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RESEARCH ARTICLE

Barriers to climate change adaptation: evidence from northeast Ghana in the context of a systematic literature review

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Despite the international significance attached to climate change adaptation, there remains a lack of understanding of the barriers that impede the effective implementation of adaptation strategies by households across sub-Saharan Africa (SSA). Better understanding of the vulnerability of agriculture-dependent households to climate variability requires exploration of the barriers that constrain the implementation of adaptation strategies. This paper uses case studies from northeast Ghana and a systematic literature review to assess the barriers that restrict effective implementation of climate adaptations in SSA. Results suggest that households are constrained by financial barriers, socio-cultural barriers, institutional barriers, technological barriers and a lack of information on climate change characteristics. We examine how the various barriers interact at different levels to influence the adaptation process. Findings highlight that the development of early warning systems, effective communication of climate information and an understanding of the local context within which adaptations take place, are necessary pre-requisites to enhance climate adaptations and rural livelihoods. Households need to be supported through the provision of micro-credit schemes, community empowerment and extension initiatives aimed at enhancing social networks within farming communities in order to reduce their vulnerability to the adverse impacts of climate change and variability.

Keywords: adaptation; climate change and variability; barriers; Ghana; sub-Saharan Africa; households; systematic literature review

1. Introduction

International studies (Boko et al., 2007; Lobell, Bänziger, Magorokosho, & Vivek, 2011) suggest that Africa is particularly vulnerable to climate change and variability. This vulnerability has been attributed to the continent's high poverty levels, low adaptive capacity, its dependence on rain-fed agriculture, as well as its limited economic and institutional capacity (Boko et al., 2007). Research suggests that food production and related livelihoods will be disproportionately affected by climate change and variability in sub-Saharan Africa (hereafter, 'SSA') (Schlenker & Lobell, 2010). Climate change has even been described as a new security threat for Africa (Brown, Hammill, & Mcleman, 2007). Climatic projections suggest that prolonged and more intense droughts are likely to cause SSA to become drier (Boko et al., 2007; Christensen et al., 2007). Increasing mean annual temperatures will increase evapotranspiration losses resulting in a reduction in soil moisture content. Boko et al. (2007) project that climate change will reduce net crop revenues by 90% by 2100. This is likely to exacerbate poverty and underdevelopment in many countries (Sissoko,

Van Keulen, Verhagen, Tekken, & Battaglini, 2011) and lead to significant migration both within countries and internationally (Warner & Afifi, 2014).

In an attempt to reduce the adverse impacts of climate change and variability, households in SSA employ several strategies to cope with climate change and variability. Adaptation is therefore not new to farming households and communities (Dixon, Stringer, & Challinor, 2014). However, climate change and its associated impacts add a new dimension and urgency to the adaptation challenge. Adaptation is the process by which stakeholders (including farmers) mitigate the adverse impacts of climate on their livelihoods and involves adjustments in lifestyle and economic structure in order to reduce the vulnerability of a system to climate change and variability (Smith, Burton, Klein, & Wandel, 2000). The importance of adaptation in managing the risks associated with climate change cannot be over-emphasized (Intergovernmental Panel on Climate Change [IPCC], 2014).

International efforts at finding solutions to climate change have recognized the role of adaptation as a

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policy option (Ford, 2007; Pielke, Prins, Rayner, & Sarwitz, 2007). For example, Article 4.1b of the United Nations Framework Convention on Climate Change (UNFCCC) commits parties to this treaty to promote adaptation to reduce the adverse impacts of climate change. In 2001, the Marrakesh Conference of Parties established the Adaptation Fund in order to finance adaptation initiatives by developing countries. The December 2010 meeting of the Conference of Parties in Cancun also established Green Climate Funds aimed at enabling long-term financing of adaptation and mitigation efforts by developing countries. Under the UNFCCC, the least developed nations have also prepared and submitted National Adaptation Programme of Actions to the Conference of Parties. Considerable research attention has been given to adaptation both in practice and politics (Pielke et al., 2007; Preston, Westaway, & Yuen, 2011).

While studies on climate change adaptation are attracting critical research attention elsewhere in areas such as Europe, Australia, Canada and USA (Barnett, Waters, Pendergast, & Puleston, 2013; Burch, 2010; Jantarasami, Lawler, & Thomas, 2010; Matasci, Kruse, Barawid, & Thalmann, 2013; McNeeley, 2012), empirical evidence is lacking on barriers to adaptation to climate change in SSA specifically (Nielsen & Reenberg, 2010; Pasquini, Cowling, & Ziervogel, 2013; Sietz, Boschütz, & Klein, 2011), and even less research has identified ways in which the barriers might be overcome. In contributing to this literature and helping to address this gap, this paper uses case studies and systematic literature review to:

- (1) Identify the key adaptation strategies used by households in case study villages in Ghana.
- (2) Assess the barriers that restrict the effective implementation of climate adaptations in case study villages and SSA more widely.
- (3) Draw policy recommendations and identify potential ways forward to enhance support aimed at reducing the vulnerability of smallholder farmers in the case study villages.

In doing so, the paper advances understanding of how barriers to climate change adaptation interact at different levels (village, regional and national) to impede the successful adaptation by farming households in the study villages. This paper addresses barriers to adaptation to current climate variability and change in the study communities and beyond. While acknowledging that some of the adaptation measures and barriers to implementing these measures identified in the case study villages and the systematic literature review may differ in future, we anticipate that many of these barriers may be applicable in adapting to future climate variability and change.

2. Reviewing the current state of knowledge on barriers to adaptation

Many frameworks and approaches have been developed to understand the limits and barriers to climate adaptations (see Dow et al., 2013; Moser & Ekstrom, 2010). In the fourth assessment report of the IPCC, limits are defined as ‘conditions or factors that render adaptation ineffective as a response to climate change and are largely insurmountable’ (Adger et al., 2007, p. 733). Limits to climate adaptation are endogenous and absolute, and therefore unsurpassable (Dow et al., 2013). Limits to adaptation are dependent on societal ethics and attitudes to risks and are broadly categorized as ecological and physical, economic and technological (Adger et al., 2009). Barriers are defined as factors, conditions or obstacles that reduce the effectiveness of adaptation strategies (Huang et al., 2011; Moser & Ekstrom, 2010) and have been distinguished from limits. In this paper, we focus on barriers, as they can be overcome with concerted efforts.

One of the key barriers to climate change adaptation that have been noted in the climate change literature is the lack of financial resources to implement appropriate adaptation strategies. For instance, Bryan, Deressa, Gbetibouo, and Ringler (2009) reported that financial barriers due to lack of credit facilities are one of the most important obstacles hindering the implementation of climate adaptation strategies by farmers in Ethiopia. Financial barriers are largely related to budget deficits experienced in many economies across SSA cities (UN-Habitat, 2010).

Previous studies (Adger et al., 2009; Jones & Boyd, 2011) have highlighted the constraints imposed by socio-cultural barriers on adaptation actions in several communities. For example, Jones and Boyd (2011) observed that societal norms and values act as a major barrier to successful climate adaptation in Western Nepal. Social barriers may be cognitive, normative or institutional, relating to governance and structures, both formal and informal (see Jones & Boyd, 2011). Cognitive barriers involve psychological and thought processes that influence individuals’ reactions to risks, including climate change (Swim et al., 2011). Normative barriers include cultural norms and values that could influence individuals’ responses to environmental (including climate) change. Individuals and groups employ a range of cognitive strategies to avoid ‘accepting the possibility of unpleasant futures and the need to act now’ (Stafford-Smith, Horrocks, Harvey, & Hamilton, 2011, p. 201). These strategies include active and casual denials, blame shifting, as well as reinterpreting the threat. In this regard, an appreciation of the local context within which climate adaptation takes place is critical.

Other studies (Burch, 2010; Pasquini et al., 2013; Seitz et al., 2011) have identified institutional barriers that may have significant influences on the adaptations undertaken

by farming households in deprived communities. Institutions are defined as the ‘social cement which link stakeholders to access to capital of different kinds to the means of exercising power and so define the gateways which they pass on the route to positive or negative adaptations’ (Davies, 1996, p. 24). Institutions may be formal, where rules may forbid or permit certain actions, or informal, in which members are governed by shared cultural norms and values (Ostrom, 1990). Informal institutions are therefore closely linked to normative barriers. Internal formal institutional barriers, including bureaucratic rules and procedures as well as ambiguous mandates from superiors within an institution, may frustrate the adaptation process (Jantarasami et al., 2010), while leadership and competing planning agendas of various governmental and non-governmental institutions have also been identified as problematic (Stringer et al., 2014).

An increasing body of work has highlighted that institutional barriers are related to politics (Eriksen & Lind, 2009; Pasquini et al., 2013). In South Africa, institutional barriers including party politics have constrained the mainstreaming of climate change adaptation into governmental policies and practices (Pasquini et al., 2013). In Kenya, Eriksen and Lind (2009) reported that people’s responses to drought are influenced by the prevailing political process. In Zimbabwe, Patt and Gwata (2002) reported that the usefulness of seasonal forecasts may be limited

by issues relating to credibility, scale, cognitive capacity and legitimacy as well as institutional and procedural barriers. A supportive institutional framework at the local, national and international levels is critical in enabling successful climate adaptations (Schipper & Pelling, 2006).

Other studies have identified informational barriers as impeding adaptation process (Boyd et al., 2013; Patt & Gwata, 2002). Informational barriers relate to uncertainties around climate projection and models as well as to low levels of awareness on information on climate change characteristics among both farming households and policy-makers (Archie, Dilling, Milford, & Pampel, 2014). Technological barriers are also problematic (including a lack of human capital) for climate adaptation in SSA (Kithia, 2011). While existing research on SSA tends to focus on specific types of barriers, it does not examine how the various barriers interact at different levels to influence adaptation. This paper seeks to help address this important research gap by analysing barriers to adaptation in three case study villages in northeastern Ghana.

3. Research design and methods

This paper uses a two-stage methodology. First, it uses primary empirical data from three villages in northeastern Ghana to provide local understanding of climate adaptation barriers. Second, it situates the locally identified barriers

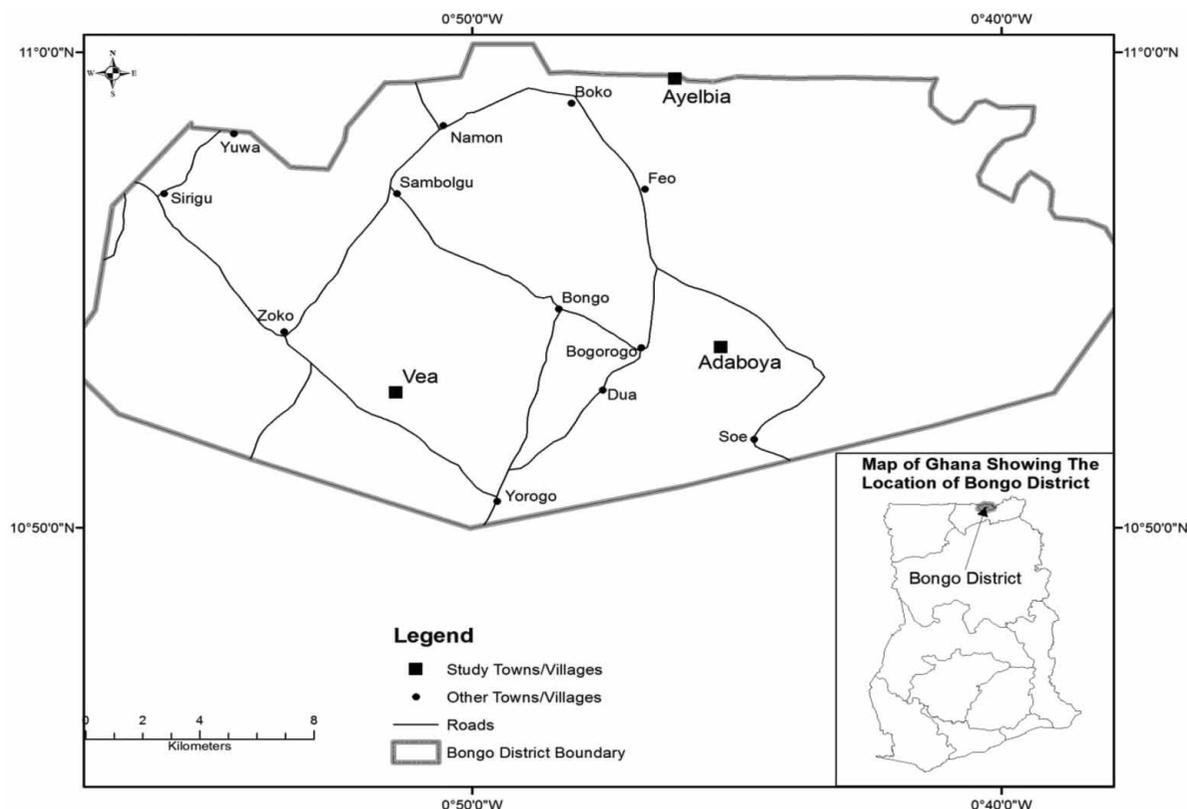


Figure 1. Case study villages in Bongo district, northeastern Ghana.

within a systematic literature review to enable a comparative analysis of key barriers that restrict the implementation of adaptation strategies in SSA.

3.1. Case study analysis

This study is situated within the context of northeast Ghana. The Bongo district of the Upper East region was selected for this study where a previous national study by Antwi-Agyei, Fraser, Dougill, Stringer, and Simelton (2012) identified this area as the most vulnerable district to drought in Ghana (see Figure 1). The Bongo district is characterized by high poverty rates and poor soil fertility. The district lies within the Sudan savannah agro-ecological zone. Uni-modal rainfall permits one main farming season from May/June–September/October (Dickson & Benneh, 1988). The district experiences average annual rainfall of 800–1000 mm (EPA, 2003), with maximum temperatures of 35°C and mean monthly minimum temperatures of 21°C (EPA, 2003). The major economic activity is subsistence agriculture with about 90% of the total population (77,885) in the Bongo district dependent on rain-fed agriculture for their livelihoods (GSS, 2010). The major crops grown include sorghum (*Sorghum bicolor*), millet (*Pennisetum glaucum*), rice (*Oryza sativa*), groundnut (*Arachis hypogea*), guinea corn (*Sorghum vulgare*) and maize (*Zea mays*). Based on expert and stakeholder interviews conducted with experts at the Ministry of Food and Agriculture, three farming villages – Adaboya, Ayelbia and Vea (Figure 1) – were selected for this study. These areas were selected as households in those communities have been exposed to drought and have struggled to deal with climate variability.

3.2. Research methods

This paper uses qualitative data collected during May–August 2010 and June–August 2011. Data collection started with a rapid rural appraisal to gain an overview of the significant social and physical features of the selected villages (Chambers, 1994). A mixture of participatory methods, including key informant interviews, household questionnaire surveys and focus-group discussions (FGDs), were used, allowing local people the opportunity to participate by sharing their experiences and knowledge to outline possible solutions to local climate adaptation barriers. A total of 135 structured household questionnaires were undertaken in the three villages (45 questionnaires in each village). The sample size represented approximately 30–40% of the total households in each community and may be considered sufficient to be representative of the communities (UN, 2005). To ensure the representation of different groups, households were stratified based on wealth (i.e. poor and rich households), using locally perceived indicators of wealth (Antwi-Agyei, 2012; Sallu,

Suckall, & Reed, 2009). A random sample of households was surveyed in each community (Antwi-Agyei, 2012). Households are defined ‘as constituting of a group of people who own the same productive resources, live together and feed from the same pot’ (Yaro, 2006, p. 129). At least one FGD was held in each farming village involving between 5 and 10 farmers differentiated by age, gender and social standing to ensure triangulation of the key issues emerging from the household questionnaire survey. During FGDs, it was discovered that socio-cultural factors constrained the less powerful members of the community (including women) from expressing themselves. To improve participation of women, three separate FGDs were held with female farmers and women’s groups. Purposive sampling was used to identify key informants. A total of nine key informants of different socio-economic and political status were selected in each village for in-depth interviews that covered the key issues raised at FGDs. These informants were selected based on their farming knowledge and experience of environmental change as presented during the FGDs and household questionnaire survey.

3.3. Systematic literature review on barriers to climate adaptation

A systematic literature review was conducted on peer-reviewed literature to explore the extent to which the barriers identified in the study villages have been reported in other studies in SSA. A realistic review approach that emphasizes depth rather than breadth of the documents reviewed was adopted. To do this, the keyword searches of terms including [barrier*] AND [climat* adaptation] AND [Africa] were conducted in the electronic database Web of Science using methods described by Thompson, Berrang-Ford, and Ford (2010), Biesbroek, Klostermann, Termeer, and Kabat (2013) and Ford, Berrang-Ford, and Paterson (2011). The search was limited to articles that were published in English since 2000 to ensure that barriers identified in the literature were current (see Table 1 for exclusion and inclusion criteria). Additionally, the reference lists of relevant articles were manually checked to ensure that no relevant published articles on barriers to climate adaptation in SSA since 2000 were missed.

3.4. Data analysis

Quantitative data from the household questionnaire were coded in a way that Microsoft Excel (Version 2010) and Predictive Analytic Software (formerly Statistical Package for Social Sciences (SPSS)) understand to enable appropriate statistical analysis to be made. Quantitative data were analysed using descriptive statistics. Qualitative data from interviews and focus groups were coded and indexed through intensive content analysis in order to

Table 1. Criteria for including or excluding articles in the systematic literature review.

Criteria	Excluded	Included	Justification
Date of publication	Articles published prior to January 2000	Articles published since January 2000–July 2013	It is assumed that considerable research attention has been given to climate change research since 2000
Language of publication	Articles that were published in languages other than English	Articles published in English	To facilitate understanding of published articles
Main theme of publication	Articles that did not give particular attention to barriers to climate adaptation. Articles that related to human evolution or adaptation were not included	Articles that have the words barriers or limits or constraints or obstacle to adaptation in title or abstract	Since the focus of this study was to explore the key barriers to climate adaptation, the theme of the article needed to closely link to the objective of the study
Availability of article	Articles that were not available in the Web of Science	Articles that were available in the Web of Science	The Web of Science provides an authoritative source for gleaning literature from published sources
Country or region of study	Articles that focused on developed countries	Articles that had Africa as the major focus of the study	The study aimed at enhancing understanding of barriers in Africa and therefore selected papers that focused on the continent
Type of article	Grey literature such as conference proceedings and meetings were not included	Only peer-reviewed articles were included	To avoid grey literature and arbitrariness in the selection of research articles

identify major themes (Krippendorff, 2004). Structuring themes permitted the categorization of the responses and identification of those that diverged from the common themes. Key informant interviews and FGDs were used to triangulate any contradictions observed in the data.

4. Results and discussion

The results of the household questionnaire surveys, FGDs, key informant interviews and the systematic literature review are presented in the following sections. First, we explore the key climate adaptations strategies used by households in the study villages and from the wider literature. Second, we outline the key barriers to the implementation of adaptation strategies in the case study villages. Third, we explore the interaction of the different barriers and their cross-scale interactions. Finally, the policy implications of the findings for climate change adaptations and rural livelihoods in study villages and SSA more widely are outlined.

4.1. Adaptation strategies employed by households in case study villages

Table 2 gives that at the micro-level, households in the study villages employ several on-farm and off-adaptation strategies, including, but not limited to, livelihood diversification, crop diversification, labour migration, planting drought-tolerant crops and using irrigation. The results suggest that other key adaptation strategies include changing the timing of planting, as well as planting early maturing varieties of crops in an attempt to reduce the negative impacts of climate variability (particularly droughts) on

their livelihoods. Other households claimed that they reduce their food consumption as well as change their diets to cope with climate variability (Table 2). Though crop diversification has long since been the traditional norm for households, focus-group participants reported that it is assuming a greater significance as a climate adaptation strategy. These results compare favourably with those mentioned in the wider literature on climate change adaptations (see Bryan et al., 2009; Warner & Afifi, 2014). For instance, the use of irrigation facilities among smallholder farmers to reduce crop failure due to meteorological drought in northern Ghanaian dryland agricultural systems has been documented (see Laube, Schraven, & Awo, 2012). Studies have also shown that local farmers in SSA have rich and sophisticated agro-ecological knowledge useful for climate adaptation (Naess, 2013; Speranza, Kiteme, Ambenje, Wiesmann, & Makali, 2010). These adaptations are perceived to be successful as farming households have depended on them to withstand the adverse impacts of the climate on their livelihoods.

4.2. Lack of financial resources

To understand what restricts households from implementing adaptation strategies, research participants were asked to identify key barriers to climate adaptations within the study communities. The results of both the case study and systematic literature review suggest that financial barriers are key barriers that restrict implementation of adaptation strategies by households (Bryan et al., 2009; Kithiia, 2011). The majority (131 households; 97%) of households in the study villages cited a lack of financial resources as a serious barrier to climate change adaptations

Table 2. Adaptation strategies in the study villages and SSA more widely.

Adaptation strategies	Type of adaptation	Long term or short term	Proportion of households in study villages ^a	Documented examples from elsewhere SSA in the wider literature
Changing the timing of planting	On-farm adaptation	Long term	90 (122)	Bryan et al. (2009) (Ethiopia and South Africa) and Waha et al. (2012)
Planting early maturing crops	On-farm adaptation	Long term	52 (70)	Cavatassi, Lipper, and Narloch (2011) (Ethiopia)
Crop diversification	On-farm adaptation	Long term	90 (121)	Mary and Majule (2009) (Tanzania)
Planting drought-tolerant crops	On-farm adaptation	Long term	71 (96)	Stringer et al. (2009) (Malawi and Swaziland)
Using irrigation	On-farm adaptation	Long term	13 (18)	Laube et al. (2012) (Ghana)
Livelihood diversification	Off-farm adaptation	Long term	36 (48)	Newsham and Thomas (2011) (Namibia)
Relying on family and friends	Off-farm adaptation	Short term	45 (61)	Thomas, Twyman, Osbahr, and Hewitson (2007) (South Africa)
Using agro-ecological knowledge	Off-farm adaptation	Long term	72 (97)	Roncoli et al. (2002) (Burkina Faso) and Speranza et al. (2010) (Kenya)
Temporal migration	Off-farm adaptation	Short term	90 (122)	Wouterse and Taylor (2008) (Burkina Faso)
Changing diets	Off-farm adaptation	Short term	73 (98)	
Reducing food consumption	Off-farm adaptation	Short term	77 (104)	

Source: Modified from Antwi-Agyei, Stringer, and Dougill (2014).

^aNumbers in parentheses indicate counts of households and those not in parentheses are percentages.

Table 3. Barriers to climate adaptation identified in case study villages.

Barriers to adaptation	Proportion of households ^a	Documented examples from the wider literature	Adaptation strategies affected in case studies and the literature more widely
Financial barriers	97(131)	Bryan et al. (2009), Huang et al. (2011), Peterson (2013), Antwi-Agyei (2012) and Measham et al. (2011)	Planting trees, planting improved varieties of crops, diversification of livelihoods activities, changing the timing of planting
Socio-cultural barriers	26(35)	Jones and Boyd (2011), Nielsen and Rosenberg (2010), Adger et al. (2009), Adger et al. (2012) and Stafford-Smith et al. (2011)	Temporary migration, changing the timing of planting
Institutional barriers including political barrier	33(45)	Jantasami et al. (2010), Biesbroek et al. (2013), McNeeley (2012), Eriksen and Lind (2009), Sietz et al. (2011), Measham et al. (2011) and Ford et al. (2011)	Planting of improved varieties of crops, development of early warning systems, using irrigation systems
Lack of information on climate change characteristics	65(88)	Boyd et al. (2013), Measham et al. (2011) and Adger et al. (2009)	Changing the timing of planting, planting early maturing varieties, irrigation practices, development of early warning systems
Technological barriers	28(38)	Most studies relate technological barriers to development of early warning systems in SSA (Boyd et al., 2013) as well as technical expertise in climate research (see Washington et al., 2004)	Development of early warning systems, developing drought-tolerant crops
Lack of infrastructural development including ready markets	7(9)	This is related mostly to lack of resources to mitigate the adverse impacts of climate change and variability	Planting drought-tolerant crops, diversification of livelihoods and crops diversification

^aNumbers in parentheses indicate counts of households and those not in parentheses are percentages.

(Table 3). According to farmers, a lack of financial resources includes insufficient funds, lack of credit facilities, loans and subsidies. Focus-group participants also

reported that even when credit is available, they lack the necessary collateral to access it. They claimed that financial barriers prevented them from accessing improved varieties

of crops that can better adapt to climate change and variability and ensure food security at the household level.

The systematic literature review yielded 63 articles which were reduced to 18 articles following the exclusion criteria described in Table 1. The results of the systematic literature review show that financial barriers were reported by 69% of papers reviewed (Table 4). Every form of adaptation entails some direct or indirect financial costs. For instance, the use of improved varieties of crops including groundnut have been reported as a key adaptation strategy for farmers in northern Ghana (see Peterson, 2013). Such fast-growing groundnuts have kept farming households in northern Ghana afloat in the midst of chaotic rainfall patterns (Peterson, 2013). However, farmers in the study villages reported difficulties in accessing such improved varieties of groundnuts, as their price is prohibitive. Thus, these farmers have often sought to use their own saved seeds or alternatively purchase such seeds from the local markets.

4.3. Socio-cultural barriers

About 26% of the respondents described socio-cultural barriers such as belief systems and local norms as being a serious obstacle to adaptation. Strongly held beliefs, cultural practices and value systems and the worldviews of individuals or groups, greatly influence the way they perceive climate change, and thereby their subsequent adaptation strategies (Adger, Barnett, Brown, Marshall, & O'Brien, 2012; Jones & Boyd, 2011). For instance, women's focus-group participants reported that cultural norms sometimes may constrain female migration compared to male migration in the study villages. This

potentially limits the adaptation options available to such female farmers, with serious implications for household food security.

Culture is central to the decision to adapt and thus, the identification of risks and the subsequent implementation of appropriate adaptation strategies (Adger et al., 2012). The results of the case study resonate well with those of the systematic literature review. For example, the systematic literature review shows that cultural practices prevented the *Fulbe* in northern Burkina Faso from embracing livelihood diversification adaptations strategies such as development work, labour migration and gardening to reduce their vulnerability to drought. Contrary, their counterparts, the *Rimaibe*, have used labour migration and diversification of livelihoods as adaptation strategies (Nielsen & Reenberg, 2010).

4.4. Institutional barriers

Institutions play a crucial role in enhancing the capacity of local communities to cope with climate variability and providing mechanisms that help to shape the social and individual interactions within the society (Burch, 2010; Seitz et al., 2011). Table 3 presents that 33% of households reported that a lack of institutional capacity to facilitate agricultural adaptation served as an important barrier. The results of the systematic literature review also shows that institutional barriers are a key restriction on adaptation in the publications that were reviewed (Table 4). The systematic literature review shows that in Mozambique, Sietz et al. (2011) asserted that institutional barriers at the individual and organizational levels could influence the mainstreaming of adaptation strategies while many of these

Table 4. Textual analysis of selected publications from systematic literature review.

Article no.	Year	Main focus of article	Information barriers	Financial (economic) barriers	Institutional (political) barriers	Technical (human capital) barriers	Socio-cultural barriers	Other barriers
1	2010	Water management	X	X	X			
2	2011	Multiple	X		X			
3	2009	Water management			X			
4	2010	Multiple	X	X	X	X		
5	2008	Water management		X		X		
6	2009	Agriculture	X	X				X
7	2011	Multiple	X	X	X	X		
8	2011	Multiple	X	X	X	X		
9	2011	Agriculture			X	X		
10	2012	Agriculture		X	X			X
11	2007	Multiple		X	X	X		
12	2012	Agriculture		X				X
13	2010	Multiple					X	

Note: X indicates that the particular barrier was identified or highlighted in the article. The other barriers include the lack of access to land, market, etc.

institutional barriers are linked to formal political barriers (Eriksen & Lind, 2009; Pasquini et al., 2013).

Adaptation policies in Ghana, like many SSA countries, tend to be top-down, driven by the central government that has often constrained adaptive strategies at the regional and local levels. The extension officers of the Ghana's Ministry of Food and Agriculture are supposed to be the link between the scientific community and farmers by facilitating the flow of scientific ways of farming, including the adoption of innovative ways of farming, to farmers. However, key informants claimed that the extension officers are overwhelmed by the numbers of communities they serve, making it impossible to attend to the needs of all farmers. The lack of climate adaptation information including weak institutional capacity coupled with a lack of explicit policies on food security and the intra-annual rainfall variability and increased temperature, places food security in the study communities and in many other communities across SSA, under considerable stress. This has a significant impact on the livelihoods of marginalized households in dryland farming systems that are characterized by a high degree of rainfall variability.

4.5. Lack of information on climate change characteristics

About 65% of the study households perceived a lack of information on climate change characteristics as a barrier to successful adaptation. Focus-group participants reported that the lack of information on the onset and distribution of the rains during the farming season was a serious challenge to adaptation strategies, including changing the timing of planting and planting early maturing varieties of crops. The results indicate that the majority (62%) of households in the study depend on their own agro-ecological knowledge. Other sources of information included relying on family and friends (18%) and listening to local radios (15%). Few (5%) of the households in the study villages indicated obtaining climate information from extension officers. Even those relying on radio stations to source information on the weather and climate reported uncertainties about such information. The systematic literature review indicates that informational barriers have been given some prominence in climate change adaptation literature. For instance, 46% of the papers included in the review highlighted the extent to which informational barriers could influence the adaptation process in SSA (Table 4).

Access to information on climate change characteristics is a powerful tool that can be used to enhance the adoption and implementation of adaptation strategies by households in SSA. This is particularly important for Africa and Ghana in particular, where there are few climate projections due to a lack of appropriate climate data. This is crucially important considering that most farming systems in SSA depend

on rain-fed agricultural systems. Hence, a lack of appropriate climate information could be critical for food security. Many of the National Meteorological Agencies in SSA also rely on coarse model projections and limited meteorological information to provide forecast for farming operations. Therefore, the majority (62%) of the households in the study communities reported relying on their own agro-ecological knowledge, based on past experience. This knowledge allowed them to form complex mental models of the climate with which they forecast the weather, and on the basis of this pursued their farming operations. Yet, this body of knowledge is largely ignored in formal scientific adaptation assessments. With rainfall becoming more unpredictable across SSA, the extent to which local farmers could continue to rely on such knowledge is not entirely clear. This may have serious implications for sustaining households' food security and livelihood activities.

Even when climate information has been provided, it usually comes in the form of seasonal forecasts that may not be useful in long-term planning of agricultural activities. This has often contributed to food insecurity in many communities across SSA. Drought preparedness involves the development of emergency plan and early warning systems that have the capacity to provide real-time climate information to aid decision-making on drought (Boyd et al., 2013). The importance of providing early warning systems and climate risk information for drought mitigation has been acknowledged by major international conferences such as the World Summit on Sustainable Development as well as the Johannesburg Plan of Implementation of Agenda 21.

4.6. Technological barriers

Another 28% of the households identified technological barriers to the successful implementation of climate change adaptations (see Table 3). With regard to the systematic literature review, about 46% of the papers reviewed mentioned technological barriers as constraints to climate change adaptations in SSA. Households can only employ the adaptation tools and options that have been developed, and which are applicable in the local context. In characterizing adaptation to climate change in agriculture, Smit and Skinner (2002) identified technological developments as one of the four key agricultural adaptation pathways. Technological developments including the development of new crop varieties adapted to warmer climates, early warning systems, as well as the development of irrigation techniques, are critical to climate adaptations in the study communities and more widely. However, limited technological development in the study communities prevents households from having the full range of adaptation options that may be available in developed countries. This means that farming households need to rely on their

own indigenous technology in ensuring the availability of food and in reducing the impacts of climate change and variability on their livelihoods.

It is worthwhile to stress that technological options for climate adaptation are also implemented within appropriate socio-economic, legal and institutional framework (Klein et al., 2001), which most SSA countries tend to lack. The Africa climate report commissioned by the UK Government identified low technical expertise in climate modelling as one of the key challenges to climate change research in Africa (Washington, Harrison, Conway, and Black, 2004). Lack of technology operates at the community and regional levels and is also directly related to inadequate funding on agriculture and climate change research by governments across Africa (Enete & Amusa, 2010). As such, this demonstrates a close link between technological barriers and institutional barriers.

4.7. Lack of infrastructural development including readily available markets

Though related to agricultural development more widely, the lack of infrastructural development including readily available markets was identified by 7% of households in the study communities to constitute a major obstacle to the successful implementation of climate adaptation strategies. This barrier also restricted the planting of drought-tolerant crops and the diversification of crops. It was revealed through the systematic literature review that the lack of infrastructural development has not been given serious research attention (Table 4). A lack of markets is related to a lack of appropriate storage facilities for farm produce in the case study villages. Indeed, the lack of storage facilities weakens the bargaining power of the small-scale farmers when it comes to negotiating the prices of farm produce.

One key adaptation strategies for smallholder farmers in dryland farming systems in SSA is the use of drought-tolerant crops. In this regard, the virtues of cassava (*Manihot esculenta*) as an answer to climate change adaptation in Africa have been documented (see Jarvis, Ramirez-Villegas, Campo, & Navarro-Racines, 2012). Despite its potential as a drought-tolerant crop, in Ghana there are difficulties in selling cassava compared to more culturally appealing crops, such as maize, millet and sorghum. The lack of ready markets as a barrier to climate adaptation is, perhaps, fully appreciated when it is related to the obligation of households to fulfil their credit repayments. If households are not able to get good prices for their produce, they will not be able to repay their loans and this will have serious implications for their ability to contract future loans to implement adaptation strategies. This demonstrates a link between infrastructural barriers and financial barriers.

5. Understanding the interactions among different adaptation barriers

It is significant to stress that the barriers outlined above do not act in isolation but rather interact at different levels to inflict enormous damage on the livelihoods of households in the study communities. For instance, the lack of appropriate information on climate change characteristics are related to the lack of national and district level infrastructural development, such as the lack of adequate and state-of-the-art equipment within meteorological departments across this region. This prevents the timely prediction and forecast of rainfall patterns that could enable farmers to make informed decisions at the local level. Technological barriers and infrastructural barriers including the lack of state-of-the-art early warning systems are also directly linked to financial barriers reported by the majority of the farming households in the study villages, a point also highlighted from the systematic literature review.

Weak institutional structures may also be related to technological barriers including lack of human capital to properly tackle issues related to climate change adaptations. Socio-cultural barriers are also linked to the extent of formal and informal institutions within the community. There is a close link between institutional barriers and a lack of information on climate change characteristics. For example, in Ghana, even when information on climate change characteristics exists, getting this to the local farmers for their farming activities may be problematic due to poor coordination among the various institutions involved in climate adaptations. In this regard, there is the need for close collaboration between the meteorological services and other agencies such as extension services for forecasts to be made available for agricultural adaptations.

Different barriers to climate adaptation may operate at different levels and phases of the adaptation process. For example, financial barriers operate at the household level. Even within the same community, households may experience differential levels of financial difficulties that may reflect the extent of their climate vulnerabilities. For instance, the four households that did not report lack of financial resource as barrier to adaptation were all households considered rich by the local communities. In contrast, socio-cultural barriers largely operate at the community level and help in understanding the kind of values cherished by these communities and how such communities are structured. Societal norms and beliefs systems constrain the behaviour of individuals within the community and therefore irrespective of whether a household is confronted with financial barrier or not, such households cannot be excluded from societal norms. Socio-cultural barriers may arise in early stages of the adaptation process, where there is a need for an understanding of the necessity to implement adaptation actions. Other barriers such as technological and financial barriers tend to operate during the

implementation stages of adaptation process (Matasci et al., 2013).

The interactions of these barriers and their operation at different phases of the adaptation process may have significant implications for climate adaptation, food security and related rural livelihoods in these study villages and more broadly in SSA. The risks presented by climate change to the livelihoods of these households are set to increase (IPCC, 2014), yet the mechanisms needed to reduce this risk are not fully supported. Farming households in the study communities rely predominantly on rain-fed agriculture for their livelihoods and, therefore, any threat to farming poses significant challenge to the sustainability of food security. Hence, it is important that efforts from policy-makers in addressing these barriers are co-ordinated in a way that help overcome many of these interrelated climate adaptation barriers.

6. Policy implications and ways forward

Climate change poses complex problems to households in the study villages at different levels and using a two-stage methodology – participatory case study and systematic literature review – provides a significantly better exploration of the issues involved in barriers to climate change adaptation. This paper has provided a nuanced understanding of the key barriers by demonstrating that households in the case study villages and SSA more widely are confronted by several factors that restrict the implementation of adaptation strategies. Key barriers identified include a lack of financial resources, socio-cultural barriers, institutional barriers, as well as lack of information on climate change characteristics. Others include technological barriers and lack of infrastructural development, including a lack of readily available markets. These barriers act interdependently to restrict the ability of households to adapt to climate change and variability. This could have significant implications for household's food security and other related livelihoods.

Policy-makers need to devise a holistic and coordinated approach in dealing with these barriers. For instance, governments across SSA and the international donor community are encouraged to invest in early warning systems on drought and floods to aid farmers in planning their farming operations. Effective communication of information on climate adaptation is known to be essential for adaptation by households as communication increases understanding and awareness (Moser, 2010). In this regard, appropriate communication mechanisms including the use of local radio stations broadcasting in local dialect and linking improved forecasting abilities with traditional agro-ecological knowledge could be used to ensure that such climate information and warnings reach the intended farmers in a form that they understand and to which they can relate. This could help reduce some of the

local uncertainties linked to forecasts based on science alone.

Climate adaptations are not undertaken in a 'stand-alone fashion' but rather within the prevailing societal norms and cultural practices (Adger et al., 2012). Therefore, adaptation practices should take cognizance of these cultural norms and belief systems in order to increase their appeal and acceptance by the local community. It is recommended that local indigenous knowledge on climate adaptations should be synthesized. Rural households in dryland farming systems in Africa have used their local knowledge to develop coping strategies to buffer against risk and uncertainties in the weather (Roncoli, Ingram, & Kirshen, 2002). Therefore, policy-makers and other stakeholders need to consider, and appropriately integrate, local indigenous agro-ecological knowledge with scientific climate assessments in the design and implementation of climate adaptation strategies. In this regard, environmental education aimed at creating awareness of the changing climate patterns and the associated adverse effects on the livelihoods of many agriculture-dependent communities should be more vigorously promoted. Education could also help to build local confidence in climate information provided in radio broadcasts.

Although the agricultural sector is considered to be the most vulnerable to the adverse impacts of climate change in SSA (IPCC, 2014; Schlenker & Lobell, 2010), the results of the systematic literature review shows that little research attention has been given to the specific barriers to agricultural adaptations to climate change in SSA. The majority of the reviewed publications focused on multiple sectors (Table 4). Hence, it is suggested that barriers to climate change adaptations in agricultural systems should be given greater research attention. While this may still require consideration of other sectors outside of agriculture, by prioritizing agriculture and placing it at the centre of research and analyses, it improves the chances of agricultural barriers being overcome.

The role of extension services in agricultural adaptation to climate change has been documented in many areas across SSA (Mustapha, Undiandeye, & Gwary, 2012). Efforts should be made by policy-makers to improve farming practices by strengthening the capacity of extension officers through increased staff numbers and training of staff with different specialisms linked to different crops, especially staple crops such as maize, rice, sorghum and millet that hold great prospect for food security in Ghana and SSA more widely.

7. Conclusion

This paper has contributed to the academic discourse on climate adaptations by providing empirical evidence to deepen our understanding of the barriers that confront small-scale farmers in their attempt to implement

appropriate adaptation strategies to manage the negative impacts of climate change and variability. It has also highlighted some of the interactions between barriers across levels, offering ways forward as to how those barriers could be tackled. Many of the barriers identified in our study villages relate to those mentioned in the systematic literature review on barriers to climate change adaptations in SSA. Nonetheless, given the socio-economic and political contexts and the current developmental challenges confronting Ghana and many across SSA, we acknowledge that these policy recommendations will be implemented within constrained resource environments and that addressing the task in hand is not going to be straightforward. For instance, the implementation of most of these policy recommendations requires significant financial investments. We also take cognizance of the fact that climate change adaptations have to compete for funding against service delivery provision at the local, regional and national levels. It is therefore envisaged that serious and concerted efforts will be needed on the part of policy-makers to address barriers to successful implementation of climate adaptations.

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