Livelihood adaptations to climate variability: insights from farming households in Ghana

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## Abstract

Climate change and variability pose one of the greatest threats to many sectors of sub-Saharan Africa’s economy. Agriculture is one of the most climate sensitive sectors because of its dependence on rain-fed cultivation. This paper identifies the main adaptation strategies used by farming households in the Sudan savannah and transitional agro-ecological zones of Ghana to reduce the adverse impacts of climate variability on their livelihood activities. It combines questionnaire surveys and key informant interviews with participatory methods. The results show that households employ a range of on- and off-farm adaptation strategies including changing the timing of planting, planting early maturing varieties, diversification of crops, relying on family and friends, planting drought-tolerant crops and changing diets to manage climate variability. The results reveal that most households use coping strategies linked to livelihood diversification to adapt to the increased climate variability seen in recent decades. Most of these households engage in multiple non-arable farming livelihood activities in an attempt to avoid destitution because of crop failure linked to climate variability (particularly drought). Some of the coping strategies identified are also reported in the literature in other sub-Saharan African countries. The findings suggest that policy makers need to formulate targeted climate adaptation policies and programmes that are linked to enhancing livelihood diversification, as well as encouraging households in different farming communities to share knowledge on climate adaptation.

Key words: adaptation, livelihoods, coping, climate change and variability, Ghana; farming households

## 1. Introduction

Although Africa is a minor player in terms of total global greenhouse gas emissions, contributing to <3% of the world’s total ([UNDP 2007](#_ENREF_66)), the continent remains vulnerable to climate change and variability ([Boko et al. 2007](#_ENREF_5); [Lobell et al. 2011](#_ENREF_35)). This vulnerability has been attributed to the continent’s low adaptive capacity and its over-dependence on rain-fed cultivation ([Boko et al. 2007](#_ENREF_5)). Within Africa, sub-Saharan Africa (henceforth, ‘SSA’), is considered to be the most vulnerable to the adverse impacts of climate change and variability ([Boko et al. 2007](#_ENREF_5)). Several studies investigating rainfall variability have noted a decline in annual precipitation in SSA especially West Africa, and particularly in the Sahel ([Hulme et al. 2001](#_ENREF_27); [Nicholson 2001](#_ENREF_45)), while temperature rises of between +2.0 and +4.5 have been projected for SSA by 2100 ([Müller 2009](#_ENREF_43)). Several studies have suggested that food production in Africa, especially SSA, will be adversely affected by climate change and variability ([Schlenker and Lobell 2010](#_ENREF_57); [Boko et al. 2007](#_ENREF_5); [Thornton et al. 2011](#_ENREF_64)), causing knock-on implications for household wellbeing in natural resource dependent communities.

Within SSA, climate change and variability pose one of the greatest threats to the Ghanaian economy, with agriculture being arguably one of the most climate sensitive sectors because of its dependence on rain-fed cultivation. The amount and pattern of rainfall plays a key role in determining agricultural productivity ([Haile 2005](#_ENREF_23)). Ghana has experienced considerable variations in temperature and rainfall patterns since the 1960s ([EPA 2003](#_ENREF_16)). Whilst uncertainties remain on future estimates of rainfall and temperature changes, the general sense is that temperature will increase whilst rainfall decreases in all agro-ecological zones in Ghana ([EPA 2007](#_ENREF_17)). Studies predict variations in the rainfall and temperature patterns, with northern Ghana projected to experience more drying than southern Ghana ([Christensen et al. 2007](#_ENREF_10)). The Intergovernmental Panel on Climate Change (IPCC) model ensemble has projected that a reduction of 80 mm in monthly rainfall is possible in northern parts of the country, particularly during the June–August farming season ([Christensen et al. 2007](#_ENREF_10)). This will be exacerbated by high inter-annual rainfall variability, characterised by a reduction in the number of rainy days ([Christensen et al. 2007](#_ENREF_10)). Ghana is also projected to experience increased incidences of extreme events such as droughts and floods linked to climate change and variability ([Boko et al. 2007](#_ENREF_5); [Christensen et al. 2007](#_ENREF_10)).

Food security in Ghana and SSA more widely will therefore be placed under considerable stress due to climate change and variability ([FAO 2010](#_ENREF_21)). Cereals including maize, millet and sorghum, which serve as important staple foods across SSA, are extremely vulnerable to climate variability (particularly to drought) as these crops require an appreciable quantity of rainfall for their growth. Intra-annual rainfall variability and increased temperature that characterised the climate in the region are also situated within a myriad of other political, economic, social and environmental challenges. This has adverse consequences for the development of SSA because the economies of many countries in this region are dependent on rain-fed agriculture. Hence, there is the need to explore the coping and adaptation strategies employed by farming households to mitigate the adverse impacts of climate change and variability. This will help identify appropriate policy interventions aimed at reducing the vulnerability of livelihoods to climate change and variability.

Adaptation is not new to farming communities in SSA. There have been many instances where societies have adapted to changes in the climate in order to survive, by altering settlements and agricultural patterns. However, climate change and its associated impacts add a new dimension to this challenge ([Burton 2009](#_ENREF_8)). In the context of climate change research, various definitions of adaptation abound. This paper adopts Smith et al’s (2000) definition as the process by which stakeholders reduce the adverse effects of climate on their livelihoods. This conceptualisation allows a better understanding of how households and communities use their adaptive capacities and various assets in reducing the adverse impacts of climate variability on food systems and livelihoods. This will help in assessing how such households and communities could be assisted by various stakeholders to withstand climatic stresses. The term ‘coping strategies’ is used interchangeably with ‘adaptation strategies’. Coping strategies refer mainly to short term actions taken to counteract the immediate negative impacts of climate variability including drought ([Yohe and Tol 2002](#_ENREF_71); [Eriksen et al. 2005](#_ENREF_18)).

Even though agriculture is one of the most widely studied sectors with respect to the impacts of climate change, until recently, research efforts have neglected the possible role of adaptation by farmers ([Schipper and Burton 2009](#_ENREF_56)). Prior to 1992, the term adaptation was considered a taboo subject and rarely used in relation to global climate policy ([Schipper and Burton 2009](#_ENREF_56); [Pielke et al. 2007](#_ENREF_52)). The focus of the international community was on mitigation: reducing the emissions of greenhouse gases and increasing carbon sinks, thereby slowing the rate of global climate change ([IPCC 2007](#_ENREF_30); [Stringer et al. 2012](#_ENREF_60)). [Stringer et al. (2009, p. 750](#_ENREF_62)) stress that “…proponents of adaptation were viewed as rather defeatist and were thought to demonstrate a lack of faith in countries’ abilities to limit emissions”. However, the world will likely continue to warm at a significant rate for many decades whatever targets may be agreed to reduce emissions. Therefore, adaptation is necessary in order to reduce the adverse impacts of climate change and variability on agriculture and rural livelihoods ([Yohe 2000](#_ENREF_70)). Adaptation as a response to climate change has been covered extensively in the Fourth Assessment Report by the IPCC, while Article 10 of the Kyoto Protocol and Article 4.1b of the United Nations Framework Convention on Climate Change are explicit in emphasising the possible role of adaptation to reduce the adverse impacts of climate change ([UN 1992](#_ENREF_65)).

Despite the significance attached to adaptation, only a few studies (Tachie-Obeng et al. 2012; Fasona et al. 2012) have explored the adaptation options implemented by farming households in SSA and their impacts on dryland farming system vulnerability (Fraser et al. 2011). This knowledge gap is important and needs urgent attention, because without an understanding of the adaptations that people are already making to cope with climate change, it is difficult to target policy support to further strengthen and upscale those actions. Against this background, the purpose of this paper is to identify the main adaptation strategies used by households in the Sudan savannah and the transitional agro-ecological zones of northern and central Ghana to mitigate against the negative impacts of climate change and variability on their core livelihood activities (i.e. agriculture). The transitional agro-ecological zone of Ghana shares the features of both savannah and forest zones and holds great prospect for food security, including the production of staples such as maize and yam. Findings from this study will inform policy development on climate change adaptation in Ghana and more widely in the SSA region. This is possible because the agro-ecological zones of Ghana share climatic features similar to the Sahel and other parts of West Africa, which experience a high degree of temporal and spatial variations in rainfall and temperature ([Hulme 2001](#_ENREF_26)).

## 2. Research design and methods

### 2.1 Selection and description of study sites

Previous studies by Antwi-Agyei et al. (2012) identified the Ejura Sekyedumase district of Ashanti region and Bongo district of the Upper East region as the most resilient and vulnerable districts in Ghana to changing rainfall in relation to its impacts on crop yields. Resilient regions or districts are locations where major droughts over the past 40 years resulted in insignificant crop losses. In contrast, vulnerable regions or districts are defined as situations where there were large losses in crop harvest following relatively minor rainfall perturbations over the past 40 years.

For this study, six farming communities were selected from the resilient (Ejura Sekyedumase) and the vulnerable (Bongo) districts (3 in each case) for local-level research, based on information gained through interviews with experts and stakeholders and census data. Within the resilient district (Ejura Sekyedumase), Aframso, Babaso and Nyamebekyere were selected as resilient communities, while Adaboya, Ayelbia and Vea located in the Bongo district, were selected as the vulnerable case study communities (Figure 1). The two districts have different agro-ecological and socioeconomic characteristics. The Ejura Sekyedumase district (Figure 1), which lies within the transitional agro-ecological zone, experiences average annual rainfall of 1200–1500 mm. It experiences bi-modal rainfall patterns with the major rainfall season from April to July and the minor rainfall season from September to October ([EPA 2003](#_ENREF_16)). This constitutes two farming seasons – major and minor, in which minimum and maximum temperatures reach 20oC and 32oC respectively ([EPA 2003](#_ENREF_16)). By contrast, the Bongo district (the vulnerable district, Figure 1) lies within the Sudan savannah agro-ecological zone, with average annual rainfall of 800–1000 mm (EPA, 2003). Here, uni-modal rainfall falls from May/June–September/October, with maximum temperatures of 35oC and mean monthly minimum temperature of 21oC ([EPA 2003](#_ENREF_16)). The district has one main farming season from May/June–September/October ([EPA 2003](#_ENREF_16)).

<*Insert Figure 1 around here*>

2.2 Research methods

Data presented in this paper were collected during two rounds of fieldwork; May–August, 2010, and June–August, 2011 using a mixture of participatory methods such as focus group discussions, household questionnaire surveys and key informant interviews. Data collection started with community gatherings and a transect walk in each of the 6 farming communities.

 A questionnaire survey was used to collect information on capital assets, endowments and demographic features at the household level. The household was selected as the main unit of analysis because major decisions about adaptation to climate change and livelihood processes including decisions about agricultural production and consumption are taken at this level ([Thomas et al. 2007](#_ENREF_63)). The questionnaire survey assessed the adaptation and coping responses used by households in the study communities. Data were collected on new crop varieties, irrigation practices, moisture conservation techniques, timing of farm operations and information systems for weather forecasting. Data were also collected on the availability of, and accessibility to, government subsidies, insurance, and general government policies particularly on land tenure systems and land use. Forty-five questionnaires were administered in each of the 6 farming communities, giving a total of 270 household questionnaire surveys.

 Sampling involved the stratification of households into different wealth groups, based on local perceptions of wealth, and a random sample was then surveyed. Individual households were evaluated at the time of the questionnaire survey. To ensure representation of the various wealth groups, key informants were used to identify appropriate households where there was under- representation of any wealth group. To triangulate the main issues highlighted during the household questionnaire surveys, 6 focus group discussions (FGDs) were conducted in the farming communities (one in each community) with between 5 and10 farmers of different socio-cultural backgrounds. During the FGDs and household questionnaire survey, individuals who demonstrated appreciable knowledge on environmental change and food security were selected for key informant interviews.

 Qualitative data were coded and indexed through intensive content analysis and the major themes that emerged were analysed ([Krippendorff 2004](#_ENREF_33)). Structuring qualitative data into major themes allowed the categorisation of the responses and identification of those that diverged from the common themes. Contradictions from household questionnaire surveys were triangulated through more in-depth key informant interviews and FGDs. To establish the extent of climatic variability in the study communities, a time series analysis was conducted using Microsoft Excel (Version 2007) for rainfall and temperature data obtained from the Ghana Meteorological Agency covering a period of 1961–2007, for which data were available.

## 3 Results

This section presents the study findings, first, by exploring the perceptions of climate change and variability within the study communities. Second, it highlights the extent of climate variability in the study areas. Finally, it explores the various household adaptation measures used to manage climate variability.

### 3.1 Farmers’ awareness of climate change and variability in the study communities

The evidence from the questionnaire survey shows that households in the study communities are aware that climate change is happening. Specifically, households were asked about their observation of changes in rainfall and temperature patterns since the 1960s. The time span for the perception study was limited to this period due to restrictions on the availability of climate data from Ghana Meteorological Agency to establish climate time series analysis. However, this length of time is considered adequate to allow the establishment of the extent of interactions between livelihood context and climate variability. Table 1 shows that 78% of the sampled households claimed to have observed increasing temperatures and that the weather has become hotter compared with their childhoods. Furthermore, the majority (90%) of households indicated that they have observed considerable changes in the onset of the rains over the past 40–50 years (Table 1). In terms of rainfall, whilst 82% of the sampled households perceived decreased rains, 18% reported increased rainfall over the 40–50 year period (Table 1). Generally, there was almost unanimous agreement across the farming households that there is a decreasing trend in the amount of rainfall as well as delays in the onset of the rainfall compared with their childhoods.

Farmers’ perceptions of climate variability are increasingly being used in climate vulnerability and adaptation studies ([Maddison 2007](#_ENREF_38); [Slegers 2008](#_ENREF_59); [Mertz et al. 2009](#_ENREF_41)). This is because farmers’ perceptions based on their past experience and future expectations may influence the type of adaptation strategy used as a response to climate problems ([Maddison 2007](#_ENREF_38)). It has been suggested that farmers are more likely to adapt to climate change if they can perceive the changes in the climate ([Maddison 2007](#_ENREF_38)). Therefore, it is essential that these perceptions are assessed in a study such as this (Simelton et al, 2013).

<*Insert Table 1 around here*>

### 3.2 Establishing the extent of rainfall variability in the study regions

Climatic data from 1961–2007 from the Ghana Meteorological Agency show that there have been some hydro-climatological changes within the study areas. Within the resilient region, Figure 2 shows that the amount of rainfall was quite substantial from 1961 until 1968 when the region recorded its highest rainfall of 2344 mm. Rainfall patterns have shown variability since this period. Figure 3 shows that there has been rainfall variability in the vulnerable region. For instance, the vulnerable region recorded the lowest rainfall amount of 670 mm in 1977, followed by a series of erratic rainfall patterns until 1999 when the area recorded its highest rainfall amount of 1365 mm. The reduced precipitation in the study region lends more credence to other studies that suggest that there has been remarkable decline in the amount of rainfall in Africa, particularly SSA ([Boko et al. 2007](#_ENREF_5); [Hulme et al. 2001](#_ENREF_27)), as well as supporting the farmer perception data. Though the prediction of rainfall patterns in Africa has been less consistent compared with projections in temperature ([Hope 2009](#_ENREF_25)), the general agreement is that there will be a decline in rainfall in most parts of SSA. The fact that there is more rain in the resilient regions (and communities) and less in the vulnerable region (and communities) is in keeping with the expectation given that these areas are in different agro-ecological zones.

### 3.3 Evidence of temperature changes in the study regions

Temperature, another important element of climate that is critical for agricultural productivity in the tropics, was also assessed ([Lobell and Burke 2008](#_ENREF_36)). A time series analysis of annual temperatures in the study regions shows that there have been changes in maximum annual temperatures over the four and half decades from 1961-2007. Within the resilient region, Figure 4 shows that there has been an increase in the annual maximum temperatures over the period from 30.2oC in 1961 to 31.8oC in 2007. The vulnerable region recorded mean annual increase of 34.3 oC in 1961 to 35.0 in 2007 oC (Figure 5).

Declining precipitation in the study regions coupled with future predictions of annual temperature increases ([EPA 2007](#_ENREF_17)) presents serious challenges to farmers since they depend entirely on rainfall for their livelihoods (i.e. crop production). Increasing temperature increases evaporation and evapo-transpiration that leads to a reduction in soil moisture content. This will shorten the length of the growing season, as experienced in many SSA countries, particularly in the Sahel ([Lobell et al. 2011](#_ENREF_35)), and will have substantial implications for crop yields and food security.

<*Insert Figures 2, 3, 4 and 5 around here>*

### 3.3 Strategies to deal with changes in rainfall and temperature in the study communities

The changes identified above in the meteorological analyses support the perceptions of farmers that the climate has been variable. To manage these changes, various adaptation strategies have been employed. Table 2 summarises these and shows that adaptation strategies employed by households in the study communities to deal with climate variability (particularly drought) can broadly be grouped into two categories. The first group is on-farm adaptation strategies that refers to a series of agricultural management practices that are undertaken by households on the farm site aimed at reducing the impacts of climate variability. Second, off-farm adaptation strategies refer to activities that are undertaken outside the farm.

Table 2 presents various on-farm adaptation strategies identified in the study communities, including changing the timing of planting (92%; n = 249), planting early maturing crops (66%; n = 178), crop diversification (79%; n = 214) and using agro-forestry systems (16%; n = 43). The majority (73%; n = 196) of households in the study communities reported planting drought-tolerant crops. This comprises 100 (74%) households in the resilient communities compared with 96 (71%) households in the vulnerable communities. Whilst irrigation was mentioned by 18 (13%) households in the vulnerable communities, none of the households in the resilient communities reported this adaptation.

Off-farm adaptation strategies that were reported by households include relying on family and friends (36%; n = 98), temporary migration (46%; n = 123), using agro-ecological knowledge (65%; n = 176) and relying on governmental and non-governmental assistance (52%; n = 141) (Table 2). In all, 15 (11%) households in the resilient communities indicated changing their diets to cope with climate variability. By contrast, this strategy was reported by 98 (73%) households in the vulnerable communities. Further, 128 (47%) out of the 270 households in the study communities reported reducing food consumption to cope with climate variability (particularly drought). Table 3 also shows that most of these adaptation strategies are used widely across SSA. For instance, temporary migration has been used as both reactive and anticipatory response to drought-induced food insecurity in many parts of SSA ([Mortimore and Adams, 2001](#_ENREF_161); [Wouterse and Taylor, 2008](#_ENREF_243)). This indicates that policy recommendations from this paper will be applicable to the wider context of SSA.

<*Insert Table 2 around here*>

One of the more significant results that emerged is that most farming households in the study communities were using coping strategies that are linked to livelihood diversification (Table 3). In dryland crop production systems in SSA that are characterised by inherently high rainfall variability, livelihood diversification has been used as a key adaptation strategy to reduce the production risk associated with climate variability ([Paavola 2008](#_ENREF_51); [Ellis 1998](#_ENREF_13)). Petty trading dominated the non-farm jobs with 28% and 15% of households in the resilient and vulnerable communities respectively indicating that they engaged in petty trading (Table 3). About 19% and 10% of households in the vulnerable and resilient communities respectively reported selling livestock (mostly goat, pigs and sheep) and poultry (fowls) to cope with drought (see, Table 3). Selling livestock is dominated by male farmers and also dependent on the capital outlay that can be invested in livestock production by a household. For this reason, rich households that may have access to credit and other forms of funds are able to invest in livestock production. Additionally, since the early 2000s, households claimed that charcoal production is becoming an important emerging non-farm coping strategy, especially amongst the households in the resilient communities, in which about 9% of households engage in it to raise funds to support the household (Table 3). Indeed, this may be an underestimate because charcoal production involves the illegal felling of trees and households may not want to state that they are involved in such activities.

A critical examination of the results suggests that engagement in a specific non-farm livelihood activity may be determined by the gender of the respondent and that livelihood activities may be clustered into three groups: (i) those that are pursued predominantly by females; (ii) those pursued predominantly by males; and (iii) those that are gender blind (i.e. those engaged in by both females and males). Non-farm activities such as petty trading, shea nut gathering and pito brewing are specifically undertaken by women. For instance, while 72% (n = 42) of the respondents that indicated petty trading were females, only 28% (n = 16) were males. On the contrary, selling livestock, sand mining, being a forest assistant, bicycle repairer and fishing are predominantly engaged in by males. None of the 39 respondents that reported selling livestock as a non-arable livelihood activity was a female. Activities such as charcoal processing and weaving are gender-blind. According to focus group participants, the women trade in different things including foodstuffs, meat, general wares, provisions, farm inputs and implements, cooking utensils and cooked food. Females engaged in these activities because of the low financial investment and skills required to participate.

Further, Table 3 reveals that households’ engagement in non-arable farming livelihood activities is greatly influenced by the location (whether the household is located in the resilient or vulnerable community). While activities such as charcoal production and working as forest assistants were predominantly undertaken by households in the resilient communities, weaving, sand mining, causal labour and pito brewing were mostly undertaken by households in the vulnerable communities.

<*Insert Table 3 around here*>

## 4 Discussion

The findings presented here suggest that smallholder farmers in the Sudan savannah and transitional zones of Ghana are employing various on-farm and off-farm adaptation strategies to cope with climate variability. These points are expanded on in the following sections and the implications for climate adaptation policy are flagged up. It is, however, significant to stress that households in the study communities, like many other dryland SSA communities, are often confronted by multiple climatic and non-climatic stresses including droughts, lack of markets, poor education and adverse economic development ([Nielsen and Reenberg 2010](#_ENREF_46)). Therefore, it is quite difficult to attribute specific adaptation strategies to climate change and variability. Nonetheless, climate variability (particularly drought) is the major threat in dryland farming systems in Africa ([UNDP 2007](#_ENREF_66)), hence, the ability of the small-scale farmer in SSA in general to withstand drought is seen as critical in coping with other non-climatic stresses.

### 4.1 Diversification of livelihood activities to mitigate the adverse impacts of drought

The results on livelihood diversification as a coping and adaptation strategy corroborate other studies (Paavola 2008; [Barrett et al. 2001](#_ENREF_4)) that suggest households may pursue non-farm livelihood activities as a way of spreading the risk associated with crop failure due to erratic rainfall patterns. This contributes to livelihood resilience at the household level ([Osbahr et al. 2008](#_ENREF_49); [Antwi-Agyei et al. 2013](#_ENREF_1)). Households engage in multiple non-arable farming activities to complement agricultural activities. Women engaged in petty trading to raise extra income to make sure there is food on the dinner table. Culturally, in Ghana, and especially in rural communities, women share the greater household management burden and hence are supposed to get food for the household ([see Assan 2008](#_ENREF_3)). Despite this, and their important role in ensuring household food security ([Ibnouf 2011](#_ENREF_29)), they lack the “political capital that is often crucial in taking decisions regarding assets management for profitable investments in non-farm activities” ([Yaro 2006, p. 149](#_ENREF_69)). Unequal power relations between women and men in the study communities have often resulted in differential access to capital assets and opportunities for livelihood diversification ([Denton 2002](#_ENREF_12)).

Farmers reported that the profits from livestock sales are invested in foodstuffs to keep the household food secure after they have run out of provisions from their own farms. Focus group participants reported that part of the income from selling livestock is invested in agricultural production in terms of buying farm inputs. Such claims by farmers are consistent with other findings that suggest that income from non-farm activities such as artisanal diamond and gold mining in Sierra Leone are invested to revive agricultural production ([Maconachie 2011](#_ENREF_37)). Households claimed that selling livestock is one of the most profitable non-farm activities in the vulnerable communities. In most agriculture-dependent rural African households, the availability of livestock represents wealth and serves as an important insurance mechanism because households can easily sell livestock to buy grain ([Hesselberg and Yaro 2006](#_ENREF_24); [Reardon et al. 1988](#_ENREF_53)).

By augmenting their livelihood activity portfolio, the smallholder farmer in dryland farming systems in SSA will inevitably be reducing the risks of an overall adverse livelihood outcome or production failure ([Fraser et al. 2005](#_ENREF_22)). For example, [Fraser et al. (2005](#_ENREF_22)) demonstrate that *Modern Portfolio Theory* can be used to reduce investment risks in order to allow investors to achieve higher returns on their investments. Similarly, by diversifying their livelihood portfolio, the smallholder farmer will inevitably be reducing the risks of an overall adverse livelihood outcome (Ellis 1998; Fraser et al., 2005).

Livelihood diversification may also be used by households to efficiently utilise their factors of production, especially labour (Paavola 2008). For instance, households in the vulnerable communities reported working as causal labourers and undertaking other menial jobs in southern Ghana, especially in the Ashanti and Greater Accra regions, where environmental conditions and job opportunities are better. These farmers depend predominantly on rain-fed agriculture for their livelihoods and shortening of the growing period linked to increased drought has resulted in a limited period (June – October) during which these farmers could cultivate their land. Hence, one of the more lucrative options is to explore other livelihoods opportunities including, but not limited to, selling labour.

Nonetheless, it has been argued that specialising in one livelihood activity could yield higher economic returns than the engagement of the household in a number of livelihood activities ([Eriksen et al. 2005](#_ENREF_18)). Further, [Bryceson (2002](#_ENREF_7)) challenged the assumed positive relationship between livelihood diversification and poverty reduction, and by extension, climate adaptation. Migration of male labour due to livelihood diversification into distant markets could result in depletion of the local productive labour force ([Ellis 1999](#_ENREF_14)), that could consequently reduce economic returns. This has the potential to negatively affect food production and food security.

### 4.2 Application of agro-ecological knowledge to deal with drought

The findings on the application and sharing of traditional knowledge in mitigating the impacts of climate variability, in relation to indigenous knowledge and social networks, are consistent with findings from other studies ([Nyong et al. 2007](#_ENREF_47); [Orlove et al. 2010](#_ENREF_48); [Roncoli 2006](#_ENREF_54)). For instance, [Orlove et al. (2010](#_ENREF_48)) observed that farmers in southern Uganda use information on indigenous climate knowledge including particular phases of the moon as indicators of impending rainfall to plan their agricultural operations. [Slegers (2008](#_ENREF_59)) observed that farmers in Central Tanzania were using signs such as stars and cloud watching as indicators of rainfall patterns.

Particularly interesting is the reliance of households on their social networks to share indigenous agro-ecological knowledge on early warning signs for climate forecasting – an essential aspect in coping with and adapting to climate variability and change. Studies have shown that local farmers in SSA have rich and sophisticated agro-ecological knowledge that could be useful information for climate adaptation ([Nyong et al. 2007](#_ENREF_47); [Orlove et al. 2010](#_ENREF_48)). According to the farmers, they use their indigenous agro-ecological knowledge to develop complex climate models which are based on changes and indicators linked to their surroundings. Such traditional climate models are used to design seasonal calendars that facilitate adaptation by way of planning when to plant their crops. This is very crucial in rain-fed dryland farming systems where crop yield could be seriously affected if farmers miss key activities in the calendar season. For instance, households in the vulnerable communities use the flowering and fruiting of certain trees such as the baobab tree (*Adansonia digitate*) and *Vitellaria paradosa* (shea tree) to indicate the onset of the rains and prepare their farmlands. Also, some households use the direction of the wind to indicate impending rains for agricultural purposes. Still others rely on past rainfall patterns including the start and ending of the rainy season to form expectations and predict the rainfall patterns for the coming season ([cf. Stringer and Reed 2007](#_ENREF_61)). This knowledge base represents a form of social capital that is shared among the members of the farming communities and can add value to climate change studies when properly integrated. This, therefore, means that this knowledge base should be considered and integrated with scientific climate knowledge in the design and implementation of appropriate climate adaptation policy in these regions as widely called for across the climate and development policy literature ([Nyong et al. 2007](#_ENREF_47); [Orlove et al. 2010](#_ENREF_48); [Stringer et al. 2009](#_ENREF_62)).

### 4.3 Coping with drought using small scale irrigation schemes

Water system technologies including small-scale irrigation facilities are increasingly being used by households, especially those in the vulnerable communities, to practise dry season vegetable farming. At Vea, where there is a large-scale irrigation dam, farmers claimed that households are allocated land around the dam where they can grow vegetables such as tomatoes. FGD participants claimed that using irrigation as a coping mechanism for drought assumed greater importance especially in the 1980s, when rainfall variability became predominant, leading to a shortened growing season. These claims by farmers corroborate other studies ([Enfors and Gordon 2008](#_ENREF_15); [Laube et al. 2012](#_ENREF_34)) suggesting that small-scale irrigation among smallholders can substantially reduce crop failure due to meteorological drought in dryland agricultural systems. For instance, [Laube et al. (2012](#_ENREF_34)) concluded that smallholders farmers in northern Ghana use shallow groundwater irrigation for dry season vegetable gardening to cope with the adverse impacts of drought.

### 4.4 Are smallholder farmers coping or adapting to climate variability in sub-Saharan Africa?

It is significant to emphasise that most of the adaptation measures highlighted above are used by farmers in Ghana and SSA more widely as risk-spreading measures to reduce the negative impacts of climate variability, but that they fail to take advantage of the opportunities presented in relatively good farming seasons ([Cooper et al. 2008](#_ENREF_11)). Such measures are more coping strategies (rather than adaptations) that reduce present vulnerabilities without necessarily accounting for future climate changes. In this regard, for adaptation strategies to be effective and successful, they should reduce present and future vulnerabilities to climate change as well as increasing resilience ([Huq et al. 2004](#_ENREF_28) ). Climate adaptations should seek to maximise the potential benefits that can be derived from a more resilient society ([Mitchell and Maxwell 2010](#_ENREF_42)). Indeed, if adaptation strategies to climate change are managed properly, many environmental benefits can be derived from them ([FAO 2008](#_ENREF_20)).

## 5 Conclusions and policy recommendations

This paper has identified the adaptation strategies used by farming households in the Sudan savannah and transitional agro-ecological zones of Ghana to manage the adverse impacts of climate variability on their livelihoods activities. This was done in the light of perceived changes by the households in relation to decreased rainfall and delayed onset of the rains for the farming season as well as increased temperature patterns compared with the 1960s and 1970s. The results have shown that households in the study communities employ a host of different on-farm and off-farm adaptation strategies.

The results show that households employ on-farm adaptation strategies such as changing the timing of planting, diversification of crops, planting early maturing varieties, planting drought-tolerant crops and using irrigation systems, where possible. Key off-farm adaptation strategies identified include relying on social networks, temporary migration, changing diets and reducing consumption. The paper has shown that households are using coping strategies that are mostly linked to livelihood diversification. With regard to livelihood diversification, this paper also presented empirical evidence that suggests that farming households in the study communities and SSA more widely engaged in non-farm activities such as petty trading, selling livestock, charcoal production, working as forest assistants, food vendors, and shea nuts gathering to cope with climate variability.

Building on previous studies on climate adaptation in SSA (Tachie-Obeng et al. 2012; Fasona et al. 2012), this paper contributes to scientific debates on livelihood resilience at the household by enhancing our understanding of how small-scale farmers in Ghana and more widely are coping with the challenges posed by climate variability. The implication of the findings is that policy makers need to formulate targeted climate adaptation policies and programmes that are linked to enhancing livelihood diversification as well as encouraging households in different farming communities to share knowledge on climate adaptation, building from the positive actions that are already been taken to manage climate change. For instance, appropriate programmes that seek to foster asset building such as skill training and craftsmanship should be integrated into the national climate change adaptation strategy to enable farming households to venture into non-farm livelihood strategies.

Although adaptation may be prompted by climate events such as droughts and floods, it should be acknowledged that these adaptation strategies are taken in response to the complex interplay of both climatic and non-climatic conditions including political, economic and socio-environmental changes ([Mertz et al. 2010](#_ENREF_40)). It is recommended that feedbacks and drivers from these non-climate factors should be considered in the design and implementation of climate change adaptation policy in order to increase its effectiveness.

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