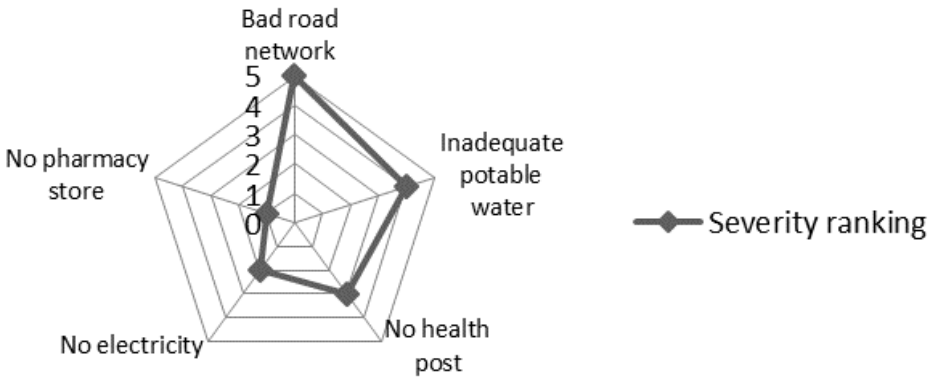

Figure 6. Severity ranking of socio-economic changes by women in Mantukwa Community.

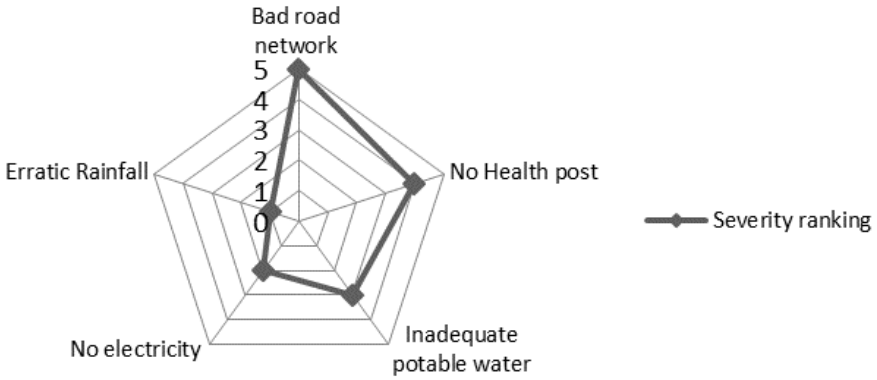

Figure 7. Severity ranking of socio-economic and climatic changes by men in Mantukwa community.

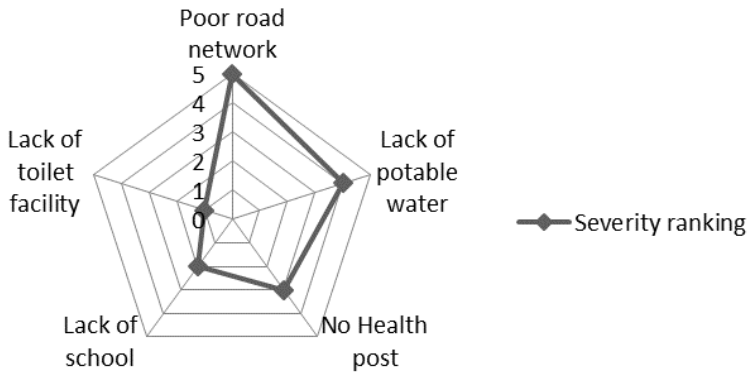

Figure 8. Severity ranking of socio-economic changes by women in Amposakrom No.2 community.

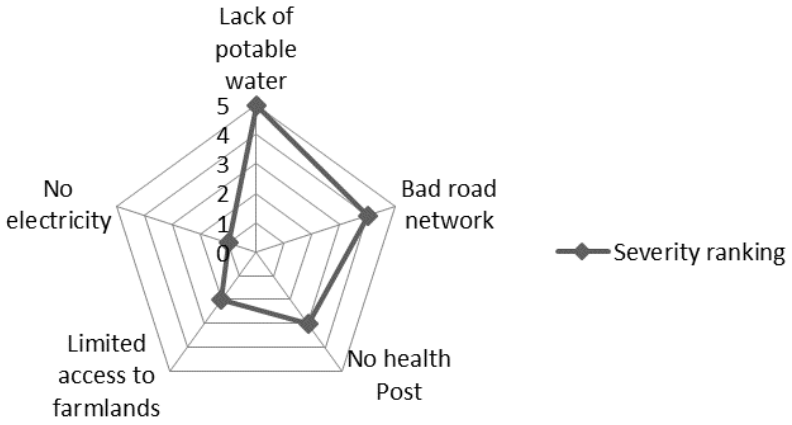

Figure 9. Severity ranking of socio-economic changes by men in Amponsakrom No. 2 community.

of agrochemicals and farming along streams are some of the factors resulting in erratic rainfall, but with afforestation and good farming practices, erratic rainfall pattern can be minimised.

Effects of changes on livelihoods

Respondents from both household survey and focus group discussions in the three communities revealed that in terms of socio-economic infrastructure to support their wellbeing they lag behind. According to the respondents, the bad state of the road network deprived them of potential buyers of their food crops. This often resulted in high post-harvest losses. This also has an effect on high transportation cost. For these farming communities, not having a health post or community health improvement services (CHIPS) compound exacerbates their hardship because, in the case of any health emergency, conveying the person to the nearest hospital was a challenge. Even though communities like Mantukwa and Meta have some basic assets such as a cassava processing machine to facilitate gari processing, and teachers' quarters, school feeding programme and construction of basic schools, they were of the opinion that the deplorable state of the road undermines development, thus exacerbating poverty.

The household survey respondents attested to the fact that regular rainfall pattern has positive effects on their farming system. It enhances crops growth, boosts yields, provides more income, and ensures household food security as well as decrease crop pests. Notwithstanding these positive factors, the drastic changes being felt now with respect to erratic rainfall and high temperature characterised by long drought results in low yield of crops and withering/dying of crops as shown in Figure 10. According to the farmers, the 2015 major planting season (April–July) was perceived to be the worst period for the past 10 years where the timing of rainfall was not predictable and frequency was low resulting in huge loss of income. For some of the farmers (n=9) the moderate dry period is good for preparation of the land towards raining season, searching for firewood, growing crops such as water yam and having leisure time, while for the majority (n=50) when the dry period extends beyond normal it results in crops withering and dying leading to low or no income, low yield, household food insecurity, and poverty.

In line with these findings, Mawunya & Adiku (2013) indicated that rainfall characteristics that have negatively affected agricultural output in Ghana included late onset and early end of rains during the cropping season. This according, to the authors, resulted in a reduction of moisture availability to crops, implying the rains may cease when the crops are still growing in the field and in need of water to complete their life cycle thus hampering photosynthesis process (ibid). Furthermore the authors indicated that poor rainfall or drought also leads to insufficient moisture or moisture stress during critical growth periods of crops, insufficient moisture during time of planting, poor seed germination and seedling emergence or sprouting of cut-crops (e.g. cassava, yams planted as cuttings) as well as poor establishment of crops in the field (Mawunya & Adiku, 2013). Effect of climate change generally in Africa will result in loss of agricultural productivity and lower yield. In Ghana, for example, it is reported that there is a decline in subsistence crops like maize and an expected high rate of hunger among the populace by 2080s (Fischer *et al*., 2002). This projection has become the reality in these communities as farmers reported of the withering and poor yield of maize.

Response to perceived climatic and Socio-economic changes

Generally, the smallholder farming system in these communities was engaging in crop diversification because of the mixed cropping system, thus safeguarding themselves against pests and diseases infestation on a particular crop. Farmers in these communities combine more than 3 crops on a piece of

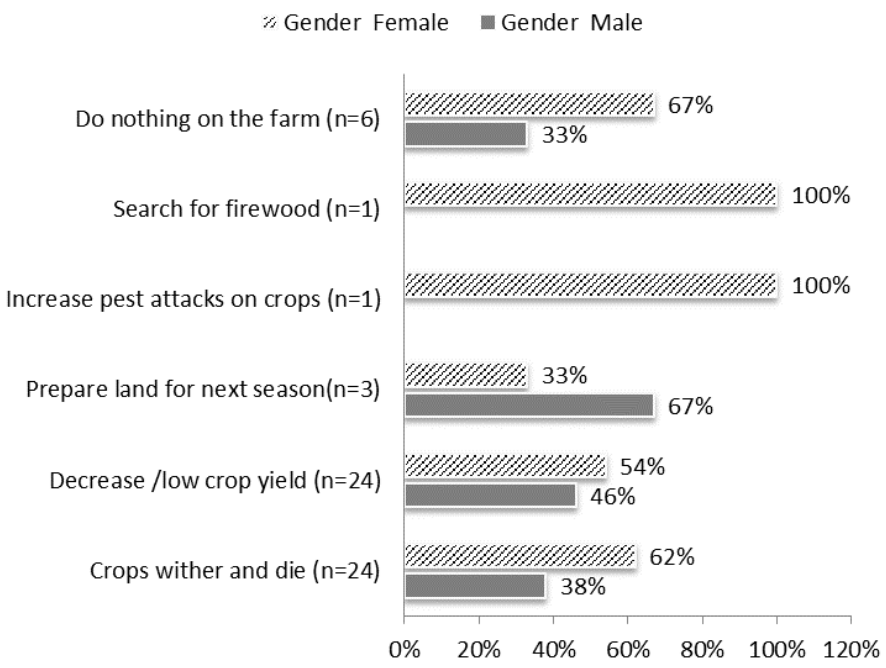

Figure 10. Factors influencing farming activities during long dry spells.

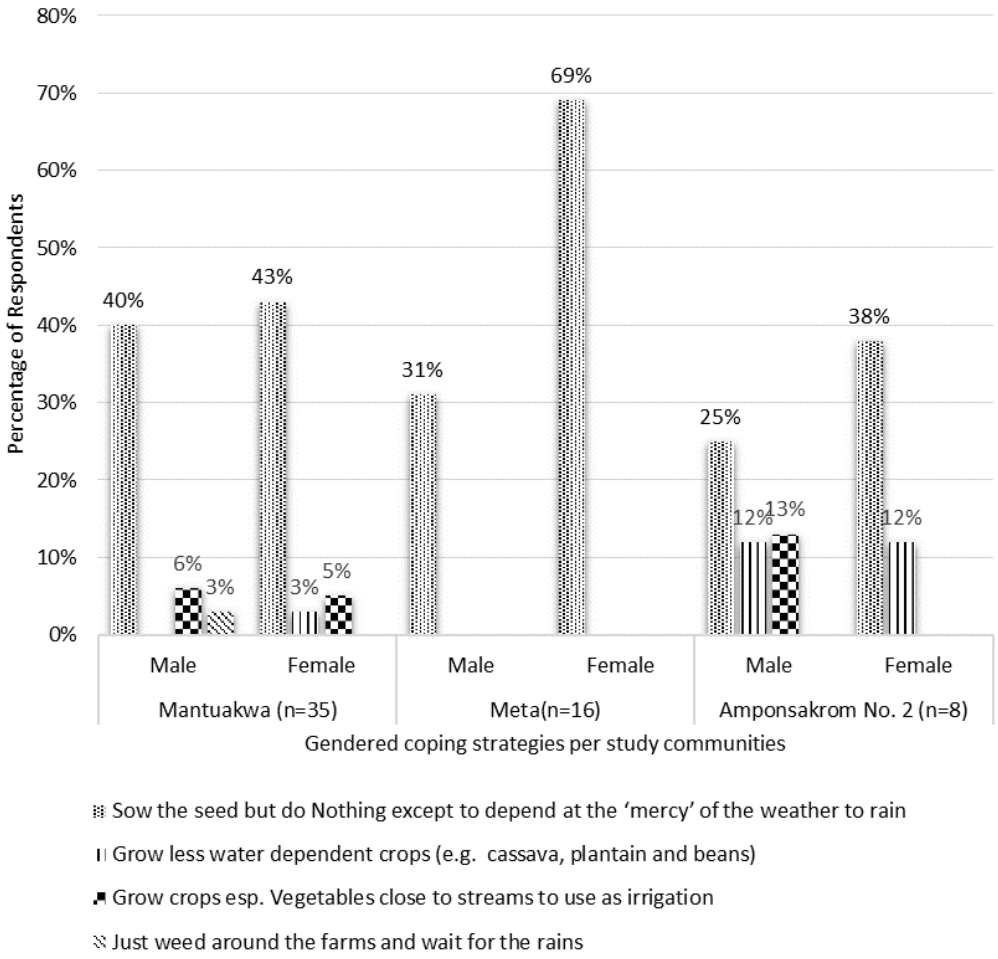

Figure 11. Female and Male farmers coping and adaptation strategies on the farming system during long dry spells.

land. Some of the key food crops are maize, cassava, plantain, yam, cocoyam, groundnuts (mostly grown by the women) and vegetables. Diversification of crops on a piece of land has been revealed to be key adaptation strategy. Adaptation strategies are said to be fundamental in reducing the risk of primary production failure, to diversify the sources of food and livelihoods and to create a buffer against future food and livelihood stress as well as human life and property (Codjoe *et al*., 2012). In the smallholders farming system, four key strategies were observed as shown in Figure 10. For most respondents in the survey, during the unexpected long dry spell and uncertainty in the timing of rainfall, they do sow their crops and 'Do Nothing' except to lie at the 'mercy' of the weather. Burton *et al.* (1993) termed it as 'Bear losses' where those affected have no capacity to respond in any other ways or where costs of adaptation measures are higher in relation to the risks or the expected damages. For these farmers, it is low capacity to deal with these challenges that prevails. Others also grow less water-dependent crops such as cassava and plantain. This practice is also confirmed by Adjei-Nsiah & Kermah (2012). For farmers who engage in vegetable cultivation, they manage to grow them close to streams for ease of water in irrigating the crops. Unfortunately, the irrigation systems which these communities desires were absent in the study communities.

It was further observed that some women in the study area have adapted to the changes in the weather and safeguard against post-harvest loss of cassava due to poor markets coupled with the bad road network. As individuals and groups, they engage in off-farming activities like gari processing, konkonte (i.e. diced dried cassava) and oil palm processing. Women who regularly processed gari participate in a group based sharing system with the buyers who offer them loans to invest. Unfortunately, men generally were not engaged in off-farm activities and still depended on farming with some adapting to new crops such as beans, cocoa, and cashew. For Meta and Amposakrom No. 2 konkonte women processors, it was ascertained that sales of the products in the weekly market centre of Abofour are done through a communal arrangement where two or three women send the wares of the others to the weekly market for sales. This is rotated among the women thus enhancing shared responsibility of sales. Similarly, group farming and maintenance structure (locally known as *'Noboa'*) also prevail thus strengthening the shared responsibility and reciprocity among the Northern migrants' men of Meta and Amponsakrom No. 2. Such adaptation strategies in marketing and farming strengthen the social ties, especially in these two predominately migrant communities. According to Kramer *et al.* (1993), negotiation-either formal or informal plays an important role in regulating social and organizational life. In this case study, the ability of the Konkonte women processors to regulate their marketing of products and the migrant farmers to engage in group farming to support each other might have gone through series of informal negotiations, consensus and compromise before becoming norms that harnessed their livelihoods. This confirms the assertion by Portes (1998:3) that social capital features such as social ties, shared responsibility, and reciprocity is not natural but must be constructed.

Sales of livestock to generate income and consumption of local fowls are also coping strategies employed by households. Food storage as a means of ensuring household food security till the next harvesting period was common among most households in the three communities. The challenge, according to the focus groups discussions was due to the poor harvest especially for maize in 2015 (because of low or erratic rainfall compounded with high temperature resulting in the withering of the crops), they, therefore, envisage food shortage in the course of the year if the minor raining season (mid-August to November) also becomes unfavourable.

Aspired adaptation strategies

Most of the farmers indicated having aspiring adaptation strategies to minimise their vulnerability to climatic factors and overcoming socio-economic challenges. Irrigation system in the form of boreholes at strategic positions in the farms will help overcome the long dry spell period was mentioned during the focus group discussions. Other strategies included growing of dry season resistant crops like cassava and plantain in place of maize and other more water-dependent crops and planting of more trees to safeguard streams and provide a conducive environment for crops. However, one's ability to adapt depends on the adaptive capacity available which is generally low in these study communities given limited basic physical assets. According to Cooper *et al*. (2008), the varied livelihood assets namely social-political, physical, financial, human and natural have been seen to play a central role in the adaptive capacity of an individual, households, and institutions thus making them more resilient. In order to enhance the adaptation strategy of these farmers and the adaptive capacity of smallholder farmers, the different institutions and actors also do have specific roles and responsibilities. Some steps that calls for policy attention as indicated by United Nations Framework Convention on Climate Change (UNFCC) in enhancing adaptation strategies and adaptive capacity of Africa are: First, effective adaptation approaches in this region needs to address a range of environmental stresses and factors linking with coordinated efforts aimed at poverty alleviation, enhancing food security and water availability, combating land degradation and reducing loss of biological diversity and ecosystem services, as well as improving adaptive capacity (UNFCC, 2007). As observed in the study smallholder farmers were not only confronted with climatic factors but also with socio-economic challenges. Second, adjusting and changing at every level – from the community to national and international. Communities' members need to build their resilience, including adopting appropriate technologies while making the most of the traditional knowledge and diversifying their livelihoods to cope with current and future climate stress. Nevertheless, local coping strategies and traditional knowledge need to be used in synergy with the national government and local government interventions. Third, workable and effective adaptation measures call for collaborative efforts from ministries and governments and non-government organizations making conscious efforts in integrating climate change in their planning and budgeting at all levels of decision-making (UNFCC, 2007).

Conclusion

This paper explored the views of smallholder farmers on climatic and socio-economic changes confronting their livelihoods and how they respond to them in the transition zone. Variations in rainfall and temperature were felt and experienced in the farming systems by both men and women smallholder farmers coupled with existing socio-economic challenges. Nevertheless, some women were adapting by engaging in off-farm activities to support the families whereas others who were constrained in terms of physical and human assets were 'doing nothing' or 'bearing losses'. Generally, communities in the transition agro-ecological zone where low rainfall or erratic and long drought periods have not been part of their livelihoods but have dawned on them as a result of current climatic changes need to learn how to cope and even adapt to the situation to survive. This could be a reality when their adaptive capacities are built in different livelihood assets such as physical, financial and human. Overcoming these challenges call for the agriculture sector to reconsider the proposal by UNFCC (2007) that enhancing adaptation strategies and adaptive capacity of Africa, there is the need to pay attention to both climatic and socio-economic issues, develop human capacity at all levels and coordinated efforts of all actors in planning and budgeting at all levels.

Data availability

Data underlying this work is available from Figshare: https://doi.org/10.6084/m9.figshare.6086198.v1 (Derkyi *et al.*, 2018).

Competing interests

No competing interests were disclosed.

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Supplementary material

Supplementary File 1 – Questionnaire with preamble used for this study.

Click here to access the data.

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Virginia Burkett
United States Geological Survey (USGS), Reston, VA, USA

Major problem with the manuscript: The survey of farmers perceptions of changes in temperature and rainfall should be compared with instrumental records, which may not be located in the three study communities but are available for Accra and several other parts of Ghana. The authors should compare farmers perceptions with rainfall and temperature records from the closest stations to the study area. The authors indicate on page 12 that rainfall trends have been analyzed by Mawunya & Adiku (2013). Perhaps just bringing in some a table with the main results of that study is all that is needed.

Page 1: The adjectives “bad” and “good” are subjective and should be avoided. A more accurate descriptor should be used in the results and conclusions stated here. In the Results, the authors might use “inadequate”, “damaged and undependable”, “very poor” or other words that convey why they believe the road network is “bad”.

Rather than saying “good road network” in the Conclusions, they might be more precise and say “improved, dependable road network”.

The words “gendered analysis” should be changed to “gender analysis” to be grammatically correct. Throughout the manuscript the word “gendered” should be changed to “gender”.

Page 1: Methods, the “N=60 for data collections in three communities” is confusing. Were there 60 surveys total in each of the three communities? Was there only one focus group discussion (59 plus 1 = 60)? The plural word “discussions” indicates that there was more than 1 but the text on page 3 indicates there was only one focus group meeting/discussion.

On page 4 it is stated that “a total of 60 respondents (30 men and 30 women) in the three communities were asked to rank the problems”, which is inconsistent with the what is said in Methods on page 1 and the table 1.

Page 1: Results, rather than stating that “it was ascertained”, the authors should state how they “ascertained” that farmers have not made conscientious efforts to adapt. For example, they could say,

“Responses of farmers to the household surveys in all three communities indicate that …..”

Page 3: A sentence in the center left column begins with the words “African’s livelihood vulnerability” is grammatically incorrect. The subject refers to one person, and I don’t think that is what the authors intended. They could begin the sentence more precisely with “The vulnerability of peasant farmers and their livelihoods in Sub-Saharan Africa … ”

Page 3: This long phrase is awkward and needs be reworded: “With the issue of climate variability and change pertaining to changes in rainfall patterns, temperature and extreme weather events,” Climate variability is not a new “issue” or phenomenon, but changes in climate is now an issue. Suggest the following: “Changing patterns of rainfall, temperature and extreme weather are becoming a major threat to food production and security due to the region’s high dependence on rain-fed agriculture.”

Page 3: In addition to mean temperature change in Ghana, what are the trends in seasonal means and maxima? The changes in patterns of extremes and growing season trends in temperature and rainfall are more important to agriculture than a 1 degree average increase over sixty years.

Page 3: In the right column, the words “of Ghana” or “of Accra” should be added after the words “Offinso North and Nkoranza South Districts”. Otherwise the reader does not know what area of Sub-Saharan Africa is being discussed.

In the same paragraph, this sentence also needs to be edited: “In order to appreciate these changes, there was the need to understand the livelihood trajectories of farmers.” The authors are not seeking to “appreciate” changes, they are seeking to “understand” or “assess” the impacts of these changes on the livelihoods of small farmers and differential impacts on women and men. Rather than saying they only asked four questions, they should say that that the “This study was designed to address four major questions: 1) What livelihood options are available …..” The term “trajectories” is a confusing term in this context and should be either explained or deleted. What is meant by "livelihood trajectory",

Page 3: Methods: what was the method of randomization used to select the three communities? Randomization in methods usually refers to a statistically valid method of selection of a subset. If the method of randomization cannot be explained, then the authors should just say they three communities were “chosen for the study” …. and they could explain why they were chosen thought not necessary. How were individual men and women selected for interviews from the three communities?

Page 3: This sentence does not make sense: “Historical analysis indicated that in this zone, rainfall variability may be the single largest component of rainfall changes affecting all agro-ecological zones in Ghana.” What is meant by “variability may the single largest component of rainfall change”? Are you talking about “variability” or long term “change” – they are not the same thing. Considering the statements that follow in the paragraph, it appears that the authors are intending to say “Historical data analyses indicate that seasonal rainfall patterns are changing across Ghana.” This makes more sense and leads nicely into the remainder of the paragraph.

Page 4: (Figure 1) The red circle in the upper left reference map should be replaced with a rectangle that matches the location, shape and orientation of the study area shown in the left panel. The size of the font showing the locations of the 3 study communities in the left panel should be larger so they appear more prominently on the map – they are the main feature of the map for this study.

Page 12: need to describe “boreholes” for irrigation. How do they work? Are they water wells? How is the

water distributed to the crop?

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
No

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 21 Sep 2018

Mercy Derkyi, University of Ghana, Accra, Ghana

Dear Reviewer,

Thanks so much for these useful inputs. The revised version will take into consideration most of the indicated gaps.

Best regards
Mercy

Competing Interests: No competing interests were disclosed.