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The role of perception in subsistence farmer adaptation in Africa

Enriching the climate finance debate

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Abstract

Purpose – Africa is a focus area for international climate change adaptation finance. Subsistence farmers are crucial for Africa's adaption. But it is unclear how those that qualify to receive adaptation finance actually perceive climate change, even though perceptions are reflected in adaptive behaviour. This paper aims to show how perceptions of climate-related hazards drive adaptation and provide recommendations for the climate change finance community to support subsistence farmer adaptation.

Design/methodology/approach – A total of 227 households in rural Ghana and Botswana were surveyed and their answers statistically analysed.

Findings – The respondents' perception of climate-related hazards is analogous to existing environmental degradation. In the complex environment in which farmers operate, high vulnerability and climate dependency do not necessarily result in autonomous adaptation. Experience, means and perceived successfulness are more important factors, but these hardly relate to individual adaptive measures.

Practical implications – Recommendations for adaptation finance institutions: build on existing development plans and policies on climate-related environmental problems; adaptation is more than a collection of adaptive measures, so financing adaptation is more than financing adaptive measures; extremely vulnerable people do not necessarily adapt autonomously, indicating that *ex post* adaptation remains important too.

Originality/value – This study shows that highly vulnerable subsistence farmers do not automatically adapt and that adaptation is more than implementing adaptive measures. The outcomes are linked to the adaptation finance institutions.

Keywords Climate change adaptation, Perception, Drought, Ghana, Botswana, Climate finance

Paper type Research paper

1. Introduction

African communities and economies are very vulnerable to climate change (Boko *et al.*, 2009) and at recent UN climate summits the continent is prioritized to receive international climate change adaptation finance (UNFCCC, 2009; decision 3/CP.15 and UNFCCC, 2010; 95/CP.16). Annual climate finance should approach US$100 billion from

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2020 onwards. How to use the share that goes to adaptation efficiently and effectively is still under discussion (Chaum *et al.*, 2011; Denton, 2010; Schalatek, 2011). This paper focuses on subsistence-based agriculture, which has a key role in adaptation in Africa.

The agricultural sector contributes on average 29 per cent of the GDP of African countries and is largely subsistence-based (UNECA, 2001). Whilst the share of the population active in agriculture is decreasing, its absolute number climbs towards 600 million in 2020 (FAO, 2011). As agriculture is generally rain-fed (FAO, 2011) it is very sensitive to precipitation anomalies. With agricultural systems already under performing and environments degraded (Magadza, 2003), subsistence farmers need to adapt to climate change. This means:

> [. . .] being able to maintain (or improve) living standards in the face of the expected changes in climate trends and the intensity and frequency of severe climate related hazards that might affect people's livelihoods' (van Aalst *et al.*, 2008).

Although changing climatic conditions are often perceived by subsistence farmers (Bryan *et al.*, 2009; Deressa *et al.*, 2009), information provision on climate change in rural Africa is generally low (van Aalst *et al.*, 2008; Nhemachena and Hassan, 2007), which is indicative for subsistence farmers' knowledge on the matter. How can international adaptation finance support millions of subsistence farmers to adapt to climate change if these people hardly know or understand what it is?

Rather than looking at climate change, this paper therefore focuses on perception of climate related hazards (CRHs: droughts, extended dry seasons, floods, etc.). Understanding present-day effects of and autonomous responses to CRHs is a prerequisite for studying the effects and responses to climate change (Adger *et al.*, 2003; Hulme *et al.*, 2000; van Aalst *et al.*, 2008). Second, the focus on perception of subsistence farmers, based on the idea that understanding the way people perceive climate risks is essential to say anything meaningful about their autonomous adaptive behaviour (Grothmann and Patt, 2005). Understanding the perception of subsistence farmers can be helpful for policymakers in promoting climate change adaptation, for example through knowledge sharing, adaptation projects and risk management strategies (Patt and Schröter, 2008; Deressa *et al.*, 2009; Bryan *et al.*, 2009; Plapp and Werner, 2006; Nyanga *et al.*, 2011; Kreibich, 2011). This paper goes beyond policymakers and draws initial lessons for international climate finance institutions.

Outline

This paper first provides a short summary of existing knowledge on subsistence farmers' adaptation to CRHs in Africa. It shows the increased emphasis on autonomous adaptiveness, which takes place in complex environments. It shows some standard adaptive measures in Africa, and that subsistence famers' perception plays an important role in adaptation to CRHs.

This paper builds on that knowledge based on 227 interviews in subsistence-farmer communities in Botswana and Ghana. Results are put in the perspective of the respective countries' agricultural, environmental and economic development. In a synopsis I compiled the Botswana and Ghana data and draw conclusions on the role of the respondents' motivation, experience and means (e.g. workforce, money, assets) in adaptation to CRHs. In the conclusion lessons are drawn for international climate finance institutions.

2. Existing research on local adaptive capacity

Historical overview of local adaptiveness

"Local adaptiveness" is described by Smit and Skinner (2002) as a climatic change related regular part of farmers' ongoing management that takes place either spontaneous or planned. It has been part of a scientific debate long before "global warming"; the Sahel drought of the 1970s already initiated a great increase in studies. At that time, the national or regional oriented desertification narrative generalized area-specific environmental phenomena (Slegers and Stroosnijder, 2008). Farmer's adaptiveness was considered as low. Communities were seen as inherently vulnerable and were considered dependent on strong governments and aid from Western countries (Mortimore and Adams, 2001; Roncoli *et al.*, 2001).

In the following three decades, researchers moved away from the diagnostic-prescriptive view on local adaptiveness towards a more long-term perspective on development and the human-environment interaction in particular. Climate variability was acknowledged; the Sahelian environment became known as unstable but resilient. Indigenous knowledge and local innovations were revisited as key for farm-level adaptation to climatic risks (Stigter *et al.*, 2005).

Climate change adaptation literature also has increased attention for the farmer, although initially distant analyses were made here too. For example, in their overview of potential adaptive measures in the agricultural sector, Smit and Skinner (2002) recognize that little research is done on the adoption of measures. Kandlikar and Risbey (2000) called the tendency to cast adaptation as a physical and market based process and the lack of attention for political and social dimensions "problematic". Without detailed knowledge of a community it is essentially impossible to develop appropriate and applicable adaptation measures for them (Smit and Pilifosova, 2003).

The increasing focus on local scale adaptation to CRHs in Africa is described in a growing body of literature. A summary of this discussion is provided in the two subheadings below. More detailed discussions are provided by Bryan *et al.* (2009), Eriksen *et al.* (2011), Maddison (2007), Slegers (2008) and Smit and Skinner (2002).

Adaptation measures in complex environments

Although the successfulness of measures to adapt to CRHs depends on the local context, some general adaptive measures prevail. These include improved soil and water management (Smit and Skinner, 2002; Stigter *et al.*, 2005), crop diversification (Nhemachena and Hassan, 2007), small-scale water harvesting and irrigation (Pauw *et al.*, 2008; Deressa *et al.*, 2009), seasonal forecasts (Patt and Gwata, 2002), education (Maddison, 2007), livelihood diversification (Thomas and Twyman, 2004), and migration (McLeman and Smit, 2006; Mertz *et al.*, 2010).

Individual farmers apply different adaptive measures (Ziervogel *et al.*, 2006) and apply measures differently (Pauw *et al.*, 2008). People's most important concern is their daily life and livelihood (van Aalst *et al.*, 2008). The climate is just one factor in the complex environment in which subsistence farmers operate (Westerhoff and Smit, 2008; Ziervogel *et al.*, 2006; Bryan *et al.*, 2009). Adaptation is influenced by socio-economic, cultural, political, institutional, ecological and geographical factors that shape the human-environment interactions (Eriksen *et al.*, 2011; Nyanga *et al.*, 2011). The application of adaptive measures depends for instance on the type of climate stimuli, the type of farming, a farmer's means (Dolan *et al.*, 2001); access to markets, availability of

credit and savings, knowledge (Gbetibouo, 2009); education and closeness to roads (Maddison, 2007). In such a complex setting it is difficult for researchers, policymakers and adaptation finance institutions to determine whether an activity constitutes adaptation and whether it can be financed as such.

Perceptions

Apart from looking at the local level, research also tries to reflect "from" the local level, through insights in people's perception of CRHs. This is useful for policymakers as perceptions are reflected in behaviour (Patt and Schröter, 2008; Deressa *et al.*, 2009; Bryan *et al.*, 2009; Plapp and Werner, 2006; Meze-Hausken, 2004; Nyanga *et al.*, 2011; Kreibich, 2011), and because differing views between governments or researchers and local people can have far-reaching implications. For example, a lack of consensus among Tanzanian farmers and scientist on the causes of declining harvests limited the transition towards more sustainable use of natural resources (Slegers, 2008); and an expensive relocation programme in Mozambique failed because policymakers and the rural population perceived flood risks differently (Patt and Schröter, 2008).

Perceptions of climatic changes do not necessarily result in autonomous adaptation. For example, whilst majorities of farmers in several African countries perceived changes in temperature and rainfall, many farmers did not adapt to these changes (e.g. 42 per cent (Deressa *et al.*, 2009); 44 per cent (Nyanga *et al.*, 2011); 37-62 per cent (Bryan *et al.*, 2009)). Explanations are found for instance in a lack of knowledge of adaptive measures, no tenure security, or restricting socio-economic conditions (Bryan *et al.*, 2009). The hypothesis of this paper is that apart from perception of climatic changes additional factors play a role in subsistence farmers' perception of CRHs and adaptation, such as perceived vulnerability and motivation to adapt.

3. Method and study sites

Ghana case study

Five villages in the Dayi River Basin (Volta region) in Southeastern Ghana were selected for surveying based on discussions with the Ministry of Food and Agriculture (MoFA) regional office and the NGO Development Institute, and the willingness of village leaders to cooperate. The villages represent three distinct ecological zones in the basin: have and Woadze represent the mountainous downstream area, and Koloenu the mid-stream transitional Savannah, where forests are largely cleared and turned into arable land. Lipke Kukurantumi and Lipke Abrani represent the upstream (still) forested area. The villages varied in size from 42 to 3,508 inhabitants (Ghana Statistical Service, 2005); in general more interviews were done in larger villages.

The fieldwork region has a tropical climate with a bimodal wet season peaking in June and September.

Local meteorological data shows that the annual rainfall decreased from 1,700 mm/year in 1975 to the present 1,400 mm/year and that the rainy season shortened. The mean annual temperature increased by 1°C in the period 1961-2000 (Westerhoff and Smit, 2008), and is projected to keep rising (2°C in 2050) (Agyemang-Bonsu *et al.*, 2008).

Precipitation projections are difficult to make for the case study region. The 21 global models used by the IPCC project an overall precipitation increase but are inconsistent (Christensen *et al.*, 2007). The more detailed medium scenario of the regional NCAP projection shows a further decline in rainfall (− 10.9 per cent in 2050) and a shortening

rainy season. This would be detrimental for agriculture and farmers have to adapt (Griebenow and Kishore, 2009; Agyemang-Bonsu *et al.*, 2008)

In a country with such diverse climatic zones and cultural diversity, the villages cannot represent Ghana as a whole. However, the large and growing agricultural labour force and arable land (FAO, 2011); constrained socio-economic engagement with water and land resources; limited irrigation (MoFA, 2006); correlation between agricultural yields and rainfall and weather hazards (Perret and Bossard, 2008; Agyemang-Bonsu *et al.*, 2008); and the high levels of deforestation (Griebenow and Kishore, 2009) are key indicators of socio-ecological interactions common both in the villages and the country.

In an integrated manner, these issues are addressed by the Dayi River Basin Board (established in 2010) and in national policies and plans such as the "Draft National Irrigation Policy" and the "Agriculture and Sustainable Land Management Strategy and Action Plan". Activities described in the latter include building institutional and technical capacity, awareness raising, knowledge development and the creation of incentives for farmers for sustainable land management (MoFA, 2008).

Botswana case study

Research took place in two villages in the Motloutse River Basin (Central district), near Botswana's border with South Africa and Zimbabwe. Gobojango has 1,631 inhabitants and Tsetsebjwe 3,457 (CSIR, 2003). They were selected in cooperation with the SADC Groundwater and Drought Management project leaders based on their representativeness for drought-prone rural villages in Botswana and the willingness of village leaders to cooperate.

Botswana has one rainy season annually (November-March). With 300-400 mm of rainfall per annum, the case study area is arid to semi-arid just like most of the country (Adedoyin and Mphale, 2002). The amount of rainfall is highly variable and characterized by a high degree of inter-annual and inter-decadal rainfall variability (Schulze, 2000) and declined by 5-15 per cent over the twentieth century (Hulme *et al.*, 2000). The temperature has a mean minimum of 6-10°C in winter and a mean maximum of 28-34°C during summer (Government of Botswana, 2000); the latter increased by 1.3°C in the period 1958-1998 (Adedoyin and Mphale, 2002).

The IPCC A1B scenario projects the mean temperature to rise by 3.5°C towards 2100 (Christensen *et al.*, 2007). Changes in rainfall are difficult to predict in Southern Africa. For 2100, mean decreases in rainfall of − 16 per cent (March-May), − 34 per cent (June-August) and − 31 per cent (September-November) are projected by Shongwe *et al.* (2009), which would shorten the rainy season. Their model is not statistically significant for the three wettest months of year (December-February). Under climate change, water stress is very likely to increase; adding pressure to rain-fed agriculture and reducing available vegetation for free range livestock.

Botswana is a middle-income country but poverty is still widespread in rural areas. The agricultural sector is of key economic importance, but yields are constrained by *inter alia* poor farming practices, poorly organized markets, degraded lands and water shortages (Government of Botswana, 2002; Government of Botswana and United Nations, 2010). The per capita annual food production declined by 60 per cent compared to the production peak in 1971 (FAO, 2011).

The Botswana Government has developed several programmes to increase the agricultural output and to reduce effects of droughts on rural communities, such as the

Labour Intensive Public Work Relief Program (still known as its predecessor "Drought Relief Programme" (DRP)) and the Integrated Support Programme for Arable Agricultural Development (ISPAAD). DRP was established in 1982 and funded through mineral exploitation revenues. It provides a safety net in times of droughts by financing bottom-up initiatives and creating temporary jobs this way. During its peak it reached 84,000 participants, providing assistance to 45 per cent of the family farm labour force and equalling 11.1 per cent of the total rural household income (Valentine, 1993). ISPAAD is smaller and started in 2008 to address challenges in the arable sub-sector of agriculture, to combat poor technology adoption by farmer and low productivity of arable farming (Government of Botswana, 2011). ISPAAD provides farmers with free seeds, fertilizers and draught power (www.agriculture.co.bw).

Method

Face-to-face interviews were administered in subsistence farmer communities in Ghana ($n = 107$) and Botswana ($n = 120$) in 2009. The survey method is based on literature on surveying perceptions of natural hazards (Bird, 2009) and household surveying in developing countries (Grosh and Glewwe, 2000). The survey started with general questions on the socio-economic and demographic situation of the respondents (e.g. education, age, agricultural practices, and income). Second, questions on *inter alia* perceived probabilities and consequences of CRHs, vulnerability, dependency, experience, successfulness, means and motivation to adapt to CRHs provided an overview of the respondents' perception of CRHs and adaptation. These concepts derive from literature (Grothmann and Patt, 2005; Patt and Schröter, 2008; Sjöberg, 2000; Maddison, 2007; Plapp and Werner, 2006) and were not predefined to the respondents to allow them to answer from their own perspective. Respondents were asked how successful they perceive certain adaptive measures that were collected from survey test rounds and literature (Agyemang-Bonsu *et al.*, 2008; Nhemachena, 2008; Ziervogel *et al.*, 2006; Bryan *et al.*, 2009). However, respondents neither always brought adaptive measures into practice, nor applied them in the light of CRHs alone.

The response format mainly consisted of closed questions. Many questions used a Likert scale from 0 (e.g. extremely low, not important) to 6 (e.g. extremely high, extremely important). Likert scales are "quite useful" when offering limited response categories (i.e. 7) and have many desirable quantitative properties (Sjöberg, 2000). Ordinal scales could have a non-linearity bias, but in this context it is not very different from an interval scale (Wright, 1997) and potential mild deviations from strict linearity can be safely disregarded (Sjöberg, 2000). Regression and χ^2-tests were used to analyse the data.

Households were randomly picked for interviewing to ensure representativeness of views and experiences. Face-to-face interviewing gave respondents the chance to ask for clarification and ensured answering of all questions. Interpreters translated in local languages if necessary. Face-to-face interviewing and the spatial probability sampling can lead to deviations in the sample. For instance, men in Botswana are usually out in the field with their cattle during the day or even during the week, forcing the interviewers to work intensively in the weekends.

Interviews lasted for 45-75 min. Response rates were 100 per cent, with 50 per cent (Ghana) and 79 per cent (Botswana) female respondents. Respondents were often but not always head of the household, with average ages of 50 (Ghana) and 53 (Botswana).

4. Survey results

This section provides the survey results based on:

- the socio-economic conditions in which respondents adapt to CRHs; and
- their perceptions of and ways to adapt to CRHs.

Unfortunately, the role of local institutions that inhibit or facilitate adaptation (markets, extension, NGOs, etc.) was not part of the study.

Socio-economic conditions

The average household size in the Ghana case study was 6.1 persons. On average respondents went to school for 11 years. Respondents complained about high levels of poverty. For example, whilst over 90 per cent lived in a brick built house, could eat three times a day and could afford their children's school fees, a majority had neither health insurance nor means of mobility. 66 per cent of the respondents mentioned an income decrease over the past five years (vs 22 per cent increase).

Of the households, 87 per cent earns more than half of their income in agriculture, mostly through common rain-fed crops such as maize and cassava. Households cultivated five acres on average. More cultivated land led to a higher harvest value (total harvest multiplied by its market value): $R^2 = 0.255$. Only six farmers irrigated land. Land tenure restricts many farmers from doing long-term investments, such as tree-planting (Rozema, 2009). Respondents stated that poverty causes deforestation, leading to short-term individual gains, but long-term adverse impacts on the community.

In Botswana, the household size averaged 5.3 persons. Respondents went to school for seven years on average. Like in Ghana, they complained about high levels of poverty. Most respondents lived in a brick built house (82 per cent) and had means of mobility (56 per cent). However, 80 per cent had no health insurance, 65 per cent did not eat three times per day, and 55 per cent could not pay the school fees of their children.

Most of the respondents grew crops (77.5 per cent) and kept livestock 58 per cent). Their yearly income varies greatly, was difficult to quantify and is unknown. Respondents complained that the surroundings are very dry and getting dryer (Bogaert, 2009). For them CRHs were droughts. They stated that present-day harvests are lower than in the past, and that they keep smaller herds than before as less vegetation is available. This in its turn caused food shortages and reduced incomes. Some respondents were less affected as they lived close to groundwater sources that were provided by the government. A complex factor in Botswana was that respondents of all ages hold the government responsible for adaptation to CRHs. According to 55.3 per cent of the respondents the government (local, national, the chief or the president) is responsible for adaptation. Another 12.2 per cent consider God responsible. Only 3 per cent of the respondents consider themselves responsible. In terms of financing adaptation to CRHs, 69 per cent considers the government responsible. People who rely on the efficacy of public adaptation will probably take less action autonomously (Grothmann and Patt, 2005).

Perception of CRHs and adaptive measures

Ghanaian respondents stated that "drought", "heat", "rainfall variability" and "prolonged dry seasons" are typical CRHs with a high probability to happen (average > 4). The perceived high climate-dependency (average 4.3) and vulnerability to CRHs (average 3.8) (Figure 1) correlated significantly ($R^2 = 0.31$). Respondents feared that CRHs would lead

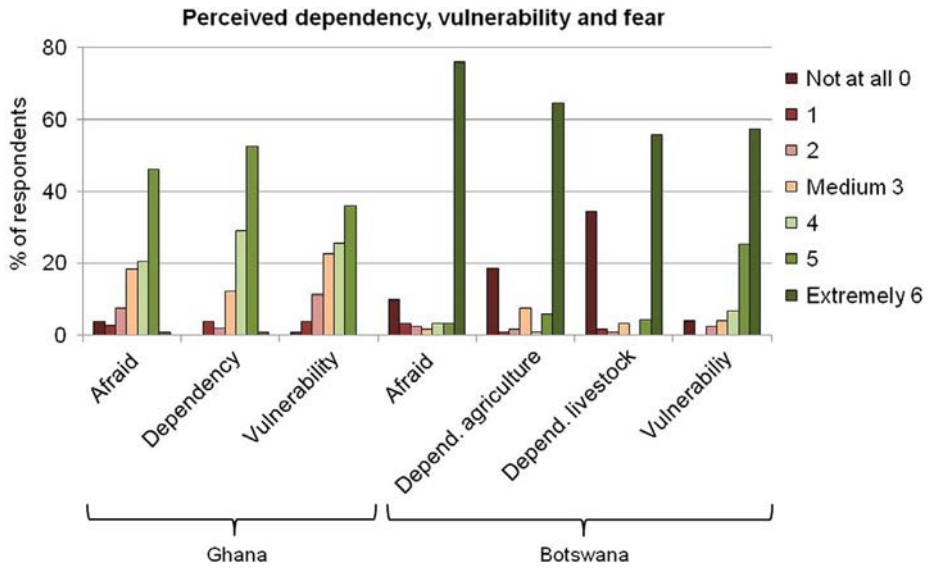


Figure 1.
Perceived fear for future CRHs, dependency on the climate, and vulnerability to CRHs for Ghana (left) and Botswana (right)

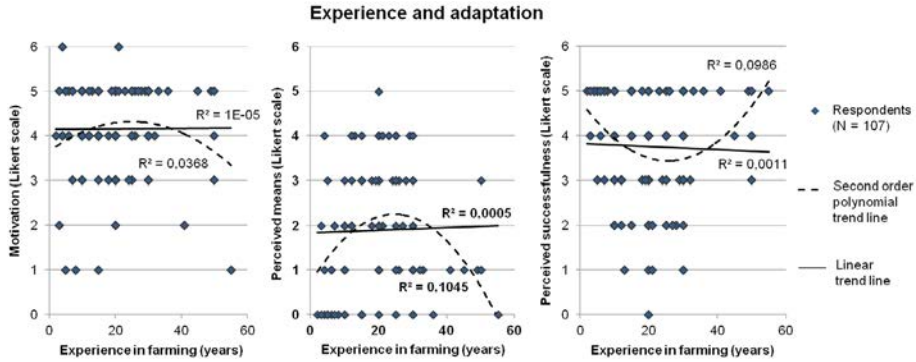
to hunger (mentioned by 91 respondents) and even death (nine times), yet in practice the most important consequence was outmigration of youth. Lack of water and failing harvests ranked second and third.

The respondents had little means to adapt to CRHs (average 1.9) and stated that financial constraints prevent control over CRHs. The motivation to adapt to CRHs was higher than in Botswana (average 4.2 vs 3.0), and had positive linear relations to their perceived experience in farming ($R^2 = 0.183$), the perceived cost-effectiveness of measures ($R^2 = 0.130$), means ($R^2 = 0.088$) and perceived successfulness in adaptation to CRHs ($R^2 = 0.051$). The latter also positively related to farmers' means to adapt ($R^2 = 0.221$) and perceived experience ($R^2 = 0.218$).

A second order polynomial trend line in farmers' motivation and years of experience/age showed that farmers around with 24.2 years of experience/the age of 55.2 were most motivated to adapt to CRHs. The age and years of experience themselves also correlated ($R^2 = 0.347$). Whilst the age correlated better with motivation than years of experience ($R^2 = 0.059$ vs $R^2 = 0.037$), the years of experience correlated better to the perceived means ($R^2 = 0.105$ vs $R^2 = 0.027$) and perceived vulnerability ($R^2 = 0.099$ vs $R^2 = 0.001$) (Figure 2).

Education, diversification of crops and irrigation were perceived as the most successful autonomous measures to adapt to CRHs; and nature conservation, irrigation and creating buffer zones around rivers as the most successful community measures. Outmigration and changing profession were considered as very ineffective (Figure 3), which needs to be seen in a socio-cultural context (e.g. the perception of failing as a farmer, or leaving elderly people behind). In practice outmigration is important in resilience of societies (Adger, 2000; McLeman and Smit, 2006) and it reduces the regional population growth from 2.5 per cent to 1.9 per cent (Ghana Statistical Service, 2005).

Diversifying crops was a successful way to increase income. Harvest values had more significant positive correlation with the number of crops grown ($R^2 = 0.401$) than with



Notes: n = 107; correlations are based on a linear trend line and a second order polynomial trend line

Figure 2.
Experience (years) of Ghanaian farmers and their perceived motivation to adapt (left), means (middle) and vulnerability (right)

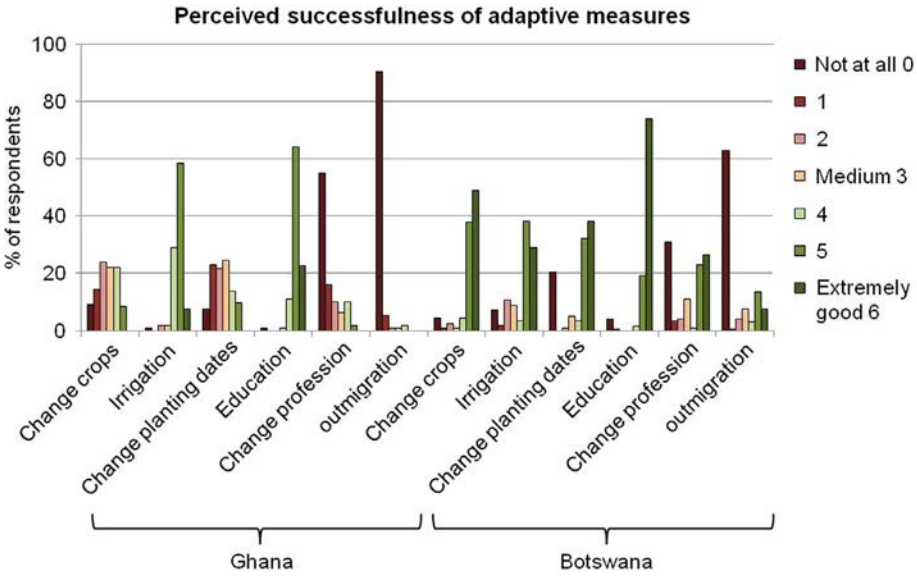


Figure 3.
Perceived successfulness of several measures to adapt to CRHs, for Ghanaian (left) and Botswana (right) respondents

the cultivated acreage ($R^2 = 0.255$). Irrigation also increases the net revenue per land unit (Kurukulasuriya *et al.*, 2006). Many respondents wanted to irrigate, but did not have the means.

Annual income and perceived means to adapt positively correlated ($R^2 = 0.216$). Respondents considered adaption to CRHs very cost-effective (average 4.6). However, as 66 per cent of them stated that their income decreased in the past five years, the available resources for adaptation are expected to decline.

In Botswana, the respondents' very high perceived vulnerability to droughts (average 5.2) and very high fear for droughts (average 5.0) correlated significantly ($R^2 = 0.15$). Respondents perceived to be highly climate-dependent (Figure 1). Inactiveness towards CRHs is not an option according to 89 per cent of the respondents.

The perceived climate-dependency decreased with increasing cultivated acreage ($R^2 = 0.17$) and increasing crop diversity ($R^2 = 0.31$). Yet neither agriculture nor livestock related climate-dependency correlated significantly with vulnerability, because the results of perceived dependencies were bipolar (Figure 1). This could be explained by the scattered groundwater provision by the government.

The respondents perceived education, changing crop types and varieties, and irrigation as the most effective autonomous measures to adapt to CRHs (Figure 3); and improving water availability, dialogues among water users, insurance and the DRP as the most effective community measures. 11 respondents partly relied on the DRP during the survey. Outmigration and changing profession were not considered successful to adapt to CRHs, yet in practice many respondents already diversified their livelihood. Despite respondents' preferences irrigation is uncommon in the area.

Respondents were only moderately motivated to adapt to CRHs (average 3.0). This probably relates to the all significantly correlating perceptions of little means to adapt (average 2.4), moderate ability to recover (2.9) and low successfulness in adapting (2.3). The low perceived experience (average 1.9) also correlated significantly to the perceived ability to recover ($R^2 = 0.197$) and perceived present and future successfulness in adaptation ($R^2 = 0.142$ and $R^2 = 0.095$, respectively)[1]. The moderate motivation could also be explained by the acceptance of droughts as the norm (Slegers, 2008) and the reliance on the government.

Wealthier farmers are better able to adapt. Both the perceived present-day successfulness in adaptation and the recovery capacity increase slowly with an increasing means to adapt ($R^2 = 0.07$ and $R^2 = 0.08$, respectively).

Synopsis: overall data

Both the respondents in Botswana and Ghana considered droughts as the most important CRH, perceived to be highly to very highly vulnerable to CRHs and climate-dependent for their livelihood. A combination of the largely complementary datasets is therefore valuable, despite many cultural, climatic, economic and social differences between the case studies. Unlike the data of the individual countries, size of the full dataset ($n = 227$) allowed for a χ^2-test on Likert scale questions. Some key factors were used that influence respondents' adaptation to CRHs, including the fear for future droughts and the means and motivation to adapt (Deressa *et al.*, 2009; Kreibich, 2011; Plapp and Werner, 2006).

Adaptive measures

Adaptation to CRHs is nothing new (Adger *et al.*, 2003) and has been successful in the past (Nyong *et al.*, 2007). Therefore, the intention was neither to discover new adaptive measures, nor to identify their successfulness. A χ^2-test was conducted to identify how respondents' perception of the effectiveness of individual adaptive measures relates to the overall adaptation to CRHs. Although education is perceived as an effective adaptive measure (Figure 3) it is at the same time influencing farmer adaptation indirectly (Maddison, 2007) and therefore not included in the analysis.

A Bonferroni correction was applied to counteract the problem of multiple comparisons. After the correction (df = 45) a p-value of $p \leq 2.2 \times 10^{-4}$ indicates a highly significant relation at $\alpha = 0.01$ level between a key factor in the perception of adaptation and an adaptive measure. In this case no results are only significant at

$\alpha = 0.05$ level (corresponding to $p \leq 1.1 \times 10^{-3}$). The χ^2-tests show no relation between either perceived overall successfulness in adaptation or recovery ability with any of the individual adaptive measures (Table I). There is for instance no relation between perceived effectiveness of changing planting dates and overall successfulness of adaptation ($p = 3.3 \times 10^{-3}$). Means and motivation were only associated with one adaptive measure ("changing planting dates" ($p = 7.8 \times 10^{-6}$) and "migration" ($p = 6.3 \times 10^{-6}$), respectively). The factors "dependency on agriculture", "fear", "vulnerability to CRHs", and "experience in adaptation" were often related to the perceived successfulness of on-farm adaptation measures (changing crops and changing planting dates) and hardly with little-practiced irrigation and off-farm adaptation.

Perception

A second χ^2-test was conducted on the relation between the nine key perception factors. After a Bonferroni correction (df = 36), 20 tests were highly significant at $\alpha = 0.01$ level (corresponding to $p \leq 2.7 \times 10^{-4}$) and two more were significant at $\alpha = 0.05$ level ($p \leq 1.4 \times 10^{-3}$) (Table II). The perceived means and climate-dependency are key for adaptation to CRHs: the former is highly significantly related to six factors ($p \leq 2.7 \times 10^{-4}$) and significantly related to one factor ($p \leq 1.4 \times 10^{-3}$); the latter is highly significantly related to seven factors ($p \leq 2.7 \times 10^{-4}$). Perceived means is only unrelated to the perceived drought probability. So even though "perceived means" showed association with the perceived successfulness of only one individual adaptive measure (Table I), it still plays a key role in the overall perception of adaptation to CRHs. Regression analysis indeed showed that respondents' motivation increased with increasing perceived means ($R^2 = 0.042$) and that increasing means lead to increased perceived successfulness in dealing with CRHs. In a second order polynomial trend line ($R^2 = 0.117$), this trend flattened to "moderately successful" (Figure 4).

Respondents with a very low and a very high perceived climate-dependency were least motivated to adapt to CRHs. Motivation decreased with increasing perceived vulnerability. "Experience" almost linearly increased motivation to adapt (Figure 5) and was highly significantly related ($p \leq 2.7 \times 10^{-4}$) to five factors but not to the respondents' perceived vulnerability or dependency (Table II). In rural farmer

	Individual adaptive measures				
	Change crops	Change planting dates	Irrigation	Change profession	Outmigration
Probability of a drought	3.00×10^{-6}*	1.17×10^{-6}*	0.001251	0.166182	0.8537
Fear of future droughts	1.03×10^{-13}*	4.66×10^{-13}*	0.013234	7.52×10^{-6}*	0.0343
Dependency on climate	1.69×10^{-11}*	4.07×10^{-14}*	0.003471	5.44×10^{-7}*	0.02551
Vulnerability to CRHs	2.03×10^{-10}*	4.41×10^{-9}*	0.097290	0.00712	0.02113
Experience	0.00294	9.51×10^{-5}*	0.000146*	0.03372	0.0086
Means to cope	0.00165	7.80×10^{-6}*	0.24076	0.28863	0.01595
Recover	0.012	0.01291	0.00648	0.0433	0.11264
Successful in adapting	0.01064	0.00337	0.05134	0.00806	0.35953
Motivation to adapt	0.00777	0.0016	0.0056	0.00616	6.33×10^{-6}*

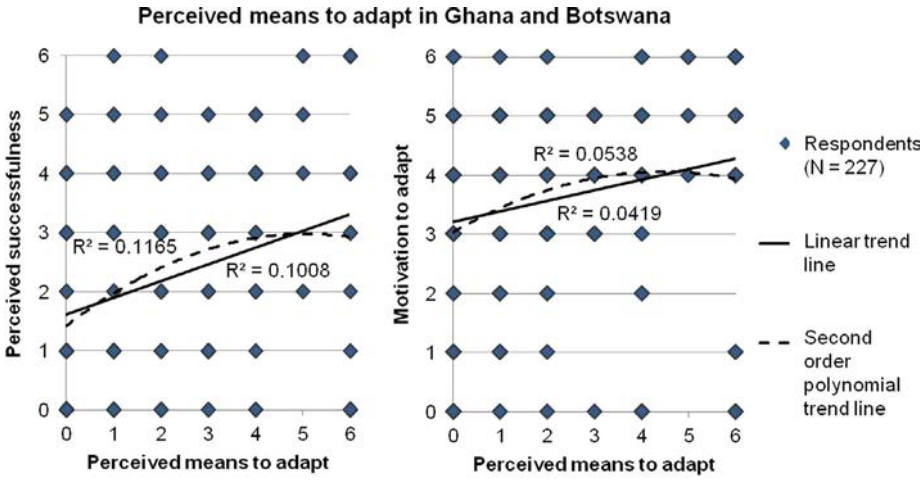
Notes: Highly significant at $\alpha = 0.01$ level after Bonferroni correction: *$p \leq 2.2 \times 10^{-4}$; a significant score means that the categorical variables are related

Table I. p-values of χ^2-test scores of the relation between perceived successfulness of individual adaptive measures and nine factors in perception of adaptation

Table II.
p-values from χ^2-test scores on nine factors that influence respondents' perception of CRHs and adaptation

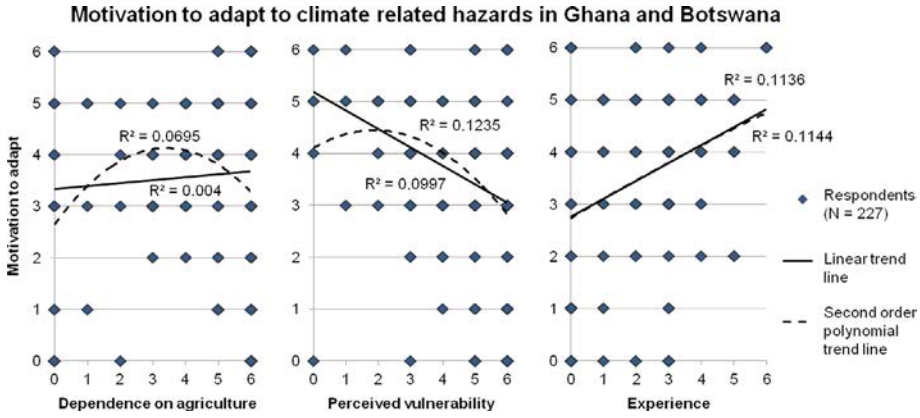
	Fear	Dependency	Vulnerability	Experience	Means	Recovery	Successful	Motivation
Probability of drought	$3.73 \times 10^{-6**}$	$1.08 \times 10^{-5**}$	0.01313	0.19217	0.03828	0.88178	0.91469	0.19386
Fear of future drought		$2.59 \times 10^{-9**}$	$7.89 \times 10^{-10**}$	$6.51 \times 10^{-6**}$	$4.43 \times 10^{-7**}$	0.2484	0.01089	$7{,}43 \times 10^{-4*}$
Climate-dependency			$3.80 \times 10^{-30**}$	0.02427	$1.87 \times 10^{-6**}$	$1.36 \times 10^{-3*}$	$2.63 \times 10^{-5**}$	$1.58 \times 10^{-5**}$
Vulnerability to CRHs				0.01462	$2.97 \times 10^{-6**}$	0.15352	$3.46 \times 10^{-5**}$	0.01851
Experience					$4.87 \times 10^{-17**}$	$4.47 \times 10^{-9**}$	$1.79 \times 10^{-8**}$	$1.05 \times 10^{-12**}$
Means to cope						$6.85 \times 10^{-6**}$	$3.32 \times 10^{-5**}$	$5.20 \times 10^{-5**}$
Recover							$4.73 \times 10^{-9**}$	0.01865
Successful in adapting								0.07895

Notes: Significant at $\alpha = 0.05$ level after Bonferroni correction: $^{*}p \leq 1.4 \times 10^{-3}$; highly significant at $\alpha = 0.01$ level after Bonferroni correction: $^{**}p \leq 2.8 \times 10^{-4}$; a significant score means that two factors are related



Notes: n = 227; correlations are based on a linear trend line and a second order polynomial trendline

Figure 4. Respondents' perceived means to adapt in relation to their motivation to adapt (right) and their perceived successfulness in adaptation (left)



Notes: n = 227; correlations are based on a linear trend line and a second order polynomial trendline

Figure 5. Respondents' motivation to adapt in relation to their perceived climate-dependence (left), perceived vulnerability (middle) and experience (right)

communities, Very experienced farmers can still be vulnerable and climate-dependent, and inexperienced people can be little vulnerable and hardly dependent on the climate for their livelihood. This adheres to the "complex environment" discourse (Section 2).

5. Discussion and conclusion

Researching subsistence farmers' perception of and adaptation to CRHs offers insight in the circumstances under which they can adapt to climate change. It shows the vulnerability and climate dependency of subsistence farmers, and their desperation to maintain their livelihood in agriculture. This study is based on only 227 interviews in

Ghana and Botswana and thus has limited inductive validity. However, three outcomes could be interesting particularly for the international adaptation finance community.

First, both case studies show an analogy between:

- respondents' perception of CRHs and existing environmental degradation; and
- respondents' measures to adapt to CRHs and the way environmental and economic problems are addressed in national development plans and policies.

Respondents react to natural resource-based development constraints (e.g. deforestation, drought impacts, soil erosion) through measures that can be considered as adaptation to CRHs (e.g. crop diversification, irrigation, outmigration). Therefore, the international climate finance community should build on existing development plans and policies in developing countries that already address climate-related environmental problems.

Second, the IPCC states that "African farmers have developed several adaptation options [...] but such adaptations may not be sufficient for future changes of climate" (Boko *et al.*, 2007). This paper concludes that it is not the "options" (here: "measures") that are most important for subsistence farmer adaptation to CRHs. The χ^2-test showed no association between the perceived overall effectiveness in adaptation, and the effectiveness of individual adaptive measures. Two examples are outmigration and irrigation. Outmigration happened in both countries, although respondents perceived it as very ineffective to adapt to CRHs. Irrigation was perceived as very effective. However, budget constraints prevent respondents from applying it. The perceived successfulness of adaptation is more dependent on the perception of experience ($R^2 = 0.165$), recovery ($R^2 = 0.172$) and means to adapt to CRHs ($R^2 = 0.101$). Based on the χ^2-tests and in line with Nyanga *et al.* (2011), this paper concludes that adaptation is more than the sum of adaptive measures. Financing adaptation thus requires more than financing adaptive measures. For example, this paper shows that increasing farmers' experience and means increases their motivation to adapt to CRHs. "Soft" adaptation (e.g. knowledge sharing, building institutions) as well as tackling development constraints that prevent successful adaptation (e.g. poverty and limited water availability) should be integrated in adaptation finance (Denton, 2010).

Finally, the respondents' motivation to adapt to CRHs decreased with increasing perceived vulnerability. In combination with the argument that adaptation measures of African farmers may not be sufficient for future climatic changes (Boko *et al.*, 2007), the message to international climate finance institutions is that *ex post* adaptation (incl. disaster relief) will remain important.

Note

1. Conform people's bias towards future risks (Patt and Schröter, 2008) the future successfulness to adapt to droughts was perceived higher than at present (average 2.6 vs 2.3).

References

Adedoyin, J.A. and Mphale, K. (2002), "Climate variability: its impacts and mechanism within the Kalahari transect of southern Africa", paper presented at Conference Paper MSAS Conference 2002.

Adger, W.N. (2000), "Social and ecological resilience: are they related?", *Progress in Human Geography*, Vol. 24 No. 3, pp. 347-364.

Adger, W.N., Huq, O.S., Brown, K., Conway, D. and Hulme, M. (2003), "Adaptation to climate change in the developing world", *Progress in Development Studies*, Vol. 3 No. 3, pp. 179-195.

Agyemang-Bonsu, W., Kojo, W., Minia, Z., Dontwi, J., Dontwi, I.K., Buabeng, S.N., Baffoe-Bonnie, B., Agyemang-Yeboah, F., Buabeng, S.N., Ofori, E., Gyasi, E.A., Karikari, O., Dugan, E., Nelson, W., Naa Debei Agbey, A., Sagoe, R., Damptey, P., Tutuah Mensah, A., Anim-Kwapong, G.J. and Frimpong, E.B. (2008), *Ghana Climate Change Impacts, Vulnerability and Adaptation Assessments; Under The Netherlands Climate Assistance Programme* (*NCAP*), Environmental Protection Agency, Accra.

Bird, D.K. (2009), "Use of questionnaires for acquiring information on public perception of natural hazards", *Natural Hazards and Earth System Sciences*, Vol. 9, pp. 1307-1325.

Bogaert, L. (2009), "Vulnerability and adaptation to climate change in eastern Botswana", Master thesis Environment and Resource Management, Institute for Environmental Studies, VU University.

Boko, M., Niang, I., Nyong, A. and Vogel, C. (2009), "Africa", in Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E. (Eds), *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Cambridge University Press, Cambridge, pp. 433-467.

Bryan, E., Deressa, T.T., Gbetibouo, G.A. and Ringler, C. (2009), "Adaptation to climate change in Ethiopia and South Africa: options and constraints", *Environmental Science and Policy*, Vol. 12 No. 4, pp. 413-426.

Chaum, M., Faris, C., Wagner, G., Buchner, B., Falconer, A., Trabacchini, C., Brown, J. and Sierra, K. (2011), "Improving the effectiveness of climate finance: key lessons", Climate Policy Initiative Paper, ODI, EDF, CPI and Brooking.

Christensen, J.H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R.K., Kwon, W.-T., Laprise, R., MagañaRueda, V., Mearns, L., Menéndez, C.G., Räisänen, J., Rinke, A., Sarr, A. and Whetton, P. (2007), "Regional climate projections", in Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L. (Eds), *Climate Change 2007: The Physical Science Basis*, Cambridge University Press, Cambridge, pp. 847-940.

CSIR (2003), *Protection and Strategic Uses of Groundwater Resources in Drought Prone Areas of the SADC Region*, ENC-P-C 2003-026 ed. Environmentek, Council for Scientific and Industrial Research, Pretoria.

Denton, F. (2010), "Financing adaptation in least developed countries in West Africa: is finance the 'real deal'?", *Climate Policy*, Vol. 10, pp. 655-671.

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T. and Yesuf, M. (2009), "Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia", *Global Environmental Change*, Vol. 19 No. 2, pp. 248-255.

Dolan, A.H., Smit, B., Skinner, M.W., Bradshaw, B. and Bryant, C.R. (2001), "Adaptation to climate change in agriculture: evaluation of options", Occasional Paper No. 6, Ed., Department of Geography, University of Guelph.

Eriksen, S., Aldunce, P., Bahinipati, C.S., Martins, R.D., Molefe, J.I., Nhemachena, C., O'Brien, K., Olorunfem, F., Park, J., Sygna, L. and Ulsrud, K. (2011), "When not every response to climate change is a good one: identifying principles for sustainable adaptation", *Climate and Development*, Vol. 3, pp. 7-20.

FAO (2011), *FAOSTAT Online Statistical Service*, Food and Agriculture Organization of the United Nations, Rome.

Gbetibouo, G.A. (2009), "Understanding farmers' perception and adaptations to climate change and variability: the case of the Limpopo Basin, South Africa", IFPRI Discussion Paper No. 849, February.

Ghana Statistical Service (2005), *2000 Population and Housing Census: Analysis of District Data and Implications for Planning*, Ghana Statistical Service, Volta Region.

Government of Botswana (2000), *Botswana National Atlas*, Department of Surveys and Mapping, Gaborone.

Government of Botswana (2002), *Botswana: National Development Plan 9. Part 1 – Policies and Objectives*, Ministry of Finance and Development Planning, Gaborone.

Government of Botswana (2011), "ISPAAD Programme", available at: www.gov.bw/en/Ministries–Authorities/Ministries/MinistryofAgriculture-MOA/Departments-of-MOA/MOA-Departments1/ISPAAD-Programme/ed

Government of Botswana and United Nations (2010), *Millennium Development Goals, Status Report 2010*, Botswana Ministry of Finance and Development Planning and United Nations in Botswana, Gaborone.

Griebenow, G. and Kishore, S. (2009), "Mainstreaming environment and climate change in the implementation of poverty reduction strategies", Environment Department Paper No. 119, The World Bank, Washington, DC, June.

Grosh, M. and Glewwe, P. (2000), "Designing household survey questionnaires for developing countries: lessons from 15 years of the living standards measurements study", Report No. 20731, Ed., The World Bank, Washington, DC.

Grothmann, T. and Patt, A. (2005), "Adaptive capacity and human cognition: the process of individual adaptation to climate change", *Global Environmental Change*, Vol. 15 No. 3, pp. 199-213.

Hulme, M., Doherty, R., Ngara, T., New, M. and Lister, D. (2000), "African climate change: 1900-2100", *Climate Research*, Vol. 17, pp. 145-168.

Kandlikar, M. and Risbey, J. (2000), "Agricultural impacts of climate change: if adaptation is the answer, what is the question? An editorial comment", *Climatic Change*, Vol. 45, pp. 529-539.

Kreibich, H. (2011), "Do perceptions of climate change influence precautionary measures?", *International Journal of Climate Change Strategies and Management*, Vol. 3 No. 2, pp. 189-199.

Kurukulasuriya, P., Mendelsohn, R., Hassan, A., Benhin, J., Deressa, T.T., Diop, M., Eid, H.M., Fosu, K.Y., Gbetibouo, G.A., Jain, S., Mahamadou, A., Mano, R., Kabubo-Mariara, J., El-Marsafawry, S., Molua, E., Ouda, S., Ouedraogo, M., Séne, I., Maddison, D., Niggol Seo, S. and Dinar, A. (2006), "Will African agriculture survive climate change?", *The World Bank Economic Review*, Vol. 20 No. 3, pp. 367-388.

Maddison, D. (2007), "The perception of and adaptation to climate change in Africa", Policy Research Working Paper No. 4308, Ed., The World Bank, Washington, DC.

Magadza, C.H.D. (2003), "Engaging Africa in adaptation to climate change", in Smith, J.B., Klein, R.J.T. and Huq, S. (Eds), *Climate Change, Adaptive Capacity and Development*, Imperial College Press, Singapore, pp. 261-283.

McLeman, R. and Smit, B. (2006), "Migration as an adaptation to climate change", *Climatic Change*, Vol. 76, pp. 31-53.

Mertz, O., Mbow, C., Østergaard Nielsen, J., Maiga, A., Diallo, D., Reenberg, A., Diouf, A., Barbier, B., Bouzou Moussa, I., Zorom, M., Ouattara, I. and Dabi, D. (2010), "Climate factors play a limited role for past adaptation strategies in West Africa", *Ecology and Society*, Vol. 15 No. 4, p. 25.

Meze-Hausken, E. (2004), "Contrasting climate variability and meteorological drought with perceived drought and climate change in northern Ethiopia", *Climate Research*, Vol. 27 No. 1, pp. 19-31.

MoFA (2006), *Draft National Irrigation Policy, Strategies and Regulatory Measures*, Ministry of Food and Agriculture Ghana, Accra.

MoFA (2008), *Agriculture Sustainable Land Management Strategy and Action Plan 2009-2015*, Ministry of Food and Agriculture Ghana, Accra.

Mortimore, M.J. and Adams, W.M. (2001), "Farmer adaptation, change and 'crisis' in the Sahel", *Global Environmental Change*, Vol. 11 No. 1, pp. 49-57.

Nhemachena, C. (2008), *Local Adaptation to Climate Change in Agriculture: Experiences from Southern Africa*, Centre for Environmental Economics and Policy in Africa, University of Pretoria, Pretoria, pp. 1-12.

Nhemachena, C. and Hassan, R.M. (2007), "Micro-level analysis of farmers' adaptation to climate change in southern Africa", IFPRI Discussion Paper No. 714.

Nyanga, P.H., Johnsen, F.H., Aune, J.B. and Kalinda, T.H. (2011), "Smallholder farmers' perceptions of climate change and conservation agriculture: evidence from Zambia", *Journal of Sustainable Development*, Vol. 4 No. 4, pp. 73-85.

Nyong, A., Adesina, F. and Osman Elasha, B. (2007), "The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel", *Mitigation and Adaptation Strategies for Global Change*, Vol. 12, pp. 787-797.

Patt, A.G. and Gwata, C. (2002), "Effective seasonal climate forecast applications: examining constraints for subsistence farmers in Zimbabwe", *Global Environmental Change*, Vol. 12, pp. 185-195.

Patt, A.G. and Schröter, D. (2008), "Perceptions of climate risk in Mozambique: implications for the success of adaptation strategies", *Global Environmental Change*, Vol. 18, pp. 458-467.

Pauw, W.P., Mutiso, S., Mutiso, G., Manzi, H.K., Lasage, R. and Aerts, J.C.J.H. (2008), *An Assessment of the Social and Economic Effects of the Kitui Sand Dams*, Report IVM R-08/08 Ed, Institute for Environmental Studies (IVM), Amsterdam.

Perret, C. and Bossard, L. (2008), "Climate and climate change", in FAO, ECOWAS-SWAC, OECD, and CILSS (Eds), *Atlas on Regional Integration in West Africa*, FAO, Rome.

Plapp, T. and Werner, U. (2006), "Understanding risk perception from natural hazards: examples from Germany", in Amman, W.J., Dannenmann, S. and Vulliet, L. (Eds), *RISK 21 – Coping with Risks due to Natural Hazards in the 21st Century*, Taylor & Francis, London, pp. 101-108.

Roncoli, C., Ingram, K. and Kirshen, P. (2001), "The costs and risks of coping with drought: livelihood impacts and farmers' responses in Burkina Faso", *Climate Research*, Vol. 19, pp. 119-132.

Rozema, J. (2009), "Evaluating the elements: a research on the risk perception of farmers in the Dayi River basin towards climate related hazards", Master thesis, Environment and Resource Management, Institute for Environmental Studies, VU University.

Schalatek, L. (2011), "A matter of principle(s): a normative framework for a global compact on public climate finance", Ecology Paper Series of the Heinrich Böll stiftung, Vol 13.

Schulze, R.E. (2000), "Modelling hydrological responses to land use and climate change: a Southern African perspective", *Ambio*, Vol. 29 No. 1, pp. 12-22.

Sjöberg, L. (2000), "The methodology of risk perception research", *Quality and Quantity*, Vol. 34, pp. 407-418.

Slegers, M.F.W. (2008), "If only it would rain: farmers' perceptions of rainfall and drought in semi-arid central Tanzania", *Journal of Arid Environments*, Vol. 72 No. 11, pp. 2106-2123.

Slegers, M.F.W. and Stroosnijder, L. (2008), "Beyond the desertification narrative: a framework for agricultural drought in semi-arid East Africa", *Ambio*, Vol. 37 No. 5, pp. 372-380.

Smit, B. and Pilifosova, O. (2003), "From adaptation to adaptive capacity and vulnerability reduction", in Smith, J.B., Klein, R.J.T. and Huq, S. (Eds), *Climate Change, Adaptive Capacity and Development*, Imperial College Press, London, pp. 9-28.

Smit, B. and Skinner, M.W. (2002), "Adaptation options in agriculture to climate change: a typology", *Mitigation and Adaptation Strategies for Global Change*, Vol. 7 No. 1, pp. 85-114.

Stigter, C.J., Zheng, D.W., Onyewotu, L.O.Z. and Mei, X.R. (2005), "Using traditional methods and indigenous technologies for coping with climate variability", *Climatic Change*, Vol. 70, pp. 255-271.

Thomas, D.S.G. and Twyman, C. (2004), "Equity and justice in climate change adaptation amongst natural-resource-dependent societies", *Global Environmental Change*, Vol. 15, pp. 115-124.

UNECA (2001), *Population, Agriculture and Environment in Africa: Some Key Indicators*, United Nations Economic Commission for Africa, Food Security and Sustainable Development Division, Addis Ababa.

UNFCCC (2009), *Copenhagen Accord*, FCCC/CP/2009/11/Add.1, United Nations Framework Convention on Climate Change, Bonn.

UNFCCC (2010), *Cancun Agreements*, FCCC/CP/2010/7/Add.1, United Nations Framework Convention on Climate Change, Bonn.

Valentine, T.R. (1993), "Mineral-led economic growth, drought relief and incomes policy: income distribution in Botswana reconsidered", *American Journal of Economics and Sociology*, Vol. 52 No. 1, pp. 31-49.

van Aalst, M.K., Cannon, T. and Burton, I. (2008), "Community level adaptation to climate change: the potential role of participatory community risk assessment", *Global Environmental Change*, Vol. 18 No. 1, pp. 165-179.

Westerhoff, L. and Smit, B. (2008), "The rains are disappointing us: dynamic vulnerability and adaptation to multiple stressors in the Afram Plains, Ghana", *Mitigation and Adaptation Strategies for Global Change*, Vol. 14, pp. 317-337.

Wright, D. (1997), *Understanding Statistics: An Introduction for the Social Sciences*, Sage, London, p. 228.

Ziervogel, G., Bharwani, S. and Downing, T.E. (2006), "Adapting to climate variability: pumpkins, people and policy", *Natural Resources Forum*, Vol. 30 No. 4, pp. 294-305.

Further reading

Kurukulasuriya, P. and Rosenthal, S. (2003), "Climate change and agriculture: a review of impacts and adaptations", Climate Change Series Paper No. 91, Ed., The World Bank Environment Department, Washington, DC.

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