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How resilient are farming households and communities to a changing climate in Africa? A gender-based perspective

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ABSTRACT

In this paper we examine conditions that underlie vulnerability and resilience possibilities for households and communities that face and respond to climate- and other changes, in nine East and West African countries. We base our analysis on a unique integrated qualitative and quantitative dataset composed of household surveys and village focus group studies carried out across a wide range of environments and agricultural systems. We identify human population growth, commercialization of the economy, and natural resource use policies, in addition to weather, as key drivers of change. We compare the agricultural and livelihood systems of male and female respondents, as well as their productive resources, organization and access to services. Women have less access than men to common property resources, as well as to cash to obtain goods or services. Women control less land than men, the land they control is often of poorer quality, and their tenure is insecure. Women engage in mutual insurance and risk-sharing networks, and benefit from non-agricultural services provided by social support institutions external to the village. Formally registered, public and private external organizations that foster agriculture and livestock production have tremendous anti-women biases, and tend to provide support primarily to men. Policies and strategies are needed to eliminate those prejudices so that men and women increase their resilience and manage well their changing environments.

1. Introduction

For the food security challenge in a world with 9.6 billion people by 2050 (United Nations DESA, 2013), climate change poses both an opportunity and a threat. The opportunity lies in the possibility of very different and more resilient agricultural systems, particularly in areas where millions of smallholder farming families currently live such as Africa. The threat is that the social, economic or ecological conditions become so dire that they overrun the systems' capacity to absorb them. Societies may alter their behavior, but such changes may not represent the extent of transformative agricultural systems change needed. Beyond a threshold, incremental changes will no longer be effective, and major alterations in structure or function will be required (Kates et al., 2012; Walker and Meyers, 2004).

Africa, and sub-Saharan Africa in particular, rank among the most vulnerable regions to climate variability and change. Under current conditions these regions have naturally high levels of climate variability and rain-dependency, high reliance on climate sensitive activities, regular food crises and water scarcity, rapid population growth, and limited economic and institutional capacity to cope with, and adapt to, climate variability and change. In addition, it is probable that, due to climate change, they will face projected increases in mean annual temperatures, greater unpredictability of rainfall that is likely to exacerbate existing water shortages, very likely reductions of cereal crop productivity, and surges in disease, pest and weed pressure on crops and livestock (Niang et al., 2014).

This paper focuses on what is known about current agricultural and livelihood systems in different environments in nine African countries, and what kind of changes farmers and their communities have been making in recent years. The goal is to better understand where vulnerabilities to climate change and resilience

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possibilities lie. We use the concepts of vulnerability, adaptive capacity and resilience to frame the analysis. The concept of vulnerability aligns three major research paradigms, namely risk-hazard, political economy/ecology, and ecological resilience. Here we adopt a political economy/ecology framework that emphasizes the need to explore and better understand how people and places are affected differently, the explanations for variance in capacities to cope and adapt, and the causes and consequences of differential susceptibility (Eakin and Luers, 2006; McLaughlin and Dietz, 2008; Miller et al., 2010). Focusing on gender relations and gendered access to resources, asset ownership, and decision making, we also utilize a feminist political ecology framework to analyze how women and men are differently affected by issues of climate change and resource degradation (Ajibade et al., 2013). We consider sociopolitical, economic and cultural conditions that result in differential hazards, impacts and capacity to recover from impacts.

Vulnerability depicts the extent to which a natural or social system is prone to damage. In social–ecological systems, vulnerability can be described as a dynamic "space" bounded by historical and socially constructed sociopolitical and economic processes and structures that are negotiated. Vulnerability affects individuals and social groups according to the rights and opportunities to which they are entitled (Sen, 1981). These entitlements often vary according to gender, ethnicity, religion, class and age conditions (Cutter, 1995; Denton, 2002; Goldman and Riosmena, 2013). They encompass resources and assets, including labor power, technology, education and information, as well as people's decision-making power and adaptive capacity (Adger and Kelly, 1999; Downing et al., 1996; Kelly and Adger, 2000; Prowse and Scott, 2008; Sen, 1981, 1990; Turner et al., 2003). Gender plays an important role here as some individuals may be constrained from pursuing particular adaptation options by a lack of access to or control over assets or by cognitive, social or cultural limitations (Meinzen-Dick et al., 2014; Meyiwa et al., 2014; Nyantakyi-Frimpong and Bezner-Kerr, 2015).

Vulnerability differs by individuals, groups and social classes, within and across communities (Goldman and Riosmena, 2013; Westerhoff and Smit, 2009; Ajibade et al., 2013), as well as by regions (Bohle et al., 1994). The who, where, and when of vulnerability are determined by the combination of human, physical and political circumstances that shape the allocation of assets in society (Pelling and Uitto, 2001), which often change over time (McDowell and Hess, 2012; Sugden et al., 2014). In the case of smallholder farmers these circumstances may include soil conditions, access to markets, declining natural resources, and weakening of societal safety nets (Rurinda et al., 2014). They may also encompass systemic weaknesses, institutional constraints (Nelson et al., 2007) and historical forms of social domination and marginalization. When assessing the vulnerability of households and individuals, it is critical to look beyond a simple binary categorization of men/women and use a broader framework to assess the 'intersectionality' of gender with other social determinants (Nyantakyi-Frimpong and Bezner-Kerr, 2015).

The current understanding of climate change vulnerability includes exposure to climate risks (such as extreme weather events, losses in agricultural productivity and alterations in hydrological patterns), sensitivity to such risks, and capacity to adapt, usually with an ecological and, increasingly, social–ecological systems viewpoint (Adger, 2006; Eakin and Luers, 2006; IPCC, 2007; Nelson et al., 2007; Smit and Wandel, 2006). The sensitivity of social–ecological systems results from a high level of dependency on climate-vulnerable natural resources and environmental services for livelihoods, food, energy and shelter (Marshall et al., 2010). In social–ecological systems, adaptive capacity is related to the ability to respond (moderate or offset) actual or expected climatic and other challenges by altering processes, practices, or structures, including governance and assets, in order to reduce vulnerability (Marshall et al., 2010; Smit and Wandel, 2006). Adaptive capacity is therefore about people's ability to convert current and future resources (financial, physical, human, social or natural capitals) into successful adaptation strategies for the future (Adger et al., 2005).

Conceptually and methodologically, it is easier to recognize vulnerability where the shocks are direct and obvious, like in an environmental hazards context. Under climate change, on the other hand, the effects are hard to appreciate because they unfold over decades of subtle shifting of conditions (e.g. rainfall patterns, timing of flowering, outbreaks of new pests and diseases, asynchrony and system interaction among pests and biological control agents, and reduction in agrobiodiversity). In addition, climate conditions in many parts of the tropics will become increasingly variable. All of this makes it difficult to determine future risks based on predictions, or to use experience and historical data to identify and plan for the likely direct and indirect impacts of climate change. Decision-making will thus be more frequently based on insufficient knowledge and limited resources. This means that building resilience is key because it makes it possible for a system to deal with surprising and unexpected stress (Tompkins and Adger, 2004). The challenge is to find points of intervention in a system to increase its resilience to future changes, including unforeseeable ones.

The original understanding of resilience emphasized strength and resistance. However, its most recent applications to ecology, social–ecological systems and disaster management assume that the normal state of ecological and socio-ecological systems is change, which often cannot be predicted. Resilience is the capacity of a social–ecological system to manage social, political and environmental disruptions and adapt to them (Adger, 2006; Folke, 2002; Gallopín, 2006; Marshall and Marshall, 2007). Resilience preparedness activities, therefore, aim not at resisting change but preparing to live with it (Folke, 2006). This underscores the following critical components of resilience: learning, new knowledge creation and governance; flexibility to experiment and adopt new practices; and capacity for deliberation, analysis and risk management (Adger et al., 2005; Berkes et al., 2003; Darnhofer et al., 2010; Gunderson, 2001; Marshall et al., 2010; Miller et al., 2010).

Fostering resilience is analogous to building on-going adaptive capacity of individuals and social organizations. Moving from vulnerability management to resilience is not simple conceptually or practically (Berkes, 2007; Gallopín, 2006; Miller et al., 2010; Tyler and Moench, 2012; Walker et al., 2002). Some resilience may be negative and perverse (Gallopín, 2006). Maru et al. note that the characteristics that persist may or may not be desirable. Short-term responses to vulnerability may increase specific resilience while creating greater vulnerability in the long-term (Maru et al., 2014).

Adding gender into the discourse on vulnerability and adaptive capacity creates an additional layer of complexity to an already complex problem. Much of the literature on gender and climate change acknowledges that women are more vulnerable to climate change, and women are often represented as a homogenous group (Arora-Jonsson, 2011). Gender alone, however, is not a significant determinant of vulnerability (Ajibade et al., 2013). While the impacts of climate change on different genders needs to be taken into account, a broad perspective beyond agricultural concerns needs to be also considered. For example, water issues caused by climate change sometimes force women and girls to walk longer distances to fetch water, exposing them to greater risk of gender-based violence (Meyiwa et al., 2014). Among vulnerable groups, comprised of both men and women, Tschakert (2007) found that

climate did not factor directly into their perceived risk assessments. Issues such as poor health, lack of money and infrastructure were much more prominent in their concerns (Tschakert, 2007).

To examine a broad set of concerns among both men and women regarding their livelihoods and their ability to cope with stress, we use a unique qualitative and quantitative dataset on household- and community level perspectives. An analysis of the dataset allows us to appreciate the extent to which those human groups are exposed to, and able to cope with and recover from multiple stresses and shocks. We consider their vulnerability and resilience from a multi-layered and multidimensional perspective of "concentric" social spaces (household, community, region) akin to a set of Russian dolls. Each one of the outer layers hinders or empowers the capabilities of people within the inner layers to define and use successful livelihood strategies. By probing those spaces we identify key resilience factors, and propose some resilience indicators.

2. Methods and data

We draw on information from a household quantitative survey and a series of rapid qualitative village focus group studies implemented from late 2010 to early 2011. Data were collected in four countries in East Africa (Ethiopia, Kenya, Tanzania and Uganda) (Kristjanson et al., 2012) and five in West Africa (Burkina Faso, Ghana, Mali, Niger, Senegal). The household survey and village studies are components of the baseline definition activities of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) (Vermeulen et al., 2011). The baseline studies were designed to provide one source of evidence for behavioral change and development outcomes to which CCAFS may have contributed, through time and at different scales (Förch et al., 2014).

One common survey questionnaire was implemented in 11 sites (six in East Africa and five in West Africa) in nine countries (Fig. 1). Within each site, the sampling frame used was a square block of land measuring approximately 10 km by 10 km in East Africa and 30 km by 30 km in West Africa (the larger sampling frames to compensate for lower population densities). CCAFS' research sites were chosen in a highly participatory manner in consultation with a wide range of partners (including NARES, NGOs, government agents and farmers' organizations), with an aim to select sites along a range of key biophysical and agro-ecological gradients with varied agricultural production systems, and with a gradient of anticipated temperature and precipitation changes. Sites were also chosen that contained established agricultural research partners, had available long-term socio-economic and weather data, were connected to a network of regional partners to facilitate scaling up, and had mitigation and/or carbon sequestration potential. The sites were also judged by expert opinion to represent a wide range of conditions faced by many rural farming households across each region (Kristjanson et al., 2012). The chosen sampling frames were mapped, and all villages within were numbered. Seven villages within the sampling frame and in turn 20 households within each village were randomly selected. A household was defined as being "composed of a group of people living in the same dwelling space who eat meals together and have at least one common plot together or one food/income-generating activity together (e.g. herding, business, fishing) and acknowledge the authority of a man or woman who is the head of household" (Beaman and Dillon, 2010). In total, 77 villages (seven villages per site) and 1540 households (11 sites × 140 households per site) were

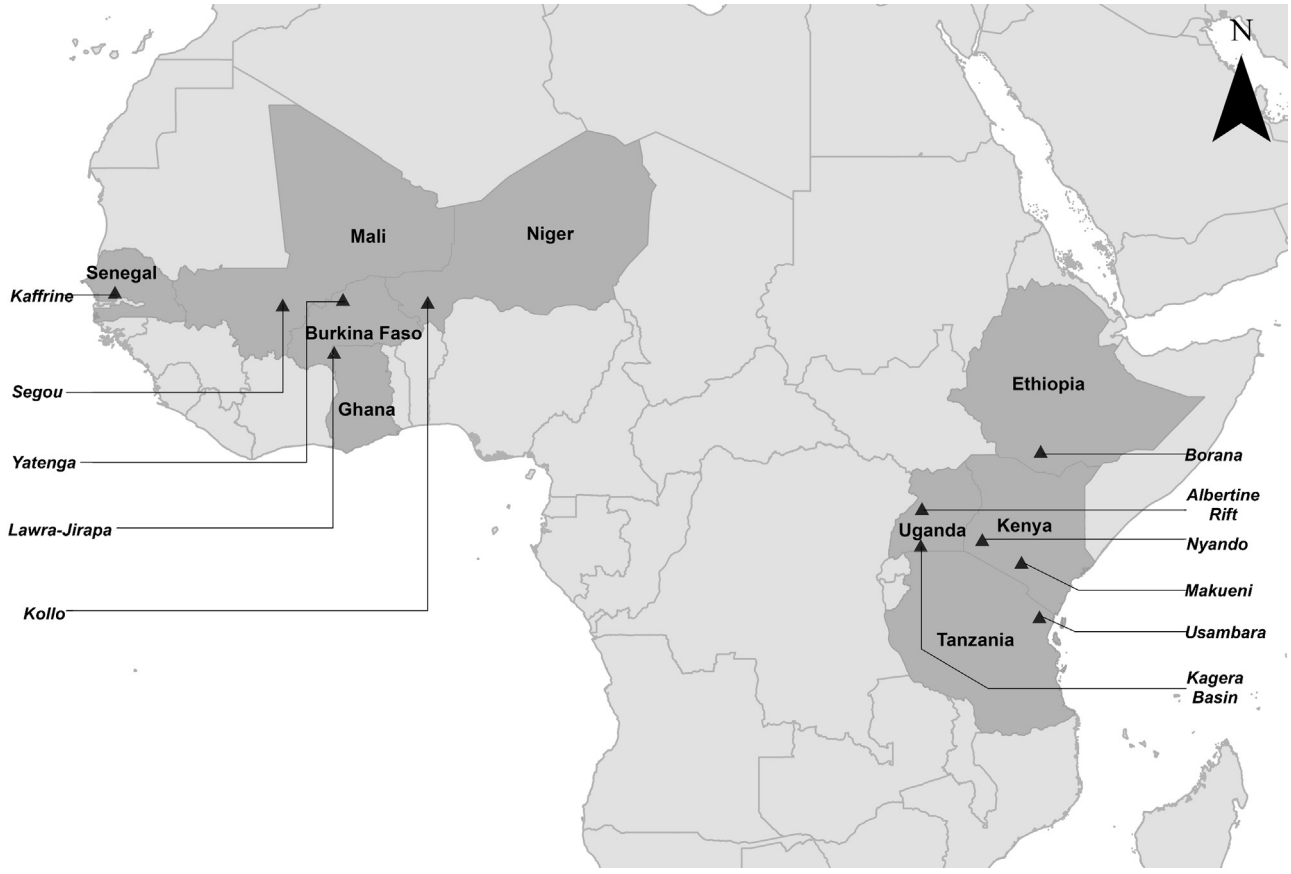

Fig. 1. Map of the baseline study sites.

included in the household survey, which resulted in 1530 viable survey responses.

The surveys included standard indicators to ensure comparability across a wide range of locations and farming systems, hence it was not as in-depth as is possible in location-specific household surveys. The nature of the baseline surveys was exploratory and not explanatory.

The baselines were made up of household- and village-level approaches. The **household** baseline survey was designed to collect baseline information about basic household level indicators to monitor progress toward a range of outcomes desired by the CCAFS program, including improved food security and resilience at the household and community levels (Förch et al., 2014). This included information about household size, household assets, sources of livelihood, natural resources access and management, adaptation strategies relating to crops, livestock, aquaculture, agroforestry and land management; food security and risk, sources of information, and social networks. Hence, the study was set to address the following research questions, among others:

- Are households with greater asset levels (e.g. those with grain storage facilities and water harvesting/storage structures) more food secure?
- Are households that are receiving climate and agriculture-related information more food secure?
- Are diverse agricultural production-related livelihood strategies and sources of income better off than those that are less diversified?
- Are households that are more market-oriented better off than those that are more subsistence-oriented?
- Are households that have made more agricultural changes in the last 10 years (i.e. more adaptable or innovative) more food secure than those making few changes?
- Are households (and women) engaged in community groups that are collectively engaged in soil, water, land management and improvement activities more food secure?
- Are communities with strong networks and linkages of community organizations engaged in natural resources management able to reduce community vulnerability to climate risks and enhance their preparedness?

The sample sizes were kept to a minimum and were designed so that the indicators developed would measure relatively large changes.

The **village** baseline study was aimed at producing and mapping out gender-differentiated information about the state of natural resources, and the concerns, opportunities and vision that communities have for their environment in the future. It also covered the organizational landscape as perceived by the community and attempts to identify the structure and extent of information networks. These qualitative, focus group based studies were conducted in one out of the seven villages at each site where the household survey was implemented. The studies lasted three days per village, and included different sets of 15 men and 15 women participants, one set for each day, who were randomly chosen on the basis of the household listings prepared for the household survey. To the extent feasible, the participant groups included individuals of different age levels as well. The village studies sought to ascertain qualitative information on indicators of natural resource use, organizational arrangements, as well as on information networks for weather and agricultural information.

Below we present analyses that use both the qualitative and quantitative information obtained from the household survey and the village studies. A detailed description of the sites, the sampling frame, the tools and the household and village study reports can be found at ccafs.cgiar.org/resources/baseline-surveys. A joint analysis of the baseline data has provided the opportunity to match problems, community priorities, organizations' agendas and resources, and gauge the extent to which important agents contribute to addressing short- and long-term problems. This allows an identification of the gaps that may exist in the actions and strategies that individuals, communities and organizations take to enhance their capacity to adapt to, and reduce risks associated with, a changing climate.

Twenty percent of the survey respondents were from female-headed households (Table 1). According to FAO data, 26% of the households in sub-Saharan Africa are female-headed (30% in Eastern Africa and 19% in Western Africa). Sub-Saharan Africa has both the highest- and the lowest prevalence of female-headed households in developing regions (respectively, Swaziland and Burkina Faso) (FAO, 2011: 118–119).

Results from the household survey were analyzed using logistic regression for each variable, adjusting for whether the household was headed by females or males (a dummy variable with male-headed = 1, female-headed = 0), whether the household was in East or West Africa (a dummy variable with East Africa = 1, West Africa = 0), and the interaction between these variables. We compared East and West Africa rather than adjusting for each country of origin because we had relatively few respondents from female-headed households in some countries.

3. Results

3.1. Livelihoods, natural resources and land use in the sites

The sample population encompasses smallholder farmers who use mainly family labor and low levels of technology, and consume most of their output directly. In a few sites it also includes pastoralists or agropastoralists who depend largely on the sale of livestock and livestock products to buy staple foods and other necessities. In general, the households purchase few inputs, sell a small proportion of their output, derive their main source of income from their farm but participate in off-farm and/or nonfarm employment whenever possible. Both agriculturalists and pastoralists engage in hunting/gathering of wild resources to meet food requirements as well as energy, clothing, health, and cash income needs.

Food security varies within and across sites. Many of the households struggle to feed their families, from any source, for one or more months of the year, and depend on government aid to get through these hunger months. In Nyando, Kenya and Usambara, Tanzania the hunger period lasts up to 6 months of the year. In Makueni, Kenya it is reported to last up to 10 months, and people depend on food relief and remittances from male family members working in Nairobi.

People fetch water from boreholes or rivers that often are muddy during the rainy season. In some cases water is salty to the point of being unsuitable for vegetable production, or dry up for a couple of months. Only the Nyando site in Kenya has clean, piped water but water provision is not regular as the pipes break and water pumps that feed them do not run constantly due to power shortages. In the Kagera Basin site, Uganda focus group participants indicated that getting water involves long hours and distances. These conditions are often linked to rape, pregnancies and the spread of HIV/AIDS among young girls.

Children in all the East African sites have access to several primary and secondary schools near the villages, even if the schools are in bad condition and poorly equipped. The government runs most of the schools but there are also Catholic schools and Madrasas. In contrast, children in the West African sites do not have easy access to schools. The only exception is the Ghana site, where there is a large school in good condition.

Table 1
Number of male- and female-headed households surveyed in each site.

Site name, country	Lat/long	Agro-ecological zone	Male-headed HHs in sample	Avg. size of male-headed HH	Female-headed HHs in sample	Avg. size of female-headed HH
Yatenga, Burkina Faso	13.828, −2.113	Sahelian agroecological zone (650 mm). Agrosilvipastoral small-scale systems.	131	11.8	7	8.7
Borana, Ethiopia	4.957, 38.567	Agropastoral/pastoral, pockets of rainfed farming; semiarid lowlands of southern Ethiopia.	101	7.6	39	5.6
Lawra-Jirapa, Ghana	10.735, −2.624	Mixed crop-livestock smallholder systems. Guinea Savannah, 950–1100 mm.	129	9.0	9	5.3
Nyando, Kenya	−0.269, 35.068	Primarily mixed rainfed crop livestock farming system. Humid to sub-humid climate.	87	5.9	50	4.2
Makueni, Kenya	−1.809, 37.724	Largely agropastoral with a mix of crops. Semi-arid climate.	93	5.5	46	5.5
Segou, Mali	13.509, −5.613	Cereal and groundnut production. Sudano Sahelian savannah (680 mm).	139	17.2	2	5.5
Kollo, Niger	13.654, 2.826	Millet fallow or millet cowpea cropping systems and agro-pastoral systems. Sahel, 300–500 mm of annual rainfall.	135	12.9	5	9.8
Kaffrine, Senegal	14.242, −15.407	Pearl millet and groundnut cropping systems. Transition zone from the Sahel toward Sudan Savannah (500–800 mm).	134	13.7	4	8.5
Usambara, Tanzania	−4.790, 38.417	Mixed crop livestock, quite intensive farming systems in higher elevation and agro-pastoral systems in lower elevation.	109	6.5	31	4.7
Albertine Rift, Uganda	1.535, 31.546	Steep rainfall gradient from highland agroforestry, mid hill coffee/tea, small-scale mixed farming/commercial to dryland small-scale agriculture/agro-pastoralism.	109	6.5	31	5.3
Kagera Basin, Uganda	−0.621, 31.484	Steep rainfall gradient from high along Lake Victoria (>1400 mm) to low in Western Rakai and Isingiro (<1000 mm)	112	6.7	27	5.7
Total			1279		251	

3.2. Drivers of change in the sites

Focus group participants identified three critical determinants of changes in the state and use of natural resources in their communities. These were human population growth, commercialization of the economy, and national government policies. In all sites participants reported that human population growth has encouraged encroachment on forests, clearing of trees and bush burning to meet the increasing demand for cropland and forest resources (fuelwood, charcoal and timber). Population growth has also led to land fragmentation and overexploitation of the area under production, soil fertility depletion, and soil erosion. In the Uganda and Ghana sites, it has resulted in increased numbers of livestock and the taking over of grazing lands for cultivation. As a result, there is not enough pasture for all and few areas of the tall grass used for thatch harvesting remain. In sites close to waterways, population pressure has increased the demand for and depletion of fish resources. The need for more land for cultivation has resulted in cultivation of wetlands on the lakeshores and the streams flowing into it. It has also led to unrestricted cutting of trees in the riparian corridor, siltation, and the cultivation of the riverbanks. These findings are consistent with research that shows a declining natural resource base linked to population pressure (Frost et al., 2007).

All these land use/land cover transformations were reported to be at the expense of wildlife. Due to deforestation, wildlife (e.g. leopards in Kenya, buffaloes in Albertine Rift, Uganda, monkeys in Makueni, Kenya) has disappeared. In Albertine Rift, Uganda, the wetland habitat for chimpanzees, Colobus monkeys and mudfish was being destroyed with deforestation. In Kagera Basin, Uganda, the hills, which are now bare, were forested in the past and provided forest products such as honey, timber, wildlife, and herbs. Currently there are very few forested areas and no wildlife.

Although buying food, clothing, inputs and services, and producing cash crops or selling wild resources is not new in Africa (Cavendish, 2000; Fisher, 2004), focus group respondents in Burkina Faso, Ghana, Senegal, Kenya (Nyando), and Uganda (Albertine Rift) indicated that the use of natural resources was changing due to "commercialization" of the local economy, i.e. participation in local markets for goods and services. Households are no longer able to meet their needs exclusively from what they produce on their farms or what they harvest from communal areas. They need cash to buy food, clothing, pay school fees, and to purchase agricultural implements and seed. There are, however, few sources of employment available to earn cash. Participants in Kenya stated that: "Today people must do farming as a business." Besides producing cash crops (e.g. coffee, cotton) households engage in self-employment opportunities based on the exploitation of natural resources. This includes the sale of fruits and medicinal leaves; wood, thatch and reeds for roofing; and timber for making furniture. People also make bricks, brew local beer, and wash cars in wetlands or riverine areas. Households in Burkina Faso, Ghana and particularly Kenya (Makueni), depend heavily on remittances from relatives who have moved elsewhere in the country in search of employment. Kenya (Nyando) participants expressed that people carve off the edges of the forest and cut live

wood that is then sold or used for social needs. In Senegal people harvest sand and laterite in their village, even if that creates deep gullies and destroys the roads.

Participants in all six East Africa sites identified national government policies as critical change factors of natural resources use. For participants in the Ethiopia site, until 20 years ago, most people were mobile pastoralists who depended almost exclusively on livestock products for their livelihood security. In order to address a series of drought events that resulted in famine, the government decided to actively discourage itinerant migration, and encourage people to settle in selected areas. This policy led to a transformation of the basis of the economy from livestock- to crop production, and from mobile pastoralism to village proliferation. Government policy to permanently settle pastoralists, lack of agricultural extension services related to cultivation, human population growth and drought are perceived as the most important drivers of land-use change in this area.

For participants in Kenya (Nyando), Tanzania and Uganda (Albertine Rift and Kagera Basin), national policies have affected land use in subtler but equally deleterious ways. In Nyando, Kenya there is no longer public land on which to plant community forests. Even riverbanks are considered private land. In Tanzania, the government removed restrictions on the use of the river and the riparian area, which created open access without regulation of use of the river and surrounding area. For Uganda (Albertine Rift) site participants, the government's policy of leasing forest to individuals (*de facto* privatization) has contributed to deforestation because of poor control. Those who lease land have obtained plots surrounding the forests. Hence, in the last seven years sugarcane plantations, operated by people from outside the area, have significantly encroached on forests. Today, many trucks transport charcoal and lumber out of the area daily as far as Kampala. The Uganda (Kagera Basin) site participants also perceived that the natural resources deterioration in their area is related to the current inability of communities to enforce measures to manage those resources due to government policies. For instance, the government has taken away the management of the lake and its resources from traditional leaders, and *de facto* has assigned it to big land leasers from outside the area. The government does not control privatized natural resources and does not allow the community to do it either.

3.3. Gender-based access to resources and ability to withstand shocks

There is a clear gender-based division of labor in agriculture and natural resource use among the village study participants, although there are still overlaps in what men and women do. In most sites, the male participants grow cereals (millet, sorghum, maize), legumes (cowpeas, groundnuts, beans), sesame, and Bambara nuts. To a lesser extent they also produce roots and tubers (cassava and potato) and horticultural crops (onions, tomatoes, cucumbers, cabbage, lettuce, melons, sorrel and okra). In some cases they cultivate cash crops (coffee, cotton in addition to sesame, and Bambara nuts). Men fish and collect timber from the trees remaining in the fields or from woodlots.

For their part, women in most sites grow vegetable crops (onions, tomatoes, marrows, sorrel and okra). In Ghana, Mali and Senegal women reported growing cereals (millet, maize), groundnuts, beans, and sesame. In Burkina Faso and Ghana, women stated being in charge of livestock production (including dairy cattle, sheep, goats and chicken) and harvesting fresh and dry fodder for animals. Women are generally responsible for the livestock that ranges freely in fields between farmlands or woodlots, and in communal and private lands.

In all sites, women are responsible for collecting firewood and forest products other than timber and wood. Those products encompass food security staples like Baobab and Ziziphus tree leaves, honey, mushrooms, and wild fruits like Néré and Shea tree nuts, from which "dawa dawa" and Shea butter are made. Yet women are not the only ones who harvest natural resources. About the same proportion of men and women reported harvesting and selling fuelwood, wild fruits and fish, and slightly more men than women are selling charcoal and honey.

Women tend fields and natural resources located near their homes, while men's fields and areas of influence are further away. In Tanzania, for instance, men have access to forests that are a three-hour walk away from the community. In two sites (Ethiopia and Tanzania) participants reported that men and women have their own, separate water pans, with different water quality and quantity. These arrangements barely hide prevalent gender hierarchies. In the Ghana site, men's crop fields are located adjacent to the main, permanent river, while women's crop fields are near a seasonal river.

Participants in all sites reported that both men and women have access to individual fields and communal ones, but only men own and inherit land. Women cultivate land given to them by their husbands (inherited, not purchased private land) or by the community (communal land). In the Mali site women have stopped cultivating communal land, and they only farm individual pieces of land allocated to them by their husbands. It was not made clear how unmarried female-headed households obtained access to land, in this case. This is because data were gathered during a semi-structured participatory exercise and the cases of unmarried women was either not explored or not recorded in the notes. As Burkina Faso participants emphasized, women more than men lack land and have no access to improved technology or equipment, manure or labor. They also have few training opportunities. In general terms, therefore, based on the focus group discussions, women have less access than men to productive resources and opportunities. An analysis of the household-level survey data supports that finding, albeit with some caveats (Table 2).

We found that in our sample there were no statistically significant differences between male- and female-headed households in either West Africa or East Africa with respect to some indicators. These include education level (of the most educated resident household member), credit use, sale of crops harvested on-farm, the perception that their cropland was declining in productivity or area, or that there was insufficient labor at critical times.

The statistically significant differences between male- and female-headed households in both East and West African sites were primarily related to access to cash, or the ability to use cash to obtain goods or services. In all sites, access to cash is less common in all female-headed households sampled. This includes cash from employment, remittances and payments. Women are also less likely to hire labor because they cannot afford to. In the West Africa sites, female-headed households are less likely to produce two or more crops for the market than male-headed households. These findings support other research suggesting that shortages of cash to hire labor, to sponsor communal labor parties or to purchase inputs are reducing the ability of female-headed households to intensify production (Pender and Gebremedhin, 2006), gain access to labor-saving technology such as oxen (Von Braun and Webb, 1989), or access capital to repay credit (Chipande, 1987).

In general, there were more significant differences between male and female-headed households in West Africa than in East Africa, and the differences were more pronounced in the West Africa sites. In West Africa, female-headed households tended to be smaller than male-headed households (the same being the case, though not statistically significant, in East Africa), and were more likely to have women doing most of the agricultural work. Significantly, female-headed households in that region were more

Table 2
Differences in farm and livelihood system variables between households headed by males and females, by region.

Variable	West Africa		East Africa	
	Logit regression	*P*-level	Logit regression	*P*-level
At least a secondary education	−0.54	$P=0.32$	−1.07	$P=0.332$
Had less land	0.694	$P=0.136$	1.461	$P=0.122$
Land is less productive	−0.271	$P=0.491$	−0.668	$P=0.405$
Women do most of the agricultural work	1.0	$P=0.01^{**}$	1.05	$P=0.219$
Household size more than 6	−1.10	$P=0.006^{***}$	−1.41	$P=0.088$
Insufficient labor when needed	0.728	$P=0.157$	1.176	$P=0.259$
Unable to hire labor because it is too expensive	1.56	$P=0.006^{***}$	2.935	$P=0.011^{**}$
More than 2 crops produced on own farm sold for cash	−0.85	$P=0.04^{**}$	−1.13	$P=0.172$
Produce harvested from own farm, sold for cash during the last 12 months	0.35	$P=0.38$	1.554	$P=0.064$
Access to any cash sources (employment, remittances, payments, etc.) during the last 12 months	−0.94	$P=0.04^{**}$	−1.85	$P=0.048^{**}$
At least one source of cash	−0.94	$P=0.04^{**}$	−1.8399	$P=0.049^{**}$
Had access to credit	−0.116	$P=0.83$	0.347	$P=0.762$
Five or more hunger months	2.0	$P<0.001^{***}$	0.003	$P=0.984$

** Variable is significant at the 5% level (i.e. *P*-value).
** Variable is significant at the 1% level (i.e. *P*-value < 0.01).

food insecure than male-headed households. They tended to experience five or more hunger months more frequently than male-headed households.

3.4. Gender-based access to social support institutions, government and NGOs

As shown in the previous section, the key constraints to, as well as opportunities for women's livelihood strategies (and adaptive capacity) are linked to the assets women possess and their levels of access to income and common property resources. We found that they are also related to the extent to which they interact with and benefit from social support institutions, government and NGOs. This confirms conclusions of Barbier (2000), Bardhan (2006), Davies and Hossain (1997), and Quisumbing and Pandolfelli (2010).

Male and female focus group participants were asked separately to identify the organizations that they considered important to the community, and those they interacted with. The organizations were placed in three categories: those working only within the community/village, those working within the locality/district, and those working beyond the locality/district. Women reported working mostly with groups that operate within the community, while men are better connected with groups that operate beyond the locality (Table 3). This is consistent with research indicating that men and women commonly depend on different kinds of social relations or networks. Men tend to rely more on bridging and linking social capital (connections with people in power and to formal institutions), while women rely more on bonding social capital, usually informal connections to family, kin and friends than men (Agarwal, 2000; Molyneux, 2002; More, 1990; Riddell et al., 2001; Westermann et al., 2005; Woolcock and Narayan, 2000).

Table 3
Number of all organizations and community level organizations identified as providing critical support to villages in the focus group sites.

Country site	Male-identified organizations		Female-identified organizations	
	All (no.)	Community-level %	All (no.)	Community-level %
Burkina	21	43	17	59
Ethiopia	12	17	11	36
Ghana	13	23	12	67
Kenya	13	31	16	50
Mali	14	43	8	87
Niger	11	9	15	40
Senegal	13	15	21	80
Tanzania	17	18	18	67
Uganda-Hoima	14	29	20	60
Uganda-Rakai	25	20	16	75

Women engage in mutual insurance, risk-sharing networks at the village level that are primarily based on relatives and friends, but also community members in general. They depend on everyday forms of flexible, reciprocal collaboration in activities such as collecting water, fetching fuel wood, and child rearing, which is consistent with observations from elsewhere (Agarwal, 2000; Cleaver, 1998). In some cases women help each other in farm work in exchange for labor, cash or produce (Burkina, Mali). They also rely on task-specific groups that sing in church and celebrate weddings, assist during funeral services by providing flour, sugar and money to the family of the deceased, and look after widows and orphans (Tanzania, Kenya, Makeuni). They participate in groups where the members grow, in communal lands, products such as watermelons, maize, tomatoes, kales, groundnuts, cowpeas, and sesame (Burkina, Ghana, Kenya, Mali, Senegal). In most cases women share the harvest among each other, and also frequently manage a mutual fund that is boosted with the sale of part of the harvest. In Kagera Basin, Uganda women in a group contribute money to buy seeds for one another in a rotating system. This arrangement allows them to maintain and increase the collective seed pool, while adding some cash to the households.

Women community organizations are not necessarily isolated from the external world. In some cases, they channel into the community resources such as micro-lending funds, medicines and school supplies that they obtain from organizations that operate in the locality or beyond. In the Burkina Faso village there is an active local chapter of the national NGO AKAFEM/BF (the Koom Association for the Self-Promotion of Women of Burkina Faso). This NGO sponsors literacy classes, credit and cowpea seed for women. Community-level women's groups in Ghana, Kenya, Mali, Senegal and Uganda make available to members loans with funds provided by external microfinance institutions. The external funds may be combined with funds that women in the group save as a requisite for being part of the group. Women use such funds to cover school fees, educational supplies, school canteen, or to pay for labor in their farms.

Importantly, the panorama of organizations operating within the community is complex. In the same way as adaptations to climate change (Fankhauser et al., 1999), women's local networks can be ad-hoc, autonomous or planned. Some of the community organizations are very small and informal. Others are large and formal even if they are not necessarily registered with, or taken

into account by the state. The focus groups identified several formal women's indigenous groups that have over 30 members. One organization in Burkina Faso includes more than 100 women members. In addition to groups organized by women, the discussions in Senegal, Tanzania, and Albertine Rift, Uganda reveal community organizations that are formally sponsored by local Muslim and Catholic religious groups. In the Senegal site, the Mosque supported the construction of horticultural sites for women and the accompanying infrastructure (wells, power pumps and fence). The Mosque also sponsored the digging of trenches for pipes to take water from the women's site to the men's site where water is salty.

In all the focus group villages, formally registered external organizations that work within and beyond the locality, rather than within the village, tend to provide support primarily to men but do not just provide resources exclusively to men. These organizations include government agencies from sundry ministries, local or international NGOs, church associations, and/or research centers with national or international affiliation. The external organizations that focus on agricultural and natural resource management issues work almost exclusively with men. Depending on the country where the villages are located, their support may include technical advice and subsidized tools, seed, fertilizers, improved livestock breeds; seedlings for reforestation. They may also encompass postharvest storage of food purchased from the farmers and food distribution in times of famine, as well as cash incentives for communal work. There are other external organizations that concentrate on education and health issues and support women. In this case, the support may include provision of school facilities, teachers' salaries, supplies, uniforms, and beds for children who stay in boarding schools. It may also entail vaccinations, provision of mosquito nets and supplemental feeding for children; tap water and boreholes; and building houses for widows and destitute children.

The external organizations ostensibly also support women's groups in all the sample villages, but their support to women is limited and generally mediated by village men. In Ghana and Mali, government agencies distribute, respectively, fertilizers and seed only to men. In Tanzania, the Ministry of Health distributes ivermectin tablets to men to control river blindness (*onchocerciasis*), even if women are the ones that manage the medicine. When training or agricultural inputs are made available for women, women do not necessarily participate or benefit from them. Women's physical mobility is typically more restricted than men's due to their substantial production and reproduction obligations, or the need to be allowed to participate by men in their households. In all the sampled villages, there are relatively few opportunities for women to improve their agricultural or livestock production. The organizations external to the village are more likely to provide training and distribution of goods for women's health or children's education activities. Examples of health-related activities include birth attendants' training, women's access to hospitals during labor, and HIV prevention. They also include vaccinations and provision of nutrition supplements for children, and training on household hygiene.

Gender division of labor and power relations do not necessarily limit women's participation in formal organizations, thus (Molyneux, 2002, for instance). It all depends on how one defines "formal organizations", especially given that women have their own formal community organizations. The situation, however, is quite different regarding formal organizations that work within and beyond the locality. In the entire sample of villages, men are the interlocutors with those external organizations, and thus assume the role of gatekeepers for women. It is not surprising that in some sites women tend to have very little information about organizations working beyond their village. In fact, they even had a hard time identifying external organizations that operated in the village. It is evident that the agricultural-related institutions that should be providing information and inputs for natural resource and agriculture-related adaptation interact less with women and female-headed households, which is likely to limit their adaptive capacity.

3.5. Adapting to agricultural risks and opportunities, including weather-induced ones

In the household survey we asked respondents which specific changes they had made with respect to crops, crop varieties, livestock, soil, water, tree and/or land management practices during the last decade. Table 4 shows the percentage of respondents that mentioned taking up adjustments to existing and/or new agricultural crop farming practices. Not all changes reported are included here, and innovations reported by fewer than 15% of households in any site are left blank.

Table 4
Crop technology and management adjustments during the last decade, by country (% of respondents).

Adjustment	BF	Eth	Gh	Ke	Ke2	Ma	Ni	Se	Tz	U-h	U-r	All
Technology												
Introduced a new crop variety	73	25	94	58	97	54	64	83	81	75	87	72
Planted higher yield variety	43	14	81	80	81	28	51	78	76	70	84	62
Planted shorter cycle variety	65	20	83	63	97	42	53	75	77	41	61	62
Introduced a new crop	30	19	56	44	74	40	41	84	84	66	58	54
Earlier land preparation	67	37	28	83	51	3	75	78	91	35	33	53
Purchased pesticides or herbicides	37	7	64	23	84	13	41	54	66	31	60	44
Use purchased improved seed	53	3	23	64	96	18	31	18	70	30	48	41
Used inorganic fertilizer	73	0	55	20	6	33	66	73	81	17	20	40
Planted drought-tolerant variety	20	17	18	78	94	12	8	2	79	39	58	39
Used pesticides or herbicides	35	1	63	11	73	1	29	59	48	14	38	34
Planted pre-treated or improved seed	56	1	50	44	77	3	7	11	64	21	27	33
Planted pest-resistant variety	2	4	20	33	62	0	1	4	67	31	48	25
Planted disease-resistant variety	5	1	19	26	50	0	3	0	74	37	51	24
Tested a new crop	11	11	5	7	52	5	24	7	15	26	32	18
Crop management												
Adopted soil management	81	8	95	26	99	26	37	92	81	32	47	57
Adopted agroforestry	46	100	49	61	77	31	13	35	59	46	81	54
Expanded crop area	57	46	49	46	68	45	56	77	46	34	61	53
Planted earlier	21	33	27	84	70	1	19	51	84	49	40	44
Reduced crop area	30	7	78	27	64	29	28	69	36	23	62	41
Planted later	22	16	99	22	78	0	49	4	74	26	16	37

Table 5
Livestock technology adjustments during the last decade, by country (% of respondents).

Adjustment	BF	Eth	Gh	Ke	Ke2	Ma	Ni	Se	Tz	Ug-H	Ug-R	All
Change in herd composition	32	3	99	16	97	100	1	83	74	26	95	52
Reduce herd size	35	2	75	52	60	35	56	67	20	42	45	44
Stopped keeping one type of animal	14	3	65	27	41	11	46	29	29	16	60	31
Fodder storage	74	33	33	11	47	23	31	68	12	0	1	30
Cut and carry fodder	31	28	65	18	25	12	25	23	65	1	12	28
New farm animals/breeds	14	8	48	36	22	86	9	37	51	30	37	27
Increase in herd size	49	6	23	39	31	23	4	48	31	18	21	26
New breed introduced	23	5	20	15	13	38	4	10	46	9	17	18
Growing fodder	9	1	12	14	12	3	4	20	50	1	10	13
Fencing	38	0	7	16	11	9	1	17	1	2	9	10
Stall keeping	1	0	25	1	4	1	1	3	36	2	9	8
Improved pastures	4	3	1	5	25	3	3	8	19	0	4	7
New farm animals tested	10	1	0	5	5	0	0	0	6	5	7	4

The respondents reported a wide range of technology and crop management adjustments to agricultural practices. The technological changes include adopting new crop varieties or crops (higher yield, shorter cycle, drought tolerance, pest resistance, and disease resistance). They also comprise using commercial inputs (seed, fertilizer, pesticides, herbicides). The crop management adjustments include soil management (contour farming and agroforestry), changing planting dates (land preparation and seeding), and modifying the plots' area (expansion or contraction). There were no reported changes in cropping systems.

We found only a few statistically significant differences between male- and female-headed households in either West Africa or East Africa in terms of changes in agricultural practices. First, compared to male-headed households, female-headed households in East Africa were less likely to plant pretreated/improved seeds (1.944, $P = 0.018$), while those in West Africa tended to expand area less often (-1.00, $P = 0.02$). Second, in both East Africa and West Africa sites female-headed households were less likely to plant disease-resistant varieties (WA 1.2, $P = 0.03$; EA 2.822, $P = 0.014$), and tended to have reduced the area under production more frequently (WA 1.24, $P = 0.01$; EA 2.41, $P = 0.008$) than male-headed households. Thus, female farmers may be more constrained than male farmers in accessing and using improved seed varieties.

Table 5 shows the percentage of respondents who indicated having made adjustments to existing and/or new livestock keeping practices within the last decade. The spectrum of these changes was focused around fewer options than in the case of crop management. The most commonly reported livestock modifications were related to herd species mix and herd size, and to fodder management.

Once survey respondents identified the changes in crop- or livestock keeping practices that they had made, they were asked about what motivated them to make those changes. No statistically significant differences were found in the expressed reasons for changing farming or livestock management practices, whether by sex of survey respondents, or by region.

Tables 6 and 7 summarize reasons for producers to engage in, respectively, crop and livestock production. The tables exclude responses from Ghana, Kenya 2, Mali and Uganda-Rakai surveys due to incomplete data. As shown in Table 6, the motivators for technological and crop management changes seem to be highly site- and time specific. The most frequently cited explanations for technological and crop management changes are responses to variations in crop productivity (increasing or decreasing), prices,

Table 6
Reasons for crop technology and management adjustments, by country (% of respondents).

Reasons	BF	Eth	Ke	Ni	Se	Tz	Ug-H	All
Better yields	68	40	85	54	75	86	42	64
Land less productive	92	11	53	88	51	74	31	57
Better price	43	19	45	9	63	79	49	44
More erratic rainfall	79	11	19	64	16	64	19	39
New opportunity to sell (markets)	32	3	16	1	83	74	26	34
Less land	43	17	42	24	23	71	9	33
More frequent droughts	56	7	56	14	1	61	12	30
Sufficient labor	56	1	41	19	9	57	11	28
More resistance to pests	32	1	37	9	2	71	31	26
New pests	33	1	23	4	1	46	31	20
Insufficient labor	37	2	42	39	25	4	14	23
Later start of rains	34	1	32	28	1	56	6	23
Earlier start of rains	11	0	64	4	0	66	6	22
Government/project told farmers	54	1	7	5	9	56	15	21
Government/project showed farmers	55	0	4	4	3	55	9	19
Unable to hire labor (too expensive)	26	1	15	48	6	25	14	19
Able to hire labor	25	1	36	13	19	14	16	18
More overall rainfall	5	4	23	4	2	34	13	12
More land	16	1	4	7	3	34	9	11
Land more productive	1	1	10	2	1	34	17	9
Policy changes	32	0	0	0	0	4	3	6
Unable to hire labor (not available)	13	1	2	2	6	1	6	4

Table 7
Reasons for livestock technology adjustments, by country (% of respondents).

Reasons	BF	Eth	Ke	Ni	Se	Tz	Ug-H	All
Better price	67	30	48	19	16	60	27	38
More productive	68	12	66	4	17	54	17	34
New diseases	33	4	55	4	56	36	16	29
New opportunity to sell	46	13	17	16	35	45	18	27
More frequent droughts	47	18	44	6	4	24	1	21
More resistant to pests	32	1	21	0	23	52	6	19
Government told producers	42	0	25	0	0	34	4	15
Government showed producers	42	0	20	0	0	39	4	15
Able to hire labor	18	0	7	1	4	14	6	7
Insufficient labor	4	0	12	1	7	5	4	5
More frequent floods	8	0	15	0	6	0	0	4
More salinization	12	0	0	0	0	0	0	2

more erratic rainfall, market opportunities, less land available, more frequent droughts. Yet these changes are not distributed consistently. Some farmers reported better yields, better prices and new produce markets, while others mentioned encountering land being less productive, soil fertility problems and pest pressure. All the reported perceived changes in weather were related to rainfall volumes or timing. More erratic rainfall and more frequent droughts were the most commonly mentioned reasons, but some farmers reported more overall rainfall. Some respondents pointed to later starts of the rains, others to earlier starts.

The most frequently cited reasons for adjustments to livestock keeping are related to adaptations in prices, productivity, pathogen and pest pressure, market opportunities, and frequency of drought (Table 7). These changes are not distributed consistently across the sites. It is possible that at one place and/or time there was more drought or more frequent flooding mentioned as a reason.

4. Discussion and conclusions

Based on the evidence presented in the previous sections, we can respond to the question on the resiliency of the households and communities in our sample. We can infer from the data some characteristics and indicators that are associated with resilience (Table 8). In the table we recapitulate exposures, sensitivities and adaptive capacity attributes which were empirically identified from the responses in our study. We focused on conditions that were deemed important by the respondents based on their own

Table 8
Characteristics of resilient social–ecological systems and evidence from study.

Characteristics of a resilient system (Indicators)	Evidence from study, and likelihood of resilience	
	Evidence	Resilience
Livelihood diversity		
• Different economic opportunities.	• Food and income mainly from farm	• Limited
• Off-farm economic options (e.g. migration, remittances)	• Restricted off-farm employment and access to cash particularly for women	• Limited
• Levels of technology.	• Low technology levels	• Limited
• Food security.	• Long hunger periods are common especially among women-headed households in WA	• Moderate
• Dependence on diverse natural resources.	• High dependence on NR	• Limited
• Population growth rates.	• High perceived population growth	• Limited
Assets		
• Wealth, access to credit.	• Limited wealth, some access to microfinance	• Limited
• Strength of natural resources.	• NR encroached, depleted	• Limited
• Soil quality.	• Soil erosion and degradation is common	• Limited
• Schools.	• Primary schools common in EA, not in WA	• Moderate
Social and economic equity within community		
• Equal access to resources for individuals.	• Unequal access to resources for women	• Limited
• Equitable distribution of wealth and assets.	• Unequal wealth and assets share for women	• Limited
• Access to land	• Women more than men lack land	• Limited
• Access to technology and inputs	• Women have limited access to improved technology or equipment, manure or labor	• Limited
• Access to agricultural training and technical support	• Women have limited access to agricultural training and advice	• Limited
Community ownership of natural resources, and voice in relevant policies		
• Communities' shared rights and responsibility for resource management.	• Women have fewer rights than men in resource use and management	• Limited
• Government-recognized community control over natural resources.	• Government disempowers communities in managing natural resources	• Limited
Community capacity to organize		
• Cooperation and coordination based on trust, norms and networks.	• Strong internal cooperation albeit divided by sex	• Moderate
• Strength of community organizations.	• Active women community organizations	• Moderate
• Strength of organizations outside the community.	• Active outside organizations provide separate support for men and women	• Moderate
• Participation in community decision-making.	• Men have more decision-making rights than women	• Moderate
• Community access to external resources and knowledge.	• Restricted access to external resources	• Limited
Effective governance		
• National policies promote durable natural resource management	• Policies often encourage unsustainable land use and overexploitation of natural resource	• Limited
• Local governments capable of planning for, preventing and responding to risks.	• There is some government risk management capability	• Moderate
• Local organizations are flexible and respond to local realities.	• Many organizations flexibly respond to local needs	• Moderate
• Local organizations capable of planning for, preventing and responding to risks.	• Some capability but limited resources	• Limited
Combining different types of knowledge		
• Indigenous local ecological knowledge used in management of resources.	• Indigenous knowledge used but not fostered by external agencies	• Moderate
• Combine local and scientific knowledge	• Not significant combination of knowledge	• Limited
Capacity to learn		
• Education, skills, knowledge levels.	• Men and women have basic education levels	• Limited

experience. We did not plan to aggregate the data into a score of vulnerability or adaptation. We tried to analyze the processes, determinants of adaptive capacity and vulnerability, and the decision-making and policy conditions that would need to be changed to influence adaptive capacity and vulnerability. The table permits us to contribute to the emerging literature on ways to operationalize the concept of resilience (Bahadur et al., 2010; Béné et al., 2011; Berkes and Seixas, 2005; Cinner et al., 2009; Marshall et al., 2010).

As the table summarizes, in all the sites studied households are exposed and responding concurrently to multiple interrelating stressors at different levels. Climate is one of many factors affecting household- and community-level farming decisions, and coping and adaptation strategies, more broadly. Communities are going through long term and broad structural changes including population growth, dependence on cash to cover essential needs, and dearth of sources of employment other than the exploitation of natural resources and sale of crop produce and animals. In some countries government policies are fostering the privatization of forests, rangelands and riparian areas, and the settlement of pastoralists. These policies are taking away the traditional decision-making powers and strategies that communities had to regulate the use and sustainable management of common-pool resources through collective action. At the production level, the stressors include low crop- and/or livestock productivity, pathogen and pest pressure, fluctuating prices of agricultural inputs and outputs, and labor supply constraints. They also entail increasing variations in weather patterns (rainfall volumes, rainfall onset time, extreme events) that affect individual producers differentially, as part of year-to-year variations.

It was beyond the scope of the baseline survey data analyzed here to collect detailed information on the components of individuals' or community's adaptive capacity, let alone resilience. We looked at available resources (financial, physical, human, social or natural capitals) that underlie adaptation and resilience possibilities for a wide range of smallholder households and communities in East and West Africa. We did not cover data on some key indicators of resilience. These include the capacity to learn and reorganize from past experiences, develop coping strategies, anticipate and prepare for disruptions, create space for iterative experimentation, and adopt flexible and decentralized government policies on natural resources (Carpenter and Gunderson, 2001; Folke, 2002; Marshall and Marshall, 2007; Marshall et al., 2010; Miller et al., 2010). Also, we could not explore the complex and dynamic nature of resilience. For instance, conceivably individuals and communities could be both very poor and resilient especially provided that they lower their expectations. Equally, high soil quality may result in increased resilience, but it might also lead to increases in land demand, which could quite plausibly decrease the resilience of the system. More than including conclusive statements the summary table allows us to define hypotheses that should be tested and refined via future research.

In general, the above-mentioned structural factors and the high dependence of livelihoods on climate-dependent natural resources make the communities particularly sensitive to climate change. Marked social and economic inequality within the communities further increases that sensitivity. Female-headed households are more insecure than male-headed households in terms of availability of productive resources and dependency on irregular income inflows from produce sale, employment or remittances. The women farmers in these villages (whether they are in a male- or female-head household) control less land than men, the land they control is often of poorer quality, and their tenure is insecure. Women farmers are less likely than men to use modern inputs such as improved seeds, fertilizers, pest control measures and tools. Finally, women have less education, less access to extension services, and less available free time, which make it more difficult to gain access to and use some of the other resources, such as land, credit and fertilizer. These findings confirm evidence from other similar studies (Quisumbing and Pandolfelli, 2010; Friis-Hansen et al., 2012; Kristjanson et al., 2014). Women farmers are sensitive to change because of those conditions, and are therefore more vulnerable to change. Yet, they may have similar or better adaptive capacity than men given the disadvantageous conditions under which women cope, adapt and survive.

People's ability to participate in formal and informal institutions within and outside their own village influences their capacity to adapt to change. Our evidence suggests that this capacity also varies by gender. Male community leaders and individuals in the sampled villages are in a more favorable position and are more adept at dealing with and benefiting from government agencies, NGOs, even private enterprises than women are. Men get from those institutions technical assistance, subsidized tools, seed, fertilizers, improved livestock breeds, water pumps, seedlings, and cash incentives for communal work. Men play an important role as mediators with those organizations, and often speak to them on behalf of women. One could interpret this male mediation role as an expedient and harmless intra-household division of labor. This would require two important assumptions. The first one is that males and females share all resources within the household. The second one is that helping men necessarily translates into helping the households (i.e. men and women). However, households have multiple and even conflicting objectives depending on their members. There is no basis to assume that individual choices are taken with the goals of the household as a whole in mind (Goldstein and Udry, 2004).

Women, more than men, are dependent on internal village groups, as opposed to organizations operating at regional or national levels. Relying on internal village groups is not necessarily disadvantageous for women. In fact, it allows them to tap into a vibrant, varied and nimble network of mutual insurance, risk-sharing village organizations. These include informal mutual help groups and formal associations, organized around secular and religious goals. The formal and informal women village-level groups excel in solidarity and local initiative. Women successfully depend on such social relations to cope with, manage or adapt to stress in their daily lives. Through those networks women gain access to food, labor and cash that facilitate their productive and reproductive responsibilities. Those networks enable some women to gain recognition as leaders within their villages.

Women's village groups are not necessarily isolated from the external world. Some of them routinely channel external resources to the community. These include microcredit funds, school supplies, vaccines and nutrition supplements for children, training for women in HIV prevention, and birth attendants' training. External organizations that focus on the provision of microfinance lending, public health, reproductive health, and education services often explicitly target women groups. This almost shockingly contrasts with the approach of government and NGO agencies that focus on agriculture, livestock, forestry and the management of soil, water and other natural resources. These groups primarily, if not exclusively, target men and their needs, which ignores the role that women play in producing food and helping protect natural resources in their communities. By not including women in such interventions, the lower use of improved and treated seed among women, as well as other low input practices, will likely continue and prevent women farmers from reaching their full potential production.

The real challenge for women, however, is not accessing outside institutions in general but specifically overcoming tremendous anti-women biases by public and private agencies that foster agriculture and livestock production. These biases make female-headed households highly vulnerable to food insecurity, and also

increase the challenges in adapting their farming practices to economic and climatic risks. It is not only women-headed households that are disadvantaged in this regard. Given the division of land and labor in many of the research sites, even women in male-headed households are not benefiting from extension services and other government or NGO capacity building efforts. Policies and strategies are needed to eliminate those prejudices so that both men and women can manage their changing environments. The required changes include giving women the right to own land and enhanced equitable access to improved inputs, credit and technical assistance. The changes also encompass strengthening traditional institutional arrangements surrounding the sustainable use and management of forests, wildlife, communal land and water through collective action, and giving women a voice in that collectivism. Indeed, global food security is unlikely to be achieved in the face of climate change without increased attention to, and investment in, the millions of women small-scale farmers.

The terms under which the communities operate and adapt to changes are being defined to a large extent by organizations and institutions that are superimposed on the villages' own internal organizations. Communities adapt to but do not influence the agendas and priorities defined by outside organizations for the provision of technical assistance, inputs, emergency food, credit or any other development goods and services. Yet, there are many flexible organizations that respond to local realities and priorities. These organizations could become major facilitators in the communities' climate adaptation and resilience. For that to happen the organizations would have to explicitly use the services that they currently provide as mechanisms to improve climate change adaptation as well as livelihood security. They would also need to make a concerted effort to work with those existing women's groups that currently meet the needs of local women in terms of credit facilities, social welfare protection and other vital community functions. Working in tandem with such existing groups, whether informal or formal, can help reach women to build their adaptive capacity, but care should be taken not to co-opt completely their original goals and objectives.

Few climate adaptation studies combine quantitative household-level analyses with qualitative work that delves into the 'why' as well as the 'what'. Even fewer examine gender issues in relation to agricultural practices. This study does both, although intra-household research is needed to get more fully at additional critical questions relating to access to and control over resources within the household, and adaptive capacity. Gender norms will play a big role in shaping how well households will be able to adapt to change, including a changing climate. But these norms do change, sometimes very quickly. Sharing the findings and issues raised here with these communities is one way of spurring more widespread dialog within and across communities and with local and national policymakers.

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