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The adaptive capacity of smallholder farmers to climate change in the Northern Region of Ghana

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ABSTRACT

Climate change is expected to adversely affect agricultural production, particularly in sub-Saharan Africa where the agricultural sector forms the backbone of most countries' economies. This thus holds true for the agriculture sector of the Northern Region of Ghana which is largely rain-fed and dominated by smallholder farmers with minimal livelihood alternatives. The main research question of this paper is how the adaptive capacity to climate change of smallholder farmers in the Northern Region of Ghana can be characterised? The paper proposes an indicator-based framework for assessing the adaptive capacity of smallholder farmers in the Northern Region of Ghana along six main determinants of adaptive capacity: economic resources, social capital, awareness and training, technology, infrastructure and institutions. Based on a thorough literature review and qualitative interviews with experts for rural livelihoods and agriculture in the study region, the determinants were ranked and three to five indicators per determinant were selected. The results of the expert interviews show that economic resources, awareness and training as well as technological capacities seem most relevant for smallholder farmers' adaptive capacity while infrastructure, social capital, and institutions were ranked least important. The study operationalized the indicators in a standardized survey questionnaire and tested it in two agrarian communities in the Northern Region of Ghana. The survey results show the aggregate adaptive capacity of respondents is low. However, disparities in adaptive capacity were recorded among respondents in terms of gender and education. Differentiating between the determinants women farmer show significantly lower capacities in fields of economic resources, technology and knowledge and awareness. This paper recommends resilience building interventions in the study area that target individuals with low adaptive capacities, especially women and farmers without formal education.

1. Introduction

Over the past few decades, climate change has adversely affected both physical and biological systems in most continents across the globe (Rosenzweig et al., 2007). According to Porter et al. (2014), in the past 30 years climate change has contributed to global agricultural production declining by 1–5% per decade. Its effects are also predicted to manifest in severe consequences for the global agricultural sector, especially in tropical and sub-tropical regions (Dewi, 2009; Thornton, 2012).

Where the economies of a majority of countries are largely driven by the agricultural sector, such as in sub-Saharan Africa, the impacts of climate change are particularly severe. The rapid and uncertain changes in temperature and rainfall

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pattern in the subcontinent deepens the vulnerability of the agricultural systems, especially food production already today (AGRA, 2014). This trend is expected to intensify in the future with the predicted climate change in tropical regions as it is expected to cause a significant decline in the production of important and staple food crops in such regions (Nelson et al., 2009; Porter et al., 2014). In response to expected changes, governments supported by international cooperation have intensified their efforts to empower the agricultural sector to effectively adapt to climate change at both national and local levels.

This holds particularly true for the Northern region of Ghana, one of the driest savannah regions of Ghana, where an increasing number of droughts, floods and bushfires heavily affect nature and humans (Dazé, 2013; Akudugu and Alhassan, 2012). It is found to be one of the most vulnerable and exposed regions to climate change and variability in Ghana (Etwire et al., 2013; Stanturf et al., 2011). At the receiving end of these impacts are millions of poor smallholder farmers with minimal livelihood alternatives who are already marginalised, poor and largely rely on nature for food and income (Frank and Penrose Buckley, 2012; Morton, 2007). Their rain-fed agriculture, forming the dominant economic activity in the region (Antwi-Agyei et al., 2012), relies heavily on a single and already modified rainy season. Over the past decade, there have been growing number of studies on possible ways of increasing the resilience of these farmers against climate change impacts in the region. Most of these studies are largely centred on farm-level adaptation methods and strategies (Wossen et al., 2014; Al-Hassan et al., 2013; Kuwornu et al., 2013; Laube et al., 2012; Armah et al., 2011). There are only a few studies on the adaptive capacity of smallholder farmers towards the new climate variabilities in the region (Nantui et al., 2012). However, knowing who among those we expect to be the most vulnerable to climate change have a higher respective lower adaptive capacity to climate change and what the relevant determinants for these capacities are provides a basis to find more effective ways for supporting smallholder farmers in the Northern region of Ghana in their attempt to sustain their agricultural production and consequently the basis of their livelihoods and urban centres in the region. Therefore, the adaptive capacity assessments bring to the decision table fundamental information for the development of climate change adaptation policy (Adger et al., 2007; Juhola and Kruse, 2015). Thus, specific assessments focussing on the adaptive capacities of smallholder farmers deliver critical information in relation to key strengths and weaknesses and help to inform policy development and interventions on climate change adaptation.

Against this backdrop, this paper fills a fundamental knowledge gap related to a comprehensive and applicable framework for assessing the adaptive capacity of smallholder farmers in context Sub-saharan Africa. It also applies the framework to the case of the Northern region of Ghana to explore the adaptive capacity of smallholder farmers to climate change and variability.

This paper answers the following research questions:

- How can the adaptive capacity of smallholder farmers in the Northern region of Ghana be characterised?
- What is the capacity level of smallholder farmers in the Northern region of Ghana to adapt to climate change and which are the specific determinants of higher or lower adaptive capacities?

To answer these questions we developed an indicator framework in a deductive and expert-driven way: a heuristic was developed grounded on a systematic review of scientific literature considering both previous approaches assessing generic adaptive capacity, specific adaptive capacity of farmers with particular focus on smallholder farmers as well as approaches focussing particularly on sub-Saharan Africa. Before applying the indicator based assessment to two communities in Northern Ghana, this deductive heuristic has been validated by expert interviews. The outcomes of this study are twofold: first, we developed a sector and region specific index for assessing the adaptive capacity of smallholder farmers in sub-Saharan context; and second, we explored the adaptive capacity of smallholder farmers in two rural communities in Northern Ghana and provide insights in the specific capacities' determinants and options for capacity building for smallholder farmers.

This paper is composed of six sections. The second section reviews literature on key concepts related to assessing adaptive capacity. The third section looks at the background of the study area and methods employed in collecting and analysing the data. Section four presents the developed Smallholder Farmers' Adaptive Capacity Index that has been revalidated by expert interviews. Section five includes results from the application of the developed indicator in the study area. The last section discusses the findings of this paper in the light of existing literature and presents a conclusive overview of the paper with recommendations for capacity building and further research.

2. Assessing adaptive capacity

The concept of adaptive capacity has been used differently in varying contexts. One of the most recently used definition in relation to climate change is taken from the Fifth Assessment Report of IPCC which defines it as "The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC, 2014. p118). The concept of adaptive capacity is highly used in relation to the vulnerability of socio-ecological systems. Vulnerability in this sense is often conceptualised as being composed of the exposure and sensitivity of a system to external stresses and the adaptive capacity (McCarthy et al., 2001; Adger, 2006; Smit and Wandel, 2006) or the coping capacity of the system to such stresses (Turner et al., 2003). The concepts of 'adaptive capacity' and 'coping capacity' are respectively used to denote long-term and short-term adjustments (Smit and Wandel, 2006; Gallopín, 2006).

The adaptive capacity of a system is determined by an array of factors which are neither independent nor mutually exclusive but a result of a combination of these factors (McCarthy et al., 2001). However, much of its current determinants are driven from vulnerability research. In the fourth assessment report of the IPCC, Adger et al. (2007) identified two dimensions of what constitutes adaptive capacity, namely, the generic and impact-specific dimensions. While the generic dimension of adaptive capacity looks at the ability of the system to respond to the general climate change stimuli, the impact-specific dimension by its name denotes the ability of the system to respond to a particular climate change stimulus. As a third dimension Schneiderbauer et al. (2013) proposed the sector-specific dimension of adaptive capacity, which is related to the capacity of a particular economic sector within a model region to adapt to the general impacts of climate change.

Generic adaptive capacity of a system is determined by factors that influence the functioning of the system. Some studies have identified economic development, education, technology, knowledge, infrastructure, institutions, equity and social capital as generic determinants of adaptive capacity (Adger et al., 2007; Jones et al., 2010; Kruse et al., 2013). Brooks and Adger (2005) also classify what determines the capacity of socio-ecological systems to adapt based on whether the factors are internal or external to the capacity of the system; these factors are also predetermined by the scale of analysis. Some determinants of adaptive capacity are also scale-specific and at the local level the capacity to undertake adaptation is influenced by factors such as managerial ability; access to financial, technological and information resources; infrastructure; the institutional environment within which adaptations take place; political influence and kinship networks (Smit and Wandel, 2006).

When assessing sector-specific adaptive capacity of smallholder farmers, social capital tends to determine the ability of local farmers to access labour resources. According to Yaro et al. (2015) this is directly linked to the farmers' capacity to cope or adapt to climate change stresses. In relation to farmers at the local level, Asante et al. (2009) and Nakuja et al. (2012) assessed their adaptive capacities by using attributes such as knowledge, use, availability, accessibility and consultation. According to Defiesta and Rapera (2014) indicators used in recent times are largely based on the Sustainable Livelihood Framework which comprises five assets categories - human, social, natural, physical and financial capital – from which livelihoods of people are built (Serrat, 2010).

Adaptive capacity at various contexts and spatial scales is assessed using the indicators of its determinants. Some of the indicators used in assessing adaptive capacity are regional, local or sector-specific. Therefore, the construction and replication of such indicators in other spatial contexts is critical and needs to be adjusted to the specific spatial and societal context (Wall and Marzall, 2006). Therefore, to develop an indicator-based assessment of the adaptive capacity of smallholder farmers in the Northern Region of Ghana, this study developed a sector and region-specific assessment designed with indicators adjusted for small-scale agriculture in Sub-Saharan Africa taking into account the regional, socio-economic and cultural context of the Northern Region of Ghana. It also calculated adaptive capacity using a composite index approach which has been applied in previous adaptive capacity assessments at the local level (Defiesta and Rapera, 2014; Nelson et al., 2010; Cuesta and Rañola, 2009).

3. Materials and methods

3.1. The study area

The Northern region of Ghana, which is the largest administrative region in Ghana in terms of land mass, occupies an area of 70,384 km^2. With an aggregate population of almost 2.5 million inhabitants, the region is comprised of 26 districts (Ghana Statistical Service, 2013). It is located in the Guinea Savannah ecological zone of Ghana which is largely characterised by a stretch of lowland and grassland. The region has a relatively dry climate characterised by a single rainy season that begins in May and ends in October with an annual rainfall that ranges between 750 mm and 1050 mm (Ghana Statistical Service, 2013). The annual mean temperature ranges between 22.4 °C and 33.9 °C (Acheampong et al., 2014). The region is characterised by a prolonged dry season between November and March/April.

Climate change and its impacts, such as recurring floods, drought and frequent bush fires are common in the Northern region of Ghana (Darko and Atazona, 2013; Asante and Amuakwa-Mensah, 2014). Over the period between 1960 and 2010, the observed rise in minimum temperature in the northern Savannah ecological zones of Ghana was estimated at 3.7%. Over the same period, a decrease of 120 mm in annual mean precipitation was also observed in the Guinea Savannah ecological zone in which the Northern Region is located (Environmental Protection Agency, 2015). The region is said to be one of the highly vulnerable regions to climate change in Ghana, both ecologically and socially, and the vulnerability is intensified by other biophysical and human-related issues in the region such as deforestation, overgrazing and human-induced bush fires (Stanturf et al., 2011).

Agriculture is the main economic activity of the Northern Region and it is done mostly on subsistent basis. The agricultural sector, which is predominantly rain-fed, employs about 74% of the working population in the region (Ghana Statistical Service, 2013). For our research question, we chose West Mamprusi district because, according to Stanturf et al. (2011), it is one of the most socially vulnerable districts to climate change in the Northern Region of Ghana. According to the Ghana Statistical Service (2013), agriculture employs 78% of the working population of the district which is similar to the overall region's average of 74%.

With a population of about 120,000 inhabitants, the West Mamprusi district is one of the 26 districts in the Northern Region of Ghana. About 63% of the population in the district live in rural areas and 85.5% of households depend on agriculture as main economic activity (Ghana Statistical Service, 2013). Crop production, which is largely rainfall dependent, dominates other forms of agricultural production. Hjelm and Dasori (2013) reports that, 99.1% of farming households in the district depend on rain-fed agriculture.

3.2. Research methods

3.2.1. Data collection

For developing a sectoral and regionally specific indicator based framework for assessing the adaptive capacity of smallholder farmers and for its application in West Mamprusi, data was gathered from both secondary and primary sources. Grounded on a systematic review of scientific literature, a heuristic framework of determinants and related indicators for assessing the adaptive capacity of smallholder farmers was developed.

The systematic literature review was realized using 'Web of Knowledge' and 'Google Scholar' to explore available research from 1990 to 2015 using the search strings "TITLE: (adaptive capacity) AND TOPIC: (smallholder farmers OR agriculture OR smallholders OR farming OR farmers)" and "allintitle: "adaptive capacity AND smallholder farmers OR farmers OR smallholders OR agriculture OR farming". Combining the two search engines enhanced the inclusion of both indexed and grey literature. The inclusion criteria was based on relevance and study cases with socioeconomic and political conditions similar to Ghana. The number of articles reviewed was 51 comprising 23 out of 63 articles from 'Google scholar' and 28 out of 51 articles from web of Knowledge.

The primary data on the other hand, was obtained in two consecutive phases of data collection. The first phase involved a determinants ranking and indicator selection process. Expert interviews were used in ranking the determinants of adaptive capacity and selecting their respective indicators. Through a thorough review of the websites of the Agriculture and Food Ministry of Ghana, and projects and initiatives geared towards agriculture, food security and climate change in the study region, ten experts were identified. Six of the experts were successfully contacted and interviewed through mobile phone using a semi-structured interview guide between August and September 2015 (see Appendix A for profiles of interviewees). The ranking exercise involved the use of pen and a piece of paper by an interviewee to arrange and score the determinants in order of importance to the adaptive capacity of smallholder farmers (c.f. Section 4.2). The results from the interviews were then used to finalise the Smallholder Farmers' Adaptive Capacity Framework.

For the application of the framework in West Mamprusi in the second phase of the research, a structured questionnaire was developed based on the indicators selected from the expert interviews. The survey questionnaire was then administered to smallholder farmers between September and October 2015 to solicit primary data from the study region. For the survey, two agrarian communities Bugiya Pala (population: 1663, No. of households: 174) and Zangum (population 2191, No. of households 234) were purposefully selected from the district based on the fact that they have similar physical, socioeconomic and political characteristics (Ghana Statistical Service, 2014; cf. Fig. 1). These communities had not been piloted for any climate change adaptation project at the time of the study. This sampling criterion ensures that data acquired from the field are relatively free from the impacts of capacity development projects.

The sample size was 80[1] and the target population was smallholder farmers who were identified using a stratified sampling technique. The stratification process was based on two criteria, namely: farm size and gender. The farm size was used here to identify smallholder farmers based on the criterion of Wiggins (2009). According to Wiggins (2009), a smallholder farmer represents a farmer with a farm size of at most two hectares. The gender stratification criterion was also based on the gender distribution of each of the communities using the 2010 Population and Housing Census of Ghana data for the West Mamprusi district (Ghana Statistical Service, 2014). Due to a lack of statistical data on smallholder farming in the communities as well as in the district we used the snowball principle as non-probabilistic sampling technique. We started the sampling with the community leaders of the two test case communities that were contacted as a community entry point and passed on first contacts to farmers holding less than two hectares. Through the entry point in each community, a first sample of 10 farmers was identified. Each respondent in the initial sample then identified a farmer for the next sample, and this process was repeated until the fourth sample of farmers was identified. This sampling technique might have led to a bias where initial informants have a high impact on the sample. This bias was intended to compensate by using several diverse initial informants in each community.

Following the principle of the "informed consent", the survey participants were informed about the anonymised use of the survey results and the protection of privacy. For the expert interviews, the names of the organisations of the expert interviewees were anonymised to protect the respondent's confidentiality.

3.2.2. Data analysis

The expert interviews were recorded, transcribed and coded in order to rank the developed sector specific indicators. The data from the survey questionnaire was coded, inputted and analysed using SPSS and Microsoft Office Excel. The data generated were then used to estimate the adaptive capacity of smallholder farmers in the region by applying the developed

[1] The target population was estimated to be 300. The sample size was calculated based on a tolerable sampling error of 7% and error probability of 10%.

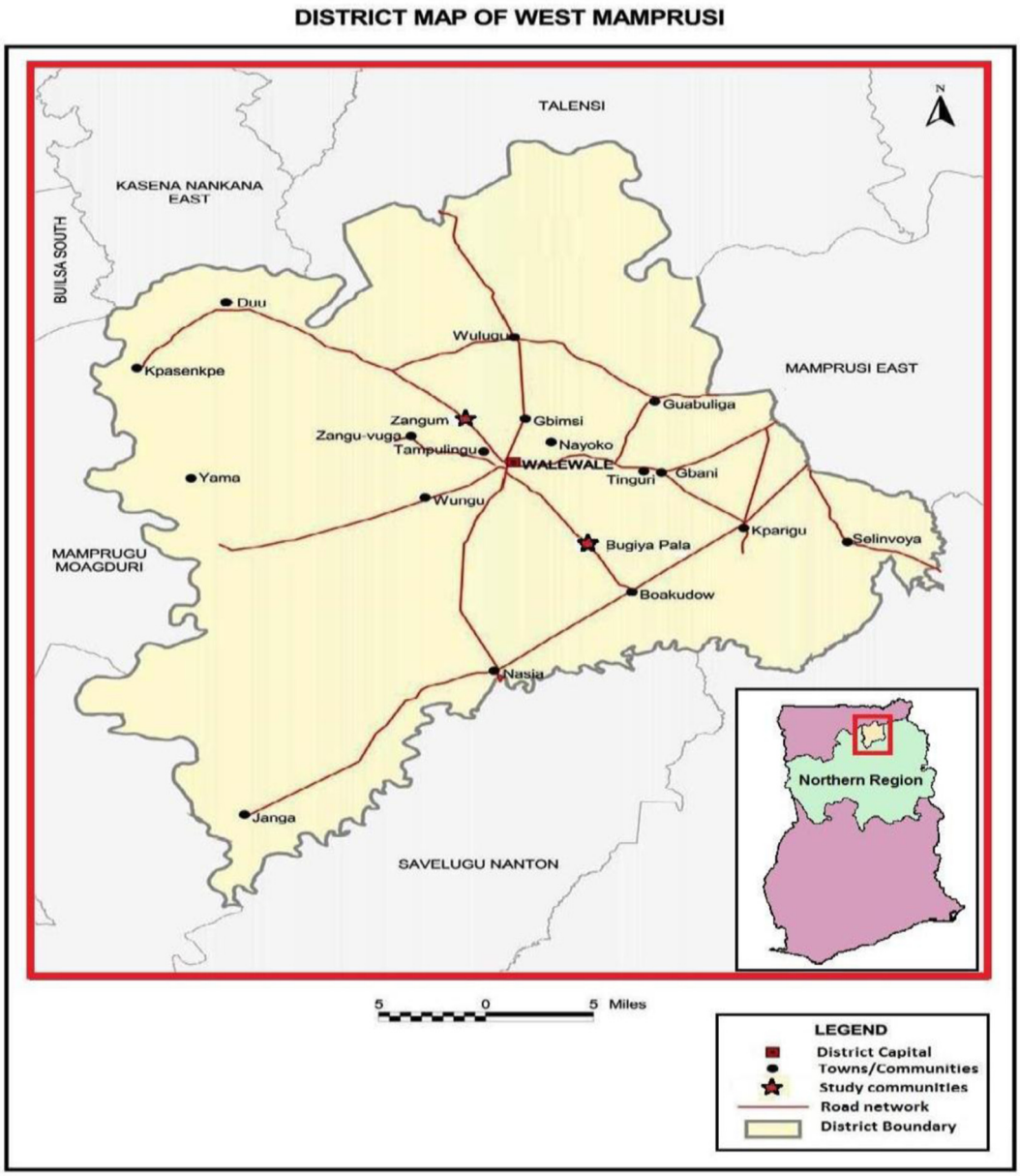

Fig. 1. Map of the West Mamprusi district in the Northern Region of Ghana (Source: modified from Ghana Statistical Service (2014)).

index (cf. Section 4.3). Cross-tabulations and descriptive statistics were run, and cross-tables, frequencies, means and percentages were used to display the results of SFACI. T-test was also run to display statistical differences in SFACI scores in relation to gender.

4. Design and validation of the smallholder farmers' adaptive capacity index

4.1. Indicators of smallholder farmers' adaptive capacity

In the first phase of the empirical study, the Smallholder Farmers' Adaptive Capacity Framework that has been developed from scientific literature (c.f. Section 2) and adaptive capacity was characterised using six determinants of adaptive capacity and their respective sets of indicators some of which are generic regardless of context and others that apply to the specific context of smallholder agriculture in sub-Saharan Africa. The determinants of adaptive capacity, their sets of indicators and their respective assumptions are illustrated in table 1.

Table 1
Determinants of adaptive capacity of smallholder farmers in the Northern Region of Ghana, specific indicators and the related assumptions.

Determinant of adaptive capacity	Indicators	Source of indicator	Indicator Assumptions/relevance
Economic resources (D_1)	Diversity of source of income, **(I 1.1)**	Armah et al. (2010): Defiesta and Rapera (2014)	A farmer with more diverse sources of income has a higher adaptive capacity than a farmer with less diverse sources of income
	Remittance **(I 1.2)**	Defiesta and Rapera (2014)	Remittances farmers receive play an important role in enhancing their capacity to adapt to climate change
	Access to credit **(I 1.3)**	Frank and Penrose Buckley, (2012): Defiesta and Rapera (2014)	Farmers with access to credit are more economically able to adapt to climate change than those with less access to credit
Social capital (D_2)	Access to family/household labour **(I 2.1)**	Eakin et al. (2011), Ibrahim (2014)	More access to family/household labour enhances the social capital of the farmers
	Participation in farmer-based organisations **(I 2.2)**	Egyir et al. (2015)	Participation in farmer-based organisations enhances social networking and increases social capital
	Participation in GBO **(I 2.3)**	Frank and Penrose Buckley, (2012)	Participation in gender-based organisation enhances social networking and increases social capital
	Participation in RBO **(I 2.4)**	Interviewee 5	Participation in religious-based organisation enhances social networking and increases social capital
	Participation in other organisation **(I 2.5)**	Interviewee 4	Participation in others organisations excluding the above mentioned types of community organisations could enhance social networking and increases social capital.
Awareness and training (D_3)	Acceptance of climate change **(I 3.1)**	Interviewee 4	Acceptance of climate change and the need to adapt is an important step to adapting to climate change and thus enhances adaptive capacity
	Level of literacy **(I 3.2)**	Deressa et al. (2008)	Level of literacy is positively correlated with adaptive capacity: in that, farmers with higher levels of education have increased potential to accept and adapt to climate change than those with lower level of education
	Access to climate information **(I 3.3)**	Lo and Emmanuel (2013)	Access to climate information increases adaptive capacity. This implies that farmers with greater access to climate information are more prepared to adapt to climate change than those with less access to such information.
	Farming experience **(I 3.4)**	Defiesta and Rapera (2014)	The number of years of experience in farming is highly correlated with the level of knowledge and skill related to adapting to climate change and climate variability using technology
	Access to extension service **(I 3.5)**	Frank and Penrose Buckley (2012)	Access to agricultural extension services enhances farmers' knowledge and skills in climate change and adaptation related practices and technologies
Technology (D_4)	Knowledge of seed varieties **(I 4.1)**	Mabe et al., 2012	Farmers with more knowledge on seed varieties stand a better chance of adopting climate resilient varieties than those with less knowledge.
	Knowledge of soil moisture retention techniques **(I 4.2)**	Frank and Penrose Buckley (2012)	Knowledge of soil moisture retention techniques increases the propensity to adopt such technologies in times of droughts
	Knowledge of soil fertility retention techniques **(I 4.3)**	David et al. (2013)	Farmers with more knowledge of soil fertility retention techniques are more capable of adapting to adverse impacts of climate change such as soil erosion than those with less knowledge of such technologies
Infrastructure (D_5)	Land holding size **(I 5.1)**	Defiesta and Rapera (2014)	Farmers with large landholdings stand a better chance of diversifying their farming practice to adapt to climate change than those with small landholdings
	Irrigation infrastructure **(I 5.2)**	Eakin et al. (2011): Aase et al. (2013): Egyir et al. (2015)	Farmers with access to irrigation infrastructure have greater capacity to adapt to drought than those with no access to irrigation infrastructure
	Access to roads **(I 5.3)**	Byrne (2014): Egyir et al. (2015)	Access to good road network enhances farmers' capacity to access markets for both their input and output. Therefore, the increasing distance of the farm to good roads is inversely related to the infrastructural capacity to adapt to climate change
Institutions (D_6)	Land tenure arrangement **(I 6.1)**	Jones et al. (2010)	The length and type of land tenure arrangement influences the farmer's preparedness to apply adaptation technologies. Long or reliable tenure arrangements create a more conducive environment for adaptation than short tenure or less reliable tenure arrangements
	Government subsidy **(I 6.2)**	Defiesta and Rapera (2014)	Farmers with access to government subsidies for agriculture input are more resilient to climate change than those with no access to government subsidy
	Disaster relief assistance **(I 6.3)**	Respondent 4	More access to disaster relief assistance enhances adaptive capacity in times of climate shocks and disturbances

Table 2
The ranking scores of the determinants of smallholder farmers adaptive capacity framework and exemplifying experts' judgements.

Determinant	Ranking score	Quote exemplifying the judgement of the determinant by interviewed experts
Economic resources (D_1)	*22*	*"... the economic resource capacity of the peasant farmer is very crucial in determining what he or she can really do on the farm...I see it to be the engine of the overall capacity of the farmer since most adaptation efforts on the field depend on the financial resources at the farmer's disposal."* Interviewee 1
Social capital (D_2)	12	*"... the community networks and social relations are necessary in building the adaptive capacity of people since for instance social relations that enable people to assist and support each other in times of disaster are very necessary in the community."* Interviewee 5
Awareness and training (D_3)	*20*	*"...awareness and training broadly embodies sensitization and skills acquisition. It is highly crucial to farmers' adaptive capacity since it provides them with information related to access to input and other things that can support them in their farming activities... The use of appropriate technology in climate change adaptation also requires some requisite training and education."* Interviewee 2
Technology (D_4)	*15*	*"...technology is important in assessing farmers' adaptive capacity. It encompasses technologies which are appropriate to the farmer's setting. Such technologies should embrace farmer's already existing knowledge, skills and the technologies that are relevant to climate change adaptation..."* Interviewee 6
Infrastructure (D_5)	*18*	*"...access to infrastructure such as roads is important to the farmer's adaptive capacity... their climate change adaption efforts will be in vain if they are not able to access roads to send their farm produce home or to the market."* Interviewee 3
Institutions (D_6)	*13*	*"Institutional arrangements play a critical role in adaptive capacity assessment and resilience building because adaptation is a collective effort... The capacity to adapt to climate change depends on critical and integrated institutional arrangements right from the community to the national level which interdependently provide the right support to farmers to plan and implement on-farm adaptation activities." Interviewee 5*

4.2. Ranking of determinants and selection of indicators of SFACI

The six determinants of adaptive capacity and their respective sets of indicators were then presented and discussed with Ghanaian experts from the field of agriculture, food security and climate change. The ranking technique[2] of Fabbris (2013) was applied to rank the various determinants of adaptive capacity in order of importance for the capacity of the farmer to adapt to climate change. Using data from the experts' ratings, each of the determinants of adaptive capacity were ranked and proportioned relative to an assumed maximum/total Adaptive Capacity score of 100. The Ranking(R) score for each determinant was therefore determined by the average of the ranking scores assigned to it by all the experts.

The average of the ranking scores for each determinant by the interviewed experts shows that economic resources (D1) are considered most important, with a ranking score of 22 out of 100. Awareness and training (D3) was second, with 20 out of 100, technology (D4) third with 18 out of 100. Infrastructure (D5) fell in the middle range with 15 out of 100. Ranking as less important determinants were institutions (D6) with 13 out of 100 and social capital (D2) with 12 out of 100 (cf. Table 2 with exemplifying specification from the expert interviews). The ranking scores were incorporated in the calculation of the Smallholder Farmers' Adaptive Capacity Index (SFACI) (cf. Section 4.3).

The indicators were appraised by interviewees using a scale of 0 to 5 (0 = Not Useful, 2.5 = Useful and 5 = Highly useful) based on their usefulness to assess the capacities of the respective determinants of SFACI in the context of smallholder farmers in the Northern region of Ghana. Indicators which obtained average scores of at least 2.5 were selected. Grounded on the experts' appraisal and the indicators selection criteria just described, all our proposed indicators and some of those proposed by the experts were considered useful to evaluate the determinants of SFACI (cf. Table 3 with exemplifying specification from the expert interviews).

4.3. Calculating the Smallholder Farmers' Adaptive Capacity Index (SFACI)

The administered survey questionnaires were scored (based on the scoring criterion on Appendix B) and a composite index approach used to characterise the Smallholder Farmers' Adaptive Capacity Index (SFACI) score for each respondent. The SFACI score for each respondent was characterised in three stages of estimations: calculation of the score for each indicator; calculation of the capacity score for each determinant; and calculation of the SFACI.

Firstly, the Indicator (*I*) score for each of the indicators was determined by aggregating the scores of responses under each indicator relative to a Likert scale of 0–5: where the highest *I* score is 5 and the lowest *I* score is 0. Therefore, the proportion of *I* score to *5* (the maximum *I* score on the Likert scale) is equated to the proportion of the *cumulative response score* to the *maximum cumulative response score*. This is illustrated by Eq. (1) below.

Equation 1: Calculation of the indicator score I (Source: own formulation)

$$\mathbf{I} = (\boldsymbol{Cumulative\ response\ score}/\boldsymbol{Maximum\ response\ score}) \times 5$$

[2] The ranking technique of Fabbris (2013) involves putting a set of items in an order of relevance, from the most relevant to the least relevant item based on an underlying construct.

Table 3
Indicators of smallholder farmers' adaptive capacity framework with exemplifying expert judgements.

	Indicators	Comments of experts/interviewees
Economic resources (D_1)	Diversity of source of income, **(I 1.1)**	"*It forms a master piece of what the farmer can do in this era of climate change and degrading soils. Once the farmer is able to harness financial credit from more formal sources, he/she is able to access essential input like fertiliser and improved seeds, as well as ploughing services.*"(Interviewee 6)
	Remittance **(I 1.2)**	"*…the financial capacity of some farming households is highly linked with the frequency at which they receive such remittances.*" (Interviewee 2)
	Access to credit **(I 1.3)**	"*Farmers who engage in other occupations such as petty trading are more likely to withstand farming related climate shocks than those with no livelihood alternatives*". (Interviewee 5)
Social capital (D_2)	Access to family/household labour **(I 2.1)**	*"Good ties with the family highly inform what the farmer can do in this part of the country. The household or family as an entity is not only a source of farm labour but also an avenue for sharing of critical climate information.*"(Interviewee 4)
	Participation in Farmer-based organisations **(I 2.2)**	Interviewee 6 finds it to be "*…more critical to the farmers' adaptive capacity to climate stress. At least if not anything, the farmer tends to learn from his colleagues about some adaptation measures or methods. Some farmers also rely on FBOs for communal labour in times of weeding, planting, etc.*"
	Participation in GBO **(I 2.3)**	"*The involvement of farmers in community-based gender groups give them some sort of synergy in terms of information or knowledge sharing, withstanding climate shocks, just to mention a few…*" (Interviewee 4)
	Participation in RBO **(I 2.4)**	*"Religious groups in communities play an important role in social networking… Through participation in these religious groups, farmers enjoy some kind of social networking which enables them get access to information as well as relief support during disasters from other members of the religious group.*" (Interviewee 1)
Awareness and training (D_3)	Acceptance of climate change **(I 3.1)**	"*Acceptance of climate change is a very paramount step towards adaptation and that a farmer who accepts climate change is more prepared knowledge-wise to accept the need for adaptation than the one who does not know or accept it.*" (Interviewee 4)
	Level of literacy **(I 3.2)**	*"Efforts to build farmers resilience towards climate change are more fruitful in literate famers than their colleagues who are not literate. This implies that literate farmers are more likely to grasp training skills in current adaptation practices than their illiterate counterparts.*" (Interviewee 2)
	Access to climate information **(I 3.3)**	"*The ability of the farmer to access reliable weather and climate information enables him or her to prepare in advance against prevailing climatic discrepancies*." (Interviewee 1)
	Farming experience **(I 3.4)**	"*Farmers who have spent several years in farming are more equipped with local knowledge in adaptation than the less experienced ones*." (Interviewees 1)
	Access to extension service **(I 3.5)**	"*…local farmers learn current adaptation methods from the training and support they receive from agriculture extension agents. So farmers who receive this kind of training are more prepared to change their farming practices against climate change than those who do not have access to such training at all.*" (Interviewee 2)
Technology (D_4)	Knowledge of seed varieties **(I 4.1)**	"*Knowledge in improved seed varieties is an important step towards increasing the yield of farmers in current climatic variability. This particular indicator can help clarify if farmers are aware of available climate resilient seed varieties*." (Interviewee 5)
	Knowledge of soil moisture retention techniques **(I 4.2)**	According to Interviewee 4, it is "*…an important indicator of technology since water is very critical to the growth of food crops. And once the farmer knows about appropriate technology in soil moisture management, he or she is able to adapt to drought.*"
	Knowledge of soil fertility retention techniques **(I 4.3)**	"*It is also an excellent indicator since it is more related to soil fertility which is basic to agriculture*"…*It is important for the farmer to use available technologies to improve the fertility of the farm in order to get more yield*." (Interviewee 1)
Infrastructure (D_5)	Land holding size **(I 5.1)**	Interviewee 6 indicated that "*…landholding size is key to increasing crop productivity in farming communities and for that matter I think farmers with access to large farms will do well in their farming activities against climate change than those with small farms.*"
	Irrigation infrastructure **(I 5.2)**	"*…definitely farmers with access to some kind of irrigation infrastructure like dams are able to survive drought than their colleagues who cannot access such kind of infrastructure.*" (Interviewee 3)
	Access to roads **(I 5.3)**	"*… once a farmer has access to good roads, he or she is able to access markets to sell his/her perishable produce which cannot withstand the adverse effect of climate change. For me, access to market for your produce also enables you to gain some income that can sustain you till the next farming season.*" (Interviewee 6)
Institutions (D_6)	Land tenure arrangement **(I 6.1)**	"*…a farmer with a long-term access to a piece of land in this part of the country is more ready to fertilise it with organic fertiliser or organic compost than for instance, a marginalised farmer who is not assured of access to his or her farm in the next one or two farming season.*" (Interviewee 6)
	Government subsidy **(I 6.2)**	"*Government subsidies are also critical to farmers' adaptive capacity though it is normally challenging to access them… Once a farmer is able to acquire a subsidy coupon for fertiliser, he is able to buy it at a subsidized price and this increases his economic capacity in a way to cope with climate change…*" (Interviewee 2)
	Disaster relief assistance **(I 6.3)**	Interviewee 5 stated that "*…farmers' adaptive capacity to climate disasters will be enhanced if there are existing institutional arrangements that enable them receive disaster relief assistance. Such assistance could be in a form of cash or kind.*"

Secondly, the score for each of the determinant of adaptive capacity was calculated. It involved the summation of the ***I*** scores for each determinant relative to their respective Ranking scores. For instance, the score for determinant $\boldsymbol{D_1}$ is illustrated by Eq. (2) below.

Equation 2: Calculation of the capacity score for determinant D1 (Source: own formulation)
Capacity score $D_1 = (\sum I_{D1}/\text{the maximum} \sum I_{D1}) \times$ Ranking score for D1
where $\sum \mathbf{I_{D1}}$ = the cumulative ***I*** scores for $\mathbf{D_1}$

Finally, the SFACI score is then calculated by the summation of the capacity scores for all the six determinants of adaptive capacity, divided by the *assumed maximum adaptive capacity score* of 100 and then converting it to an adaptive capacity index between 0 and 5 (where 5 is the maximum index level). This means that the proportion of *SFACI* to *5* (which is the maximum index score) is equated to the proportion the *summation of capacity scores for all the determinants* to *100* (which is the maximum cumulative capacity score for all the determinants). The SFACI Score is illustrated by Eq. (3) below.

Equation 3: Calculation of Smallholder Farmers' Adaptive capacity Index Score (Source: own formulation)
$SFACI = (\sum D/100) \times 5$
where $\sum \mathbf{D}$ = the summation of the capacity scores of all the determinants

4.3.1. Categorisation of levels of adaptive capacity

The levels of adaptive capacity were determined using a categorisation criterion modified from Egyir et al. (2015) where adaptive index scores categorised into very low adaptive capacity (AC) level, low AC level, moderate AC level, high AC level and very high A/C level. See illustrations of Table 4.

5. Application of the smallholder farmers adaptive capacity framework and assessment of smallholder farmers in the study area

5.1. The individual and aggregate adaptive capacity of smallholder farmers in West Mamprusi

The Smallholder Farmers' Adaptive Capacity Index (SFACI) score for individual respondents was calculated using the survey results. The results show an uneven distribution of respondents under the various levels of adaptive capacity (cf. Fig. 2). While none of the respondents scored a *very high AC* level, 11.25% scored a *high AC* level and 22.5% scored a *moderate AC* level. With 58.75%, the majority of the respondents scored a *low AC* level and 7.5% scored a *very low AC* level. The SFACI score for all was 2.22 (cf. Table 5) indicating a *low Adaptive Capacity (AC)* level.

5.2. A gender-related differences of adaptive capacities in West Mamprusi

The results show statistically significant differences in the aggregate SFACI scores between male and female respondents in the study area with a P-value of 0.00 (cf. Appendix C). For male respondents the aggregate SFACI score was recorded with a score of 2.51 representing a *moderate AC level;* higher than that for their female counterparts that scored 1.95 which corresponds to the *low AC level* (cf. Table 5).

Based on a *Determinant's Normalised Capacity Score*, there were also some recorded gender-related differences in AC levels of the determinants. The *Determinant's Normalised Capacity Score* involves the normalization of the capacity score of a determinant of adaptive capacity in relation to the maximum score of the determinant using a Likert scale of 0–5 (where 5 is the

Table 4
The levels of adaptive capacity based on the ranges of index scores (Source: modified from Egyir et al., 2015).

Level of AC	SFACI score range
Very high AC	4.01–5.00
High AC	3.01–4.00
Moderate AC	2.50–3.00
Low AC	1.51–2.49
Very low AC	0.00–1.50

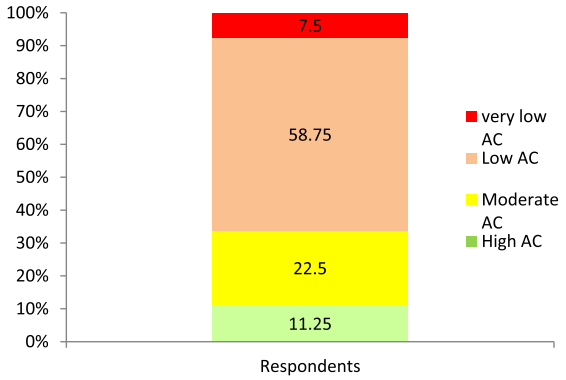

Fig. 2. Distribution of respondents by Adaptive Capacity levels (Source: own research).

Table 5
Aggregate SFACI Scores and Aggregate Determinant Capacity Scores of all Respondents, Male Respondents and Female Respondents (Source: Own research).

Category of respondents	*All respondents*	*All male respondents*	*All females respondents*
Number of respondents	*80*	*39*	*41*
Economic Resources (D1) Capacity score (Maximum = 22)	6.44	7.82	5.12
Social Capital (D2) Capacity score (Maximum = 12)	6.74	7.05	6.44
Awareness and training (D3) Capacity score (Maximum = 20)	9.33	10.67	8.06
Technology (D4) Capacity score (Maximum = 18)	8.6	10.71	6.59
Infrastructure (D5) Capacity score(Maximum = 15)	9.53	10.1	8.98
Institutions (D6) Capacity score	3.88	3.93	3.83
Cumulative Capacity score (Maximum Score is 100)	44.50	50.28	39
SFACI Score	***2.22***	***2.51***	***1.95***

maximum score). The survey results show that, apart from the *Social Capital (D2)* determinant in which both gender groups recorded the same determinant capacity level, the male respondents had higher levels than the female respondents in all the other five determinants of adaptive capacity (cf. Table 6).

Gender differences are also reflected in the distributions of respondents who scored the various AC levels (cf. Fig. 3). Overall, the male respondents reached higher adaptive capacities levels than their female counterparts. As illustrated on Fig. 3 below, none of the two gender groups recorded a *very high AC level.* 23.08% of the male respondents were assigned to the high AC level, while none of female respondents fell under this category. The results also illustrate that 35.9% of male and 9.75% of the female respondents respectively scored a moderate AC level. Further, there was a wide variation between the proportion of male and female respondents who recorded a low AC levels with more than twice as many female respondents (78.05%) assigned to this level than males respondents (38.46%).

5.3. Variations in adaptive capacity among respondents with and without formal education in the West Mamprusi

Besides the gender-related differences among the respondents the study records another variation in adaptive capacity among respondents with and without formal education. A great majority (76.3%) of the respondents had no formal education while only few (23.7%) received formal education (cf. Table 7). The respondents without formal education scored on average lower in adaptive capacity with an SFACI score of 1.79, while those with a formal education scored comparatively higher with an SFACI score of 2.37.

There was however some variation recorded between respondents with and without formal education in terms of their distribution in AC levels. The proportion of respondents who scored at least a moderate level of AC was higher among those with formal education than those without formal education. It was recorded that 57.9% and 26.1% of those with and without formal education respectively scored at least moderate levels of AC (cf. Fig. 4).

6. Discussion and conclusion

6.1. Specification of an indicator-based framework for adaptive capacity of smallholder farmers in the Northern Region of Ghana and its application

In our research we propose an indicator-based framework that helps to characterize and assess the adaptive capacity of smallholder farmers in sub-Saharan Africa to climate change. The framework was validated and the proposed indicators

Table 6
Determinants' Normalised Capacity scores and Determinants AC Levels of Respondents in the West Mamprusi district by gender (Source: own research).

Determinant	Males		Females	
	Determinant's normalised Capacity Score	*Determinant's AC Level*	*Determinant's normalised Capacity Score*	*Determinant's AC Level*
Economic resources (D1)	1.78	Low	1.16	Very Low
Social Capital (D2)	2.94	Moderate	2.68	Moderate
Awareness and training (D3)	2.67	Moderate	2.01	Low
Technology (D4)	2.97	Moderate	1.83	Low
Infrastructure (D5)	3.37	High	2.99	Moderate
Institutions (D6)	1.51	Low	1.47	Very Low

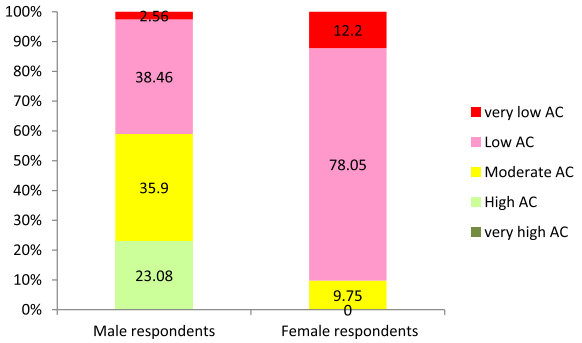

Fig. 3. Gender distribution of smallholder farmers in West Mamprusi by the levels of adaptive capacity (Source: own research).

Table 7
Proportions of and Aggregate SFACI of Respondents with and without Formal Education in the West Mamprusi district. (Source: own research).

Have you attended formal education?		
Response	*Percentage of respondents*	*Aggregate SFACI*
No	76.3	1.79
Yes	23.7	2.37

were assessed by experts in the field of climate change adaptation and smallholders farming in Ghana through interviews with Ghanaian experts in the fields of agriculture, development and climate change. The developed indicators characterizing the adaptive capacities of smallholder farmers were based on a literature review and were broadly supported by the experts. The expert's appraisal and rephrasing of the indicators (cf. 3) helped to operationalize the indicators for a standardized survey questionnaire. For the calculation of the Smallholder Farmer's Adaptive Capacity Index (SFACI) the experts weighing of the six determinants was decisive. The results from the expert interviews show that economic resources (D1), awareness and training (D3) as well as technological capacities (D4) seem most relevant for smallholder farmers' adaptive capacity in the Northern Region of Ghana. Social capital (D2) and institutional capacities (D6) are ranked as least important. Concerning the choice and description of the proposed indicators, the expert interviews supported the framework. Summarizing, the generic literature based framework for assessing adaptive capacity (cf. Section 2) has been adequately transferred into an indicators-based SFACI and thus in an operational tool that helps to specify adaptive capacity for the specific case of smallholder farmers in the Northern Region of Ghana.

Interestingly, the experts' ranking of the determinants of adaptive capacity is mirrored in the empirical results from the questionnaire survey that operationalized and applied the developed indicator-based survey. The gender sensitive analysis of the empirical results (cf. Section 5.2) shows that gender disparities among the adaptive capacity determinants are highest concerning the determinants economic resources (D1), awareness and training (D3) and technological capacities (D4) with females reaching a lower score while the differences between genders is smallest concerning the determinants social capital (D2) and institutional capacities (D6). This seems to back the experts view and with this the calculation of the SFACI where the weighing of the determinants has been fed into (cf. Section 5).

Apart from the validation of the developed framework for assessing adaptive capacity the results from the application of the framework in West Mamprusi reveal some crucial insights in disparities between smallholder farmers with relatively

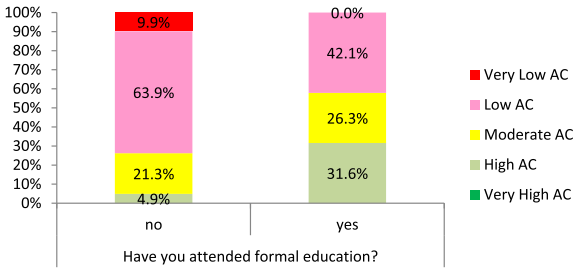

Fig. 4. Distribution of Respondents with and without Formal Education against Levels of AC (Source: own research).

high and relatively low adaptive capacity. While the distribution of respondents among the levels of aggregated adaptive capacity – with the most part of smallholder farmers having a low or very low adaptive capacity and none reaching a very high level – is in itself not surprising, the differences between male and female smallholder farmers' adaptive capacity shows that there is a clear social disparity in relation to gender and education. Male farmers have better access to economic resources such as higher diversity of incomes and better access to credit, to technological resources such as better knowledge of soil fertility and soil moisture retention techniques as well as awareness and training such as level of literacy, access to climate information and extension services. Further, those with formal education perform significantly better than those farmers without formal education. These results confirm Asante and Amuakwa-Mensah (2014) who based on a literature review expect women to be among the groups that are negatively impacted by climate change and variabilities. Further, the results show that though Ghana reports progress in poverty reduction, educational attainment and reducing gender inequalities (cf. FAO, 2012) rural population especially in the North lag behind with direct impact on their adaptive capacity.

6.2. Implications for building adaptive capacity for smallholder farmers in the Northern Region of Ghana

Based on the summary of results and the strong influence of gender and education on the level of adaptive capacity we propose the following approaches for building adaptive capacity for smallholder farmers in the Northern Region of Ghana: we conclude that starting points for building resilience should target smallholder farmers with low adaptive capacity, especially women and farmers without formal education. Capacity developments programs in (Northern) Ghana are so far largely driven by international donors and concentrate on knowledge and awareness and dissemination of improved technologies, e.g. the West Africa Agricultural Productivity Programme (WAAPP). In 2012 a report by the FAO on gender inequalities in rural employment in Ghana concludes that great progress has been made in poverty reduction during the past ten years on the national scale attaining one of the highest levels in sub-Saharan Africa but that despite this progress there is a significant gap between urban and rural areas, and between the northern and the southern regions, with regard to poverty levels and between men and women (FAO, 2012). Northern regions show the most accentuated gender differences in adult literacy, and gender differences in literacy are more significant in rural areas. An extremely high percentage of women and men in the country have not completed primary education, the situation being more critical for women. Therefore, the low level of education of farmers, their inability to access extension service and unacceptance climate change can be expected to impede the progress of capacity building programs for climate adaptation that do not focus specifically on the lower poverty level in rural areas with a special attention to women. The results of our study show that in these conclusions still reflect in the adaptive capacities of smallholder farmers in Northern Ghana.

Some non-governmental activities exist to specifically support smallholder farmers in Northern Ghana[3] that work with land extension services to provide information on weather, use of indigenous seeds and tree planning. Our study sampled smallholder farmers from communities where no pilot projects have been launched so far to strengthen the specific capacities. Thus, a comparative study that focusses on the effect of these interventions would create important insights for the effectiveness of these capacity building activities.

To further improve the knowledge basis of how supportive instruments effect the adaptive capacity of smallholder farmers we propose, secondly, to conduct further research based on a mixed-methods approach including qualitative methods. This would help to further investigate the explaining factors for the revealed gender and educational biases. We expect it to be especially fruitful to focus on cases that perform surprisingly well, e.g. farmers within the highest aggregated adaptive capacity or determinant scores as well as best performers among women and respondents without formal education. These sampling techniques combined with a qualitative and explanatory approach involving the perspective of the smallholder farmers themselves in focus groups will enable the identification of factors that support smallholder farmers in strengthening their adaptive capacity to climate change.

[3] Cf. http://www.rainsgha.org.

Further, we consider, based on good practice examples that training programs specifically focused on climate change impacts and their implications for smallholder farmers, as well as general training on agricultural issues as well as better access to economic resources will enhance the adaptive capacity.

6.3. Limitations and further research

There are several general limitations connected to a deductive indicator-based assessments. First, a deductive and expert driven approach does not include the perspectives of the community members on their own adaptive capacity. Participatory indicator development (cf. Asare-Kyei et al., 2015) could also be used as a complementary approach helping to further differentiate indicators and also validate or revise both content and weighing of indicators. Second, indicators provide only an indication for a certain state of a system and do not shed light on how to explain the results. For explaining results either qualitative, participatory studies should complement the research, that involves both smallholder's perspectives as well as those of policy makers. Combining a participatory assessment that included the perspective of the smallholder farmers was not possible within the present research project but could add a further perspective not only on the adaptive capacities but also on specific capacity building options. Further, the applied case study approach including only two communities could be substantiated by applying the developed index in different kinds of communities (with/without pilot projects, nearby bigger cities/further away from bigger cities etc.) could further reveal influencing factors and starting points for capacity building in the Northern Region of Ghana. For further refining the developed framework it would be beneficial to include more experts in the validation and adaptation of the framework to region specific circumstances. Focus groups with both small holder farmers (Hennink, 2013) and Delphi methods experts on smallholder farming (Linstone and Turoff, 2002) could be used to further differentiate and specify the proposed framework especially when it is transferred to the assessment of smallholder farmers in other regions and countries.

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Appendices

Appendix A: Profiles of experts interviewed

Reference number	Function/Position of the Interviewee	Type of Organisation
Interviewee 1	Regional Environment officer	Regional Governmental organisation
Interviewee 2	Agricultural Extension Agent	Local Governmental organisation
Interviewee 3	Agricultural Extension Agent	Local Governmental organisation
Interviewee 4	Project Advisor	International Development Aid Organisation
Interviewee 5	Project Manager	International Non-Governmental Organisation
Interviewee 6	Program Officer	Local Non-Governmental Organisation

Appendix B: Survey questionnaire with indicators scoring criterion

Farmer's Personal Information

1) Sex: [ ] Male [ ] Female
2) Age: [ ] under 18 years [ ] 18–25 [ ] 26–35 [ ] 36–45 [ ] 46–55 [ ] 56–65 [ ] 66+
3) Are you the head of the household? [ ]Yes [ ] No
4) What is the size of your household? . . . . . .
5) What is the size of the farm you have cultivated this season? [ ]<1 hectare [ ] 1–2 hectares
6) Which crops have you planted this season? [ ] Maize [ ] Millet [ ] Groundnut [ ] beans [ ] soya beans [ ] others. . . . . .
7) Community. . . . . .

NB: The maximum score for each indicator is 5 points

1. ECONOMIC RESOURCES

1.1. Diversity of Source income)

8) Is crop farming your only source of income? [ ] Yes [ ] No. (if 'yes' score the indicator 0 and skip to 10)
9) Which other economic activities do you engage in?
   [ ] animal rearing ----3 points
   [ ] trading ----4 points
   [ ] mining ----3 points
   [ ] civil service ----5 points
   [ ] others. . . . . .

1.2. Remittances received

10) Do you receive money from family/relative work outside this community? [ ]Yes [ ] No (if 'no' score the indicator 0 and skip to 12)
11) If yes, how often?
   [ ] monthly ----5 points
   [ ] quarterly---- 4 points
   [ ] yearly---- 3 points
   [ ] others

1.3. Access to credit

12) How do you finance your farming activities? (If 'loans/borrowing' is not selected, score the indicator 0 and skip to 14)
   [ ] own financial resource ----0 points
   [ ] loans/borrowing----2 points
   [ ] remittances----0 points
   [ ] Others. . . . .
13) From whom do you borrow or take your loan?
   [ ] individuals----1 point
   [ ] farmers' cooperative group/organisation----2 points
   [ ] microfinance organisation----3 points
   [ ] bank----3 points
   [ ] others. . . . .

2. SOCIAL CAPITAL

2.1. Access to household/family labour

14) Do you receive free labour from household/family for your farming activities? [ ] Yes [ ] No. (if 'no' score the indicator 0 and skip to 16) ----2 points
15) From whom do you receive free farm labour?
   [ ] household/nuclear family----1 points
   [ ] extended family members/relatives within the community----1 points
   [ ] extended family members/relatives outside the community----1 points

2.2. Participation farmer-based groups/organisations (FBOs)

16) Are you member of any farmers' groups/organisation? [ ]Yes [ ] No (if 'no' score the indicator 0 and skip to 20)
17) Which group(s)/organisation(s)?. . ....
18) Since when have you joined it? (a) <5 years ----1 points (b) 5–10 years 2 points (c) >10 years 3 points
19) How will you rate your involvement in the group's activities (use a scale 1 to 5; 1 = inactive; 3 = active)? [ ] 1 ----0 [ ] 2 ----1 points [ ] 3 ----2 points

2.3. Participation in Gender-based groups/organisation

20) Are you a member of any men/women group? [ ]Yes [ ] No (If 'no' score the indicator 0 and skip to 23)
21) Which group(s). . . . . .
22) How will you rate your involvement in the group's activities (use a scale 1 to 3; 1 = inactive; 3 = active)? [ ] 1 ----1 point [ ] 2 ----2.5 points [ ] 3----5 points

2.4. Religious group/organisation

23) Are you a member of any religious group/organisation? [ ] Yes [ ] No. (If 'no' score the indicator 0 and skip to 27)
24) Which group(s)……
25) Since when? (a) <5 years ----1 points (b) 5–10 years ------2 points (c) >10 years -------3 points
26) How will you rate your involvement in the group's activities (use a scale 1 to 3; 1 = inactive; 3 = active? [ ] 1 [ ] 2 [ ] 3

2.5. Other group(s)/organisations

27) Are you member of any other group/organisation? [ ] Yes [ ] No. (If 'no' score the indicator 0 and skip to 31)
28) Which group(s)……
29) Since when have joined it?
(a) <5 years----1
(b) 5–10 years -----2
(c) >10 years-----3
30) How will you rate your involvement in the group's activities (use a scale 1 to 5; 1 = inactive; 3 = active? [ ] 1 ----0 [ ] 2 ----1 point [ ] 3 ----2 points

3. AWARENESS AND TRAINING

3.1. Acceptance of climate change

31) How would you access the rainfall patterns of this community within the last 10 years? (a) Changed/altered -----2 points (b) stayed the same ----0 points (c) don't know 0 [If (a) is not selected score the indicator 0 and skip to 34].
32) If altered/changed, what do you think has caused it? (a) climate change related reason ---- 2 points (b) superstition/ religion ----0 (c) others -0(d) don't know ----0
33) What do you do because of the altered rainfall patterns?
    a. Adapt my farming practices to the changes----2 points (b) do nothing ----0 (c) others……

3.2. Level of literacy

34) Have you attended formal education? [ ]Yes [ ]No. If 'no' score the indicator 0 and skip to 36
35) What is your level of education? (a) Primary school----2 points (B) Junior secondary/high school or middle school ----3 points (c) secondary school ---4 points (d) vocational school---- 4 points (d) Tertiary (e) Non-formal(night school)----- 2 points (f) others

3.3. Farming experience

36) How long have you been farming? (a) 0–4 years ----1 point (b) 5–9 years ----2 points (c) 10–19 years ----4 points (d) 20–29 years ----5 points (d) 30+ years -----5 points

3.4. Access to formal extension Service

37) Have you receive any agriculture (cropping) training within the last five years? [ ]Yes [ ] No (if 'no' score the indicator 0 and skip to 40)
38) From whom did you receive the training? (a) Mofa ----2.5 points (b) Private companies ----2.5 points (c) NGOs----2.5 points (d) others……
39) What kind of training……. ----score 2.5 points if it is adaptation-related

3.5. Access to climate/weather information

40) Do you have access to weather information? [ ]Yes [ ] No (if 'no' score the indicator 0 and skip to 43)
41) What kind of weather information? [ ] Rainfall -----1 point [ ] temperature ----1 point [ ] others
42) From which medium do you receive the weather information? [ ] radio ----2 points [ ] TV ---- points 2 [ ] agriculture extension service? ----2 points [ ] others……

4. TECHNOLOGY

4.1. Knowledge of seed variety

43) What is the main crop you have sown this season?...
44) Do you know of other available varieties of this crop? [ ]Yes [ ] No
45) Which other varieties are available?
    [ ] early maturing variety -----2 points
    [ ] drought resistance variety----2 points
    [ ] flood resistant variety----2 points
    [ ] disease resistant variety----2 points
    [ ] other varieties:...maximum----3 points
46) Why do you use it instead of other varieties?
    [ ] don't know ----0
    [ ] drought resistance---- 2 points
    [ ] flood resistant ----2 points
    [ ] disease resistant ----2 points
    [ ] other reasons:...maximum 2 points

4.2. Knowledge of soil moisture retention techniques

47) Do you use know any technique(s) to retain soil moisture for your crops/plants especially in times of drought? [ ] Yes [ ] No-0
48) Which soil moisture retention technique(s) do you use/know?
    [ ] mulching ----2 points
    [ ] cover cropping----2 points
    [ ] other methods-2 points

4.3. Soil fertility techniques

49) Have you fertilised your farm for cultivation within the last five farming seasons? [ ] Yes [ ] No--0
50) How do you fertilise it?
    [ ] chemical fertiliser application---2 points
    [ ] organic composting----2 points
    [ ] organic manure---2 points
    [ ] others

5. INFRASTRUCTURE

5.1. Land holding size

51) What is the size of the land you have access for cultivation? (a)<1 hectare ----1 points (b) 1–2 hectares ----2 points (c) >2 hectares----5 points

5.2. Irrigation infrastructure

52) Do you irrigate your farm when there is drought? [ ]Yes [ ] No (if 'No' score the indicator 0 and skip to 54)
53) Where do you obtain water for irrigation?
    [ ] river/stream--5 points
    [ ] lake--5 points
    [ ] dam--5 points
    [ ] well/dugout--3 points
    [ ] tap water---5 points
    [ ] borehole---5 points
    [ ] others...

5.3. Access to good roads

54) How far is your farm from the nearest main road that connects to the district capital?
    [ ] <1 km----5 points
    [ ] 1–5 km-----4 points
    [ ] between 5 and 10 km----3 points
    [ ] >10 km ----2 points

6. INSTITUTIONS

6.1. Land tenure system

55) How did you obtain your land/farm?
[ ] purchased----5 points
[ ] family land----4 points
[ ] from village chief/government----3 points
[ ] rented----2 points
[ ] others

6.2. Government subsidies

56) Do you receive agriculture subsidies from the government? [ ]Yes [ ] No (if 'No' score the indicator 0 and skip to 58)
57) What kind of subsidies do you receive?
[ ] fertiliser subsidies--2 points
[ ] pesticides subsidies--2 points
[ ] seeds subsidies--2 points
[ ] others----------------------maximum 5 points

6.3. Disaster relief assistance

58) Have you been affected by a natural disaster such as flood within the last 10 years in this community? [ ]Yes [ ] No (If 'No' skip to 65)
59) Which kind of natural disaster(s) affected you?. . ...
60) Did you incur some losses from such disaster(s)? [ ] yes [ ] No
61) What kind of losses did you incur?
[ ] loss of crop yield
[ ] others. . .. .
62) Have you ever received disaster relief assistance when you were affected by the natural disaster? [ ]Yes [ ] No --0 (if 'No' skip to 65)
63) From whom did you receive such assistance? (a) Government ----1.5 points (b) NGO's ----1.5 points (c) others. . .. . Maximum score is 2 points
64) Which of the following is true about you?
[ ] I sometimes receive disaster relief from the government and/or NGOs---1 point
[ ] I mostly receive disaster relief from the government and/or NGOs---2 points
[ ] I always receive disaster relief assistance from the government and/or NGOs---3 point

Appendix C: The independent samples T-test for aggregate SFACI scores between male and female respondents. (Source: Own Research).

Independent samples test

		Levene's Test for Equality of Variances		*t*-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
SFACI Level	Equal variances assumed	24.640	0.000	5.442	78	0.000	0.81926	0.15055	0.51955	1.11898
	Equal variances not assumed			5.372	59.621	0.000	0.81926	0.15251	0.51416	1.12437

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