Gender and Institutional Aspects of Climate-Smart Agricultural Practices:

Evidence from Kenya

Working Paper No. 79

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Photos:

Abstract

This paper analyses gender differences in awareness and adoption of climate-smart agricultural (CSA) practices. It examines what factors are associated with the likelihood of adoption of a wide range of CSA practices for 376 women and 375 men in two different areas of Kenya. This information is aimed at improving the targeting and design of interventions that are trying to achieve greater and more equitable agricultural development in East Africa and elsewhere. Our results suggest there is still much work to be done in increasing awareness of improved agricultural practices that enhance livelihoods and resilience to change, including a changing climate. Simply put, increasing awareness is necessary to increase adoption. Contact with extension agents, agri-service providers, farmers' organizations and other conventional sources of agricultural and climate-related information are not yet significantly increasing awareness of CSA practices. In addition, providing information to one spouse (usually the husband) does not mean that the other spouse also learns about options and opportunities that meet their needs. These needs can be quite different for spouses, and for women, are usually integrally related to whether the household is food/nutritionally secure or not. Importantly, while women are less aware of CSA practices than are men, if they know about the practice, women are no less likely to adopt most practices. Moreover, women's access to credit is positively associated with the adoption of CSA practices, although the household's access to credit does not influence the uptake of CSA practices, and thus is likely being used for non-farm purposes.

We also find significant impacts related to the attitudes of individuals (i.e., whether they identify themselves as innovative or traditional). A better understanding of these social factors may help practitioners better target awareness and adoption of CSA practices. Similarly, the significant association between community trust and attitudes towards working together and the adoption of CSA practices highlight the importance of addressing issues of collective action and suggest the need to work to strengthen local institutions.

Access to weather forecasts, while limited, has no positive impact on adoption of most technologies that could enhance resilience to a changing climate. Similarly, we did not find an expected link between property rights or ownership of assets and the adoption of CSA practices. Use of information channels favored by agricultural development programs—extension services, farmer organizations, and agri-service providers – do not significantly improve awareness of CSA. We also found little association between awareness and adoption of these practices and age.

These findings suggest a great need to reach out to, and better target CSA-related information to women in particular, as well as to young people. Traditional bearers of information need to be better trained on CSA practices and/or new ways for reaching target groups need to be identified, such as cellphones, radio, television and targeted messaging at meeting places, such as markets or places of worship.

These results suggest that many factors are involved in the adoption of CSA practices, including norms of cooperation and trust, social and economic factors, attitudes and orientation of individuals, and access to a variety of information types. Some of these factors, such as improving information channels, are amenable to interventions that can increase awareness and adoption of CSA. However, the fact that many of the commonly-identified interventions to increase CSA (and agricultural technology) uptake, such as extension services, and agri-service providers, do not have a significant positive effect, whereas innovative attitudes and established trust do play an important role, indicates that there are not necessarily clear and mechanistic "policy levers" that will lead to widespread adoption. Rather, development practitioners and projects must pay greater attention to social and behavioral/attitudinal factors to encourage and facilitate greater adoption of CSA practices.

Keywords

climate smart agriculture; gender; technology adoption; climate change; institutions

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Contents

Table of Contents

List of Tables and Figures

Introduction

In recent years there has been considerable attention to the intersection of gender and climate change, focusing particularly on the adverse impacts of climate change on women. However, these studies often lack a systematic empirical basis (beyond localized or anecdotal examples); and available data are often limited to comparison of male- and female-headed households.[1] A further weakness is that many studies portray women as victims of climate change, without examining the extent to which women and men can be proactive in reducing adverse impacts of climate change or its consequences (Goh 2012; Arora-Jonsson 2011; Meinzen-Dick et al. 2014). This paper builds on a descriptive analysis by Twyman et al. (2014) that largely used the same dataset as this paper.

The concept of "Climate Smart Agriculture" (CSA) has been promoted by development organizations in recent years (FAO 2010, 2013). CSA practices are defined as those that sustainably increase agricultural productivity and incomes, build resilience and capacity of agricultural and food systems to adapt to climate change, and reduce and remove greenhouse gases (GHGs) while enhancing national food security (Neufeldt et al. 2013). There are many constraints holding back farmer uptake of CSA practices, as CSA may require smallholder farmers to acquire new knowledge, change behaviors and invest significant quantities of time, labor and cash (McCarthy et al., 2011). These constraints are not just practical or technological in nature, but also relate to insufficient institutional and policy support for these changes (Kristjanson et al. 2013, Farnworth et al. 2013; Meinzen-Dick et al. 2013).

There is increasing evidence that widespread neglect in meeting the needs of women farmers has had a negative impact on food security in many countries, and gendered inequities are holding women back from achieving their full agricultural potential (for example Peterman et al. 2011; Doss and Morris 2000; Ragasa 2014). Few studies have explored gender issues in relation to the challenge of realizing more widespread uptake of CSA practices, however.

[1] Assumptions about "headship" are problematic (see Budlender 2003; Buvinic´ and Gupta 1997; Deere et al. 2012). Following Alkire et al. (2013), we classify households in terms of whether there are both male and female adults (dual-adult households), only female adults, or only male adults.

This paper explores the gender differences in awareness and adoption of CSA practices as well as associated institutions in two sites in Kenya. We begin by briefly reviewing the literature on factors affecting adoption of agricultural and natural resource management practices, followed by a description of the study areas, the sample population, and methodology. The following sections present the results of factors affecting awareness and adoption of CSA. The concluding section draws out lessons for increasing CSA adoption by men and women.

Background: Climate-smart agriculture, gender and institutions

Climate-smart agriculture (CSA)

Climate change poses potentially large risks for farmers in the developing world, impacting yields, growing seasons, water availability, and increasing weather uncertainties (Nelson et al. 2009). The adoption of new technologies and alternative practices has the potential to reduce adverse yield impacts (Rosegrant et al. 2014). Moreover, many yield-enhancing technologies have the ability to reduce carbon emissions from agriculture. Agriculture thus plays a key role in adaptation to and mitigation of climate change.

In 2010, the FAO identified 'climate-smart' agricultural to be practices that "sustainably increase productivity, resilience (adaptation), reduce/removes greenhouse gases (mitigation) while enhancing the achievement of national food security and development goals (FAO 2010, ii). This term has since caught the attention of the global community (Scherr et al. 2012), although not without provoking the criticism that it encompasses virtually any practice (Neufeldt et al. 2013). Some climate activities and development practitioners also reject the term, seeing it as an act of corporate greenwashing.[2]

For the data described in this paper, the authors consulted with field staff, researchers, and experts to compile a set of potential climate-smart practices for East Africa, West Africa, and South Asia. The list below describes the practices identified by experts and further examined in this paper.

- **Agroforestry**: Planting trees together with crops on the farm. These are trees that produce or are primarily used for fruit, fodder, or fuel wood production or that

[2] http://www.ipsnews.net/2014/09/climate-smart-agriculture-is-corporate-green-washing-warn-ngos/

provide other benefits, such as reducing runoff or erosion, enhancing soil fertility, providing shade, and providing medicines.

- **Terraces and bunds**: Physical structures placed along the contours to slow the speed of water.
- **Water harvesting**: Structures for collecting water from a surface area, to be used for irrigation or for improved filtration. These can be both larger and smaller systems, encompassing individual farm and plot level systems to larger ones. These can include water ditches, water pans, and dams.
- **Irrigation**: Covers all types and systems of irrigation, from both ground and surface water sources.
- **Planting pits**: Pits for planting and to help conserve water; they can be of different sizes.
- **Crop Residue Mulching**: Leaving crop material on the fields after harvesting to improve soil texture, prevent erosion, and help with water filtration.
- **Composting**: Removing crop residues to allow them to decompose and then adding them back to the soil to improve soil fertility and texture and allow for improved water filtration.
- **Cover cropping**: Crops grown to ensure that fields are covered by vegetation in between seasons, intended to protect soil against erosion. May also enhance soil fertility and suppress pests.
- **Livestock manure management**: The collection of livestock manure that can be stored and then applied to fields.
- **Efficient use of fertilizer**: Applying appropriate amounts of fertilizer by increasing fertilizer use to increase yields and improve soil fertility where it has been under-applied, reducing fertilizer where is has been over-applied, or switching fertilizer types based on crop requirements. It also refers to the use of fertilizer practices that produce more yield with the same fertilizer (ceteris paribus) or to the same yield with less fertilizer, for example, through the mixing of fertilizer components to reflect actual soil and crop needs, deep placement of fertilizer, microdosing, changing from one fertilizer application at the beginning to three (smaller) fertilizer applications, or changing application based on extension advice.
- **Improved, high-yielding varieties (HYV)**: Purchasing or breeding varieties to improve and increase the yield.
- **Stress tolerant varieties (STV)**: Use of varieties adapted to climate challenges that a particular region faces, including drought/flood/saline/submergence and pest resistant seeds.
- **No till/minimum tillage**: Opening soil only where the seeds are placed, with as little soil disturbance as possible.

- **Improved feed management**: Storing animal feeds (stover, grass, napier, etc); making better use of the feeds (through combining feeds); growing grass varieties better suited to the agro-ecological zone, fodder conservation and fattening animals, among others.
- **Destocking:** Reducing the number of livestock to improve resilience and make the herd more manageable as a conscious decision and not due to hardships.
- **Switching to drought tolerant species or breeds of livestock**: Purchase or breeding of animals that are more tolerant to drought or disease. This can include switching the type or the species of animal. Zebu cattle and small ruminants are common examples of more drought tolerant species.
- **Pasture management**: Includes rotational grazing and setting paddocks aside in case of drought.

Gender and climate-smart agriculture

The adoption of specific technologies and natural resource management techniques cannot be assumed to occur in the same manner in different households and among different individuals. Just as the geographic location and socioeconomic status of a household must be considered, so too must the gender breakdown of the household's individuals. Differences in needs and preferences, access to assets and resources, risk profiles and attitudes, modes of access to information and sources of information can all influence if and how specific land-management practices, including CSA practices, are adopted (Villamor et al. 2014; Pandolfelli et al. 2008).

For many years a unitary model of the household was the standard, wherein resources are understood to be pooled and collective decisions made to maximize household utility (Becker 1965; Becker 1981). In the last couple of decades, however, this model has been critiqued because it does not allow for individual differences in preferences, budget constraints, or incomplete pooling of resources, and, specifically in regards to gender, it does not look at what factors affect men's and women's bargaining power within the household, and how gender may influence social norms and motivations (Manser and Brown 1980; Doss 1996; Agarwal 1997). Empirical evidence since then has strengthened the argument for a collective household model approach (see, for example: Udry 1996; Quisumbing and Maluccio 2000). This research approach suggests that men and women have their own interests and preferences that influence their individual decisions. For example, a growing body of work has found gender differences in risk preferences. A review of ten studies in Western contexts by Croson and Gneezy (2009) finds that women are consistently more risk-averse than men. Other studies conducted in developing countries find similar results (Wik et al. 2004; Gong

and Yang 2012). However, recent work has challenged these findings, arguing that they overstate the differences in responses to risk between men and women (Nelson 2014).

Men and women may also make decisions about different things, or have different levels of decision-making authority in different spheres of life. For example, women tend to have more decision-making authority over issues concerning household food consumption and nutrition (Smith 2003) and less authority over decisions relating to household land (Kes et al. 2011; Jacobs et al. 2011), though this can vary by country and context.

Control over land and other assets has been suggested as a key measure of women's bargaining power (see review in Quisumbing and Maluccio 2003). However, recent work on the adoption of the orange-fleshed sweet potatoes (OSP) found that greater female bargaining power, proxied by the share of land exclusively controlled by female household members, did not "unambiguously increase" the probability of adopting OSP (Gilligan et al. 2013). Instead, parcels under joint control were more likely to have OSP, illustrating the importance of joint decision-making, and suggesting that solely targeting women for OSP adoption may not be effective because they are, perhaps, not the sole decision-makers on what to plant.

The gendered nature of agricultural work, and of smallholder livelihood strategies, also means that men and women may perceive the risks of climate and other shocks differently, may be vulnerable to different shocks and might experience different impacts from climatic shocks, such as asset disposal. While there are some gendered differences in climate change perceptions (Twyman et al. 2014), there is mixed evidence on the extent to which the perception of climate shocks can actually drive changes in adaptive behaviors and how much is constrained by local institutional factors (Tucker et al. 2010). Carr (2008) finds for Ghana that while men and women are both vulnerable to cropping and environmental shocks, because of their reliance on the market, men might be additionally vulnerable. Studies in Bangladesh have shown that women's assets are often more liquid and less related to the main income source and therefore more likely to be disposed of when climatic shocks hit (Rakib and Matz 2014).

In addition, social norms, opportunities, and practices can structure access to resources, information, and technologies in ways that may complicate, or facilitate, the adoption of certain practices. Kiptot and Franzel (2012) identify various beliefs and practices that limit women's participation in agroforestry in Africa south of the Sahara, including land and tree tenure, household decision-making, financial assets, labor, education, extension visits, customs and taboos. Van Koppen et al. (2012) found that owing to their lighter workload and lack of domestic chores, coupled with their easier access to agricultural equipment and input

stores, finance, public support, transportation, and markets, men in Zambia and Ghana can more easily adopt small-scale irrigation technologies. Moreover, because of differing social networks men and women may have differential access to agricultural information and resources. Recent work in India found that poorer women had large social networks, often including other poor women, while men had smaller networks, but were more likely to be connected to wealthier and more progressive farmers, which would have implications for their abilities to access and learn about new agricultural technologies (Magnan et al. 2013).

Some agricultural practices, such as conservation agriculture and no-till or minimum till, can increase the amount of manual weeding needed, an activity often performed by women in Africa south of the Sahara (Giller et al. 2009). Researchers and practitioners have identified several strategies to make interventions more accessible to women, including facilitating adoption through collective action that reduces the investment costs, promoting divisible technologies or smaller input packages that are more affordable, and improving access to credit for women (Quisumbing and Pandolfelli 2010). CSA interventions vary not just in their resource requirements, but also in terms of their labor requirements, which, depending on cultural norms, may imply a greater contribution from men or women.

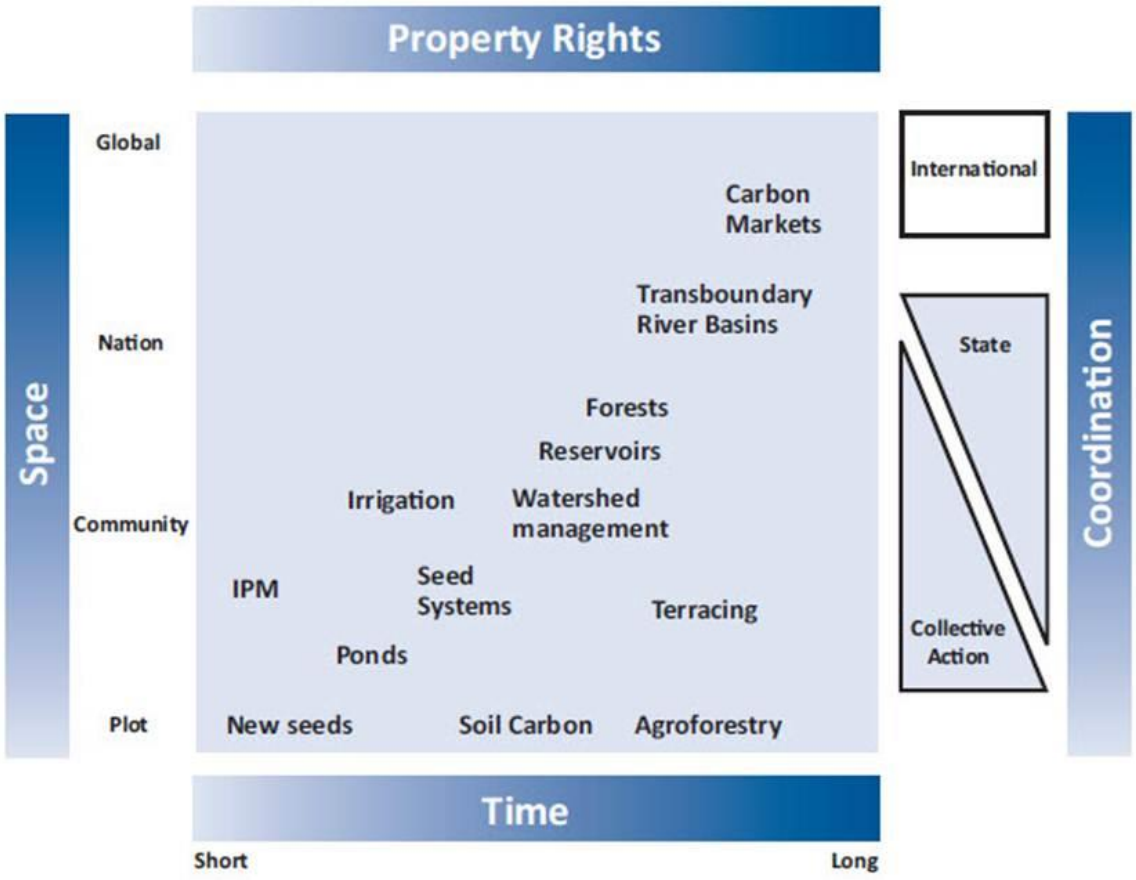
In contexts where the gender division of labor is rigid, the knowledge that each individual has is likely heavily influenced by the tasks that he or she performs on a daily basis. In some communities, men and women perform highly gendered tasks, with women performing the majority of domestic duties within the household. In other communities, the sharing of work is more flexible (see, for example, Elmhirst 1998). The distribution of workload can also be influenced by factors like age or human capital (Fafchamps and Quisumbing 2003) or by occurrences like migration (see for example, Djoudi and Brockbaus 2011), and can shift over time for a variety of reasons (Resurreccion, 2006). Understanding who performs what tasks and under what circumstances is important for appropriate targeting of interventions and information.

Understanding the challenges and constraints that men and women face given their gender and the work they perform is also critical. Political, financial, social, and other constraints may exist generally for all members of a community or may themselves be gendered. For example, in countries where female seclusion is highly valued, like Bangladesh, women's movement to and from the marketplace or other public places is a gender-specific constraint (Amin 1997; Quisumbing et al. 2013). In other instances, poor infrastructure may be a constraint faced by all. Further, these constraints can complicate information dissemination and access to different types of climate information (Twyman et al. 2014; Roncoli et al. 2010).

Institutions and adoption of CSA practices

The importance of institutions in the adoption of CSA practices has been underemphasized, yet is of critical importance, especially given their importance in providing information and in enabling innovation, investment, and insurance (Meinzen-Dick et al. 2013). Institutions, defined as"[t]he rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction" (North 1990), include not only markets and state institutions, but also local-level and customary institutions—all of which have the potential to influence the adoption and use of CSA practices by smallholders. Empirical evidence highlights the importance of collective action and property rights in facilitating not only the adoption of many agricultural technologies or natural resource management practices (Meinzen-Dick et al. 2002), but also for facilitating risk pooling (McCarthy et al. 2000, 2004), and for enabling people to build assets that can help them withstand shocks (Di Gregorio et al. 2008). Moreover, local level institutions play a key role in structuring access to and control over resources, in addition to facilitating access to resources outside of communities (Agrawal 2010). Recent literature suggests that intra-community bonds of trust and cooperation may result in inward-looking behavior, making individuals less likely to adopt and search out new agricultural innovations (van Rijn et al. 2012) and also that social capital may not play a role in private adaptations that do not require labor or resource pooling or overcoming of information constraints (Nam 2011).

CSA practices also have different institutional implications, depending on the spatial scale, costs, and payback period of the investments, as demonstrated in Figure 1. Actions at the individual level (such as planting a drought-resistant crop or building a farm pond) generally do not require much in the way of institutions for coordination. When moving up the scale to actions that operate at the group or community level (such as a small reservoir to serve a group or community), some form of coordination becomes necessary. At this local level, collective action institutions are often the most appropriate for such coordination, although some state institutions may also be relevant (for example, giving technical advice to a group of farmers digging or operating the reservoir). These institutional implications each have gender dimensions, as discussed above.



Source: Meinzen-Dick, Markelova, and Moore 2010.

Figure 1. Collective Action and Property Rights Framework: Source: Meinzen-Dick, Markelova, and Moore 2010.

Based on our review of literature on CSA practices, gender and institutions, we propose to test three gendered, institutional hypotheses for CSA adoption. The hypotheses are: 1) Longer-term practices (e.g. practices where the benefits are accrued after years rather than months, such as fruit trees or pasture management) will require special attention to institutions, such as property rights and tenure security; 2) Those practices that require cooperation (either through community bylaws, joint work, or enforcement) will require more community-level social capital; and 3) Women adopt those practices that are of special interest to them – for example, those that provide food security without being overly labor or cash intensive. Focusing on the gender and institutional aspects of CSA practices will add value to ongoing work to the CGIAR-led compendium of climate-smart practices. The authors have attempted to categorize the various CSA practices that form a part of this survey according to the listed criteria.

Table 1. CSA Practices: Long-term nature of benefits, cooperation, special interest to women

CSA Practice	Long-term nature of benefits	Cooperation needed to implement	Special interest to women
Agroforestry	X	X	X
Terraces/bunds	X	X	
Water harvesting	X	X	X
Irrigation	X	X	
Planting pits	X		
Crop residue mulching			
Composting			X
Cover cropping		X	X
Manure management			X
Efficient fertilizer use			
Improved high-yielding varieties (HYV)			X
Improved stress tolerant varieties (STV)			X
No/minimum tillage	X		X
Improved feed management	X		X
Destocking			
Switching to drought tolerant livestock			
Pasture management	X		

Source: Authors

Methodology and site description

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is involved in promoting a range of CSA practices, which are monitored in sites in select countries in Asia, Africa, and Latin America. These sites were chosen to represent major farming systems and agro-ecological zones in the various regions, but the purposeful selection means that the sites cannot be considered nationally or regionally representative. To integrate gender in its monitoring and evaluation (M&E) system, CCAFS added an intrahousehold survey in 2013, developed by IFPRI, ILRI, ICRAF, and CIAT.[3] In order to minimize the burden on respondents, the survey team designed the intrahousehold survey to build upon a comprehensive farm characterization survey called IMPACTLite (Integrated Modeling Platform for Mixed Animal Crop System, Quiros et al., 2011) that CCAFS was already conducting in the baseline sites. This was a modified version of the IMPACT tool developed by Herrero et al. (2007). It includes household- and plot-level information and captures variability within sites with respect to key performance and livelihoods indicators. The IMPACTLite survey collected data for approximately 200 households in each selected CCAFS site, stratified to reflect the different farm production systems that exist within the research grid. Only households engaged in crop and other agricultural activities were interviewed. IMPACTLite collects a wide range of data on household production practices, farm inputs, outputs, labor, at a plot and subplot level, as well as food consumption.

The additional gendered intrahousehold survey contains 13 modules, posing questions at a household and individual level on land tenure and ownership; on agricultural, livestock, and household decision-making; adoption and knowledge of climate-smart practices; access to and use of climate and agricultural information services; access to and use of credit; membership in groups; fuel and water use; coping strategies for dealing with shocks; perception of climate change and its potential impacts; identification of adaptation strategies; and cognitive decision-making and personal values questions. In order to better understand gender dynamics, household bargaining, and gender-differentiated adaptation strategies and preferences, the survey asked most questions separately of multiple household members, usually the principal male and female adult decision-makers (see discussion in Doss 2013). For polygamous households, the survey teams identified additional wives and conducted the interview with all of them. Both IMPACTlite and the intrahoushold survey selected local enumerators, familiar with local customs and local languages, to carry out the work. The

[3] All survey tools are available at http://thedata.harvard.edu/dvn/dv/CCAFSbaseline

survey was conducted in 6 CCAFS sites across 4 countries: Kenya (2 sites), Uganda (1 site), Senegal (1 site), and Bangladesh (2 sites). This paper presents only the results from the two Kenya sites. The data allow us to not only measure the extent of CSA adoption by men and women, but also to explore the constraints to adoption, and the extent to which these differ between women and men.

Figure 2: A map of the study sites. KE01 is Nyando and KE02 is Wote (Source CCAFS).

Nyando site – Lower Nyando River Basin, Western Kenya

The CCAFS site in the Nyando Basin in western Kenya is located in the humid and sub-humid zones with rainfall of 900-1200 mm spread over two rainy seasons. Land degradation

characterized by soil erosion and water run-off are substantial challenges and contribute to the formation of deep gullies that affect about 40 percent of the landscape (ICRAF 2008). Increased variability in climate patterns and extreme events such as droughts and floods are already occurring, affecting agricultural production and food security (Förch et al. 2013). More than half of the population lives below the poverty line, and human health issues such as high HIV prevalence are widespread. Most people rely on mixed crop-livestock farming for their livelihoods with farm sizes of less than 1 hectare; the area is also characterized by low agricultural production. Most of these farming households have made very few changes to their agricultural practices in the last decade. The food security and nutritional status of roughly one-fifth of households is dire, as they are unable to meet their food needs (from any source) for 3-4 months in a year (Mango et al. 2011). In Nyando, the IMPACTlite survey team identified three main agricultural production systems: (1) maize, sorghum, and local livestock; (2) maize, sorghum, sugarcane, and crossbred livestock; and (3) maize and dairy. In Nyando, 200 men and 200 women were interviewed, from 200 households.

Wote site – Wote Division, Makueni County, Eastern Kenya

Located only an hour's drive east of Nairobi, with an elevation of 900-1000 meters and an average bimodal seasonal rainfall of 520 mm, Makueni is located in the semi-arid agroecological zone of the country. Farmers in this area have also been experiencing highly variable and unpredictable rainfall in recent years. This arid to semi-arid area has primarily mixed crop-livestock systems that focus on producing maize, cowpea, and pigeon peas. Other livelihood options include beekeeping, small-scale agricultural produce trading, livestock keeping, and fruit farming. Small-scale, rain-fed agriculture is common, and terracing of the hillsides is widespread, as it was promoted by government and NGOs starting in the 1970s. Key challenges faced by the site include increasing population and problems of water stress and soil erosion (Förch et al. 2013). Some 22% of the population reports facing a period of hunger for at least 3-4 months of the year (Mwangangi et al. 2012). For the Wote site, the team identified two key production systems: (1) mixed food crops with indigenous livestock, and (2) mixed food crops, fruits, and livestock. In Wote, 176 men and 175 women were interviewed; 35 individuals interviewed were from households with only 1 adult decisionmaker (23 women and 12 men).

Analytical Method

Adoption of any agricultural technology or practice requires prior awareness, but different factors and conditions may affect adoption and awareness. This paper employs a two-stage model to look at the adoption of CSA practices, using the Heckman selection model to account for awareness of a particular CSA practice (at the individual level) and then adoption

of the CSA practice (reported at the individual level on a plot managed by the responding individual). The Heckman selection model assumes that those that are aware of technologies are not randomly selected, but that there is a self-selection bias that needs to be corrected to obtain an unbiased estimate of adoption (Heckman 1976). The model also assumes that awareness and adoption are not explained with exactly the same set of explanatory variables. Previous work has used similar models to look at awareness and adoption of agricultural practices, as well as awareness and adaption to climate change (for example, Deressa et al. 2010; McBride and Daberkow 2003; Kaliba et al. 2000). Table 2 lists the variables used in the first stage (awareness), and in the second stage (adoption) regressions.

Hypotheses regarding **awareness** of CSA practices

The first stage of the model considers awareness of the various CSA practices, constructed as a binary variable at the individual level for each practice. Responses were recorded as 1 if they reported being aware of a particular practice; and 0 otherwise. We hypothesize that awareness of certain practices depends on a set of individuals' socio-economic characteristics such as age, sex, access to different channels of information, as well as household level characteristics (e.g. land size, assets) and intrahousehold norms. These explanatory variables and the direction of the influence they are expected to have on awareness are described in Table 2.

Table 2. Variable descriptions and hypothesized direction of influence on awareness and adoption of various CSA practices

Variables	Description	Hypothesized direction of influence on	
		Awareness	Adoption
Innovative	1-5 index from self-assessments of likelihood of seeking new information and willingness to try new practices, 5 being more innovative	+	+
Traditional	1-5 index from self-assessments of importance placed on traditional approaches to agriculture and cultural values, 5 being more traditional	-	-
Female	1 if respondent is female; 0 if male	+ for female-dominated practices; - for male dominated	+ for female-dominated practices; - for male dominated
Spouse Awareness	1 if spouse reports being aware of the practice; otherwise 0	+	
Contact with extension agent	Individual reported contact with an extension agent in the last year	+	
Access to information from NGO	Individual reported having access to agricultural or climate information from NGO in the last year	+	
Access to Information from community meetings	Individual reported having access to agricultural or climate information from community meeting in the last year	+	
Access to information from farmer organization	Individual reported having access to agricultural or climate information from farmer organization in the last year	+	
Access to information from religious group	Individual reported having access to agricultural or climate information from	+	

	religious group in the last year		
Access to information from agriservice providers	Individual reported having access to agricultural or climate information from agri-service providers in the last year	+	
Access to information from family members	Individual reported having access to agricultural or climate information from family members in the last year	+	
Access to information from neighbors	Individual reported having access to agricultural or climate information from neighbors in the last year	+	
Access to information from radio	Individual reported having access to agricultural or climate information from radio in the last year	+	
Access to information from traditional knowledge	Individual reported having access to agricultural or climate information from traditional sources in the last year	+	
Age	Age of respondent, in years	-/+, depending on the practice	-/+, depending on the practice
Age2	Age of respondent, squared	-/+, depending on the practice	-/+, depending on the practice
Assets	Number of household assets	+ if wealthier households get more information	
Education	Respondent's years of formal education	+	+
Sugarcane and crossbreed livestock (Nyando)	Production system. Dummy variables (default is maize, sorghum, and local livestock in Nyando and mixed food crops and indigenous livestock in Wote).	-/+, depending on how practice fits in with existing production systems	-/+, depending on how practice fits in with existing production systems
Mixed Crop and Improved Livestock (Wote)			
Maize dairy (Nyando)			
Land owner	Respondent considers self as owner of any land. 1 if yes, otherwise 0		+ (especially for technologies with longer-term payoff)
Other income	At the household level, 1 if household reports off-farm income, otherwise 0		+ (especially more input-intensive practices)
Credit access	Access to credit by anyone in household, 1 if yes, otherwise 0		+ (especially technologies that require significant investment)
Community "trust others"	1-5, index score for responses to attitude questions on trusting others to help in time of need, 5 being more trust		+ (especially practices requiring cooperation)
Difference "trust others"	Difference between individual level trust scores and community trust scores		+ (especially practices requiring cooperation)
Work together	Personal value: cooperation and working together (1-5, high-low)		+ (especially practices requiring cooperation)
Memberships	Number of memberships per individual at the community level		+ (especially practices requiring cooperation)
Self decisionmaker	Whether or not the person considers him/herself the main decision-maker on any plot, 1 if owner, otherwise 0		+
Female land owner	Interaction term between variables female and self owner		+ (especially for those practices of special interest to women)
Female gender decisionmaking	Interaction term between variables female and gender decisionmaking		+ (especially practices of special interest to women)
Female credit access	Main female in the household has access to credit, 1 if yes, otherwise 0		+ (especially practices of special interest to women)
Female percent of assets	At the household level, the percentage of assets owned by the female respondent		+ (especially practices of special interest to women)
Gender decision-making	Personal values: Importance of women participating in household decisions (1-		+ (especially technologies that

	5, low-high)		require household collaboration)
Access to information on drought, flood, or extreme event	Respondent reported having access to information about extreme events, 1 if yes, otherwise 0		-/+, depending on the practice
Access to forecast on start of rains	Respondent reported having access to information about the start of the rains, 1 if yes, otherwise 0		-/+, depending on the practice
Access to seasonal weather forecast	Respondent reported having access to a seasonal weather forecast, 1 if yes, otherwise 0		-/+, depending on the practice
Crop-related shock	Reports experiencing a shock resulting in crop loss or damage, 1 if yes, otherwise 0		+ for technologies that make crops resilient/hardier
Water-related shock	Reports experiencing a shock resulting in water changes (availability etc), 1 if yes, otherwise 0		+ for technologies that impact water
Soil erosion shock	Reports soil erosion as a result of a shock, 1 if yes, otherwise 0		+ for technologies that protect soil
Future Drought impact	Respondents expect that droughts will greatly impact their livelihoods in the future, 1 if some or great impact, 0 if little or no impact		+ for technologies that counteract drought - for those impacted by drought
Future Flood impact	Respondents expect that floods will greatly impact their livelihoods in the future, 1 if some or great impact, 0 if little or no impact		+ for technologies that counteract floods - for those impacted by floods
Total farm area	Total area of plots owned by the farm (in acres)		+ for practices with economies of scale, - for practices with resource constraints
Income	Total income (household level), in previous year		+ for more resource intensive practices
Household size	Total household size		+ for more labor intensive practices

Source: Authors

Sources of information. Agricultural extension officers serve as one likely source of information of CSA practices. The extent and quality of this information depends on whether extension agents are themselves trained in or are aware of CSA practices. However, a long literature identifies likely gender differentiated access to and impacts of agricultural extension (for example, Meinzen-Dick et al. 2011). Extension agents are not the only source of information about new agricultural practices; other sources include: NGOs, community meetings, farmer organizations, religious groups, family members, neighbors, radio, private sector agri-service providers, cellphones, and traditional knowledge (Aker 2011; Feder et al. 2011). We hypothesize that individuals may have different levels of and access to channels of information based on age, sex, and social norms, in addition to valuing some channels of CSA information over others (Chaudhury et al. 2012). While household members do share some information, one cannot assume that information is fully shared within the household (Johnson et al. 2013). We included a variable indicating whether the other primary respondent in the household (typically the spouse) knows of each CSA practice. If the spouse is aware of the practice, the respondent would have a score of 1 for this variable. This variable highlights issues of intrahousehold decision-making and communication, and we hypothesize

that this variable would have a positive effect on awareness if there is good communication within the household.

Attitudes.

There is increasing attention to the social, economic, and biophysical characteristics that surround agricultural technology (see for example, Meijer et al. 2015). These studies recognize that agricultural technology adoption (and changes) are complex socio-technical and political processes that are shaped by social environments, including the social goals and institutions (Reimer et al 2014; Crane et al. 2011). In addition, innovation and innovativeness, which can be developing new practices, modifying or adapting existing practices, or experimentation, can help to increase adoption of new practices (Tambo and Wünscher 2014); however, the adoption of new practices may also subject to community-buy in and other social norms (Reimer et al. 2014). At the same time, individuals may have preferences for existing practices, or may have other behavioral barriers to adopting new practices (de Jalon 2014).

Based on a series of questions designed to understand motivations and behaviors, we created two variables that are indices of self-reported 'innovative' and 'traditional' attitudes and behaviors. For the innovative index, questions included self-assessments as to how likely individuals were to seek new information and their willingness to try new practices. For the traditional index, respondents evaluated the importance they placed on traditional approaches to agriculture. We hypothesize that individuals with higher innovative scores (those that say they are more likely to try new things, seek new information, and are willing to accept and use new information) will be more aware of CSA practices and more likely to adopt these practices as well. On the other hand, those adhering largely to traditional methods and cultural practices related to agriculture and farming are likely to be less aware of CSA practices, unless these are specific CSA practices that fit into the "traditional" repertoire.

Individual and household characteristics. At the individual level, we include female (as a dummy variable) age, age squared (age2), and the years of an individual's formal education (education) as explanatory variables. In addition, using information collected from IMPACTLite survey, we calculated an assets variable (both agricultural and non-agricultural) at the household level (i.e. both the male and female respondents in the survey have the same asset value) as a proxy for household wealth. We hypothesize that older individuals, those with more education, and those in wealthier households are more likely to be aware of improved agricultural practices. Whether women or men are more aware would likely depend on whether the particular practice is primarily seen as women's or men's domain.

Agricultural production system. We include variables to capture the different agricultural production systems in an exploration of how much some of the relationships we are testing are unique to different systems. For Nyando, we have a sugarcane cross system (which represents the maize, sorghum, sugarcane, and crossbred livestock system) and maize dairy (which represents the maize and dairy animal system), to understand the impacts of having those production systems as opposed to maize, sorghum, and local livestock (which was the default). For Wote, we created a variable for a mixed food crops, fruits and improved livestock production system, whereas the default is mixed food crops and indigenous livestock.

Hypotheses regarding adoption of CSA practices

For adoption, we also assign binary variables for each practice, corresponding to whether or not the individual reported adopting it on a plot that they managed or co-managed. Each practice is considered at the individual level. We hypothesize that adoption, like awareness, can be explained to some extent by a mixture of individual, household, and community-level characteristics (Table 3). We calculate adoption for each practice, in order to see the difference between the various practices.

Ownership and decision-making. We include an individual level variable to look at property rights. 'Land owner' measures whether the respondents listed themselves as the owner of any of the household's plots and subplots reported in the survey. As noted above, we hypothesize that for practices with a long-term horizon, including agroforestry, water harvesting, irrigation, terracing, and planting pits, property rights will be important. We also interact this term with 'female', to understand if the impact of land ownership/tenure is stronger for women. In addition to ownership, we create a variable that represents whether an individual lists him/herself as the main decisionmaker of any plot. We hypothesize a positive relationship between primary decisionmaker and the adoption of CSA practices.

Innovativeness. We assume that innovative individuals will be more likely to adopt CSA practices than more tradition-oriented farmers.

Collaboration and Trust. Coordination, cooperation, and collaboration are necessary and important for the adoption of many CSA practices. 'Works together' measures perceptions related to how strongly an individual values cooperation and working together with members of the community. It is calculated as an average score of a set of related questions on the importance of community cooperation and work. We also include the number of group memberships, hypothesizing that this can serve as both a method of learning about new technologies, but also for securing additional labor or improving market access.

We include a measure of "trust in others" that respondents feel regarding whether community or family members will help them in times of need. Recent studies suggest that strong social norms that ensure that assistance is given when needed may actually decrease investments in new practices (see for example Di Falco and Bulte 2013). We created this proxy variable at the community level. We also calculated a variable that measured how far a person's individual score was from the community level score. Another variable labeled 'gender decisionmaking' was created, which is an average of individual attitude scores about the importance of men and women in collaborating on household decisions; a higher score reflects a greater belief in collaborative and joint decision-making. We expect that increased appreciation of collaboration will increase the likelihood of adoption of CSA practices. We further interact that with the 'female' dummy variable, to see if the effect of increased collaboration is more important for women.

Household characteristics. At the household level, we measure total farm size in hectares. We expect to see that for some practices, farm size may contribute to a greater likelihood of taking up the practice; for others, this may make it harder to adopt, as materials may be scarce. We also look at share of assets owned by females (at the household level). This variable, created from reported agricultural and non-agricultural assets owned by the individuals in the household, serves as a proxy for the individual respondents' control of assets. We hypothesize that greater female control and ownership of assets will lead to a higher adoption rates (again, at the individual level), specifically for those practices that are of interest and relevant to women. We include two variables related to access to credit, which has been found to be important for overcoming financial constraints to adoption of agricultural technologies. The first, credit access, is whether or not the individual reported anyone in the household having access to credit. The second, female credit access, is a household level variable reporting whether or not the main female decisionmaker in the household reports having access to credit. We also include a variable that looks at the impact of off-farm income on the adoption of these technologies. This is a binary variable, measured at the household level, where 1 indicates some off-farm income. In addition, we include total income (from the previous year), which is a household-level variable.

We expect to see a positive relationship between education and the adoption of certain practices, and include age to explore whether younger or older people are more likely to adopt CSA practices.

Climate information access. For adoption, we hypothesize that having access to climate and weather-related information may make people more willing to adopt certain climate-smart technologies, in particular those practices that are designed to buffer against changes in

climate. These include forecasts of drought, flood or extreme events, forecasts for the start of the rains, and seasonal weather forecasts. Previous studies have found that climate information helps farmers to overcome knowledge barriers and to help evaluate (and adopt) agricultural technologies that may be useful responses to weather variability and changes (Hansen et al. 2007; Ziervogel and Ericksen, 2010; Adger et al. 2009; Rosenzweig and Udry 2013; Vermeulen et al. 2011). Again, this recognizes that specific information interacts with a set of established social norms and rules that dictate the resources that individuals have access to and the amount of time and money that they have to dedicate to them (Roncoli et al 2010).

Climate-related shocks. We also test whether or not experiencing shocks relates to the adoption of CSA practices. Some recent work has found that climatic factors play a key role in explaining the adoption of agricultural technologies, such as minimum soil disturbance (Arslan et al. 2014; Asfaw et al. 2014). Most households in the study areas had reported experiencing shocks, so we looked at the shocks based on their reported impacts: shocks that reduced crop productivity or yields, shocks that affected the amount of water available (drought, flood, too much rainfall etc.), and finally, shocks that resulted in soil-erosion effects. We expect that individuals that have experienced shocks will be more likely to adopt technologies and practices that can help to alleviate these shocks. At the same time, experiencing a shock may make individuals less likely to invest in practices that are jeopardized by recurrence of these shocks.

Furthermore, we asked respondents to identify the impacts of future droughts and floods on their livelihoods and created a binary variable with a value of one if respondents predicted that floods/droughts would have a substantial impact on their livelihoods in the future. We hypothesize that individuals who believe that floods or droughts will have a greater impact on their livelihoods in the future will be more likely to adopt CSA/adaptive practices now, if possible, especially those that may reduce the impacts of these extreme events.

Results

Awareness and adoption of CSA practices

We look first at differences in awareness (Table 4) and adoption (Table 5) of the different CSA practices, by gender.

Table 3. Awareness of Climate Smart Practices

Practice	Nyando		Sig Dif	Wote		Sig Dif
	Women (n=200	**Men (n=200)**		**Women (n=175)**	**Men (n=176)**	
Agroforestry	52%	76%	*	98%	100%	*
Terraces/bunds	60%	81%	*	100%	100%	
Water harvesting	38%	73%	*	94%	94%	
Irrigation	72%	77%		85%	91%	*
Planting pits	12%	14%		37%	25%	*
Crop residue mulching	95%	88%	*	96%	97%	
Composting	20%	44%	*	27%	48%	*
Cover cropping	40%	24%	*	13%	4%	*
Manure management	88%	89%		93%	85%	*
Efficient fertilizer use	64%	73%	*	11%	35%	*
Improved HYVs	86%	61%	*	94%	99%	*
Improved STVs	18%	12%	*	91.4%	98.3%	*
No/min tillage	57%	72%	*	7%	33%	*
Improved feed management	33%	40%		68%	73%	
Destocking	27%	28%		70%	63%	
Switch to drought tolerant livestock	14%	10%		53%	30%	*
Pasture management	21%	5%	*	32%	2%	*

Source: CCAFS/IFPRI/ILRI Gender Survey 2013, authors' calculations. Sig Dif is significant difference. HYVs is High Yielding Varieties and STV is stress tolerant varieties.

As can be seen in Table 4, there is still a very low awareness of many water-conserving and soil-enhancing agricultural practices that could increase climate resilience (along with other livelihood benefits).

Levels of awareness are significantly lower for women than for men for most practices in both sites, with the exception of planting pits, disease-resistant livestock breeds, manure management (Wote only), higher yielding varieties, stress-tolerant varieties, crop residue management (Nyando only), cover cropping, and improved rangeland management practices (both sites).

Other notable findings are that in Nyando, only 50% of surveyed women were aware of agroforestry opportunities (and just three-fourths of men), compared to nearly all respondents of both sexes in Wote. Similarly, in Nyando, 40% of women are unaware of terraces and bunds, but again, in Wote, nearly 100% of respondents are aware of such practices. In Nyando, water harvesting for agriculture is known to only 38% of women and 73% of men. Crop residue mulching, manure management, high yielding varieties and efficient fertilizer use enjoy relatively wide awareness by both men and women.

In Wote, both men and women are highly aware of agroforestry, terracing, and water harvesting, presumably as the site is in the semi-arid agroecological zone and thus practices that conserve soil moisture are more important compared to the Nyando site. Cover cropping has low awareness among men and women (4% and 13% respectively).

Table 4. Proportion of those who adopt the practice, if aware

	Nyando		Sig Dif	Wote		Sig Dif
	Women (n=200	Men (n=200)		Women (n=175)	Men (n=176)	
Agroforestry	34%	24%	*	72%	93%	*
Terraces/bunds	45%	41%		95%	98%	*
Water harvesting	38%	21%	*	29%	31%	
Irrigation	21%	14%	*	9%	10%	
Planting pits	48%	26%		6%	7%	
Crop residue mulching	92%	67%	*	75%	87%	*
Composting	62%	24%	*	28%	31%	
Cover cropping	78%	57%	*	85%	84%	
Manure management	61%	55%		0%	13%	*
Efficient fertilizer use	87%	82%		91%	99%	*
Improved HYVs	60%	30%	*	92%	99%	*
Improved STVs	47%	18%	*	8%	0%	*
No/min tillage	41%	23%	*	66%	36%	*
Improved feed management	43%	29%		40%	25%	*
Destocking	60%	48%		38%	0%	*
Switch to drought tolerant livestock	43%	50%	*	47%	65%	*
Pasture management	78%	33%	*	41%	33%	

Source: CCAFS/IFPRI/ILRI Gender Survey 2013, author's calculations

The trend of lower rates of awareness by women does not translate into lower levels of adoption of these practices in the Nyando site. Once aware of the practices of water harvesting, crop residue mulching, composting, manure management, drought/heat/ flood tolerant varieties, minimum tillage, and cover cropping, a higher proportion of women than men are taking up these practices.

In Wote, however, we see less adoption of most practices by women than by men, except for livestock-related practices including: manure management, improved feed management, destocking, and rangeland management. A greater proportion of women are taking up no/minimum tillage and cover cropping practices, although this pertains to relatively few cases.

Gender differences in perceptions, decisionmaking and access to information

Table 5 presents gendered differences in the key variables for the Nyando and Wote sites.

Table 5. Differences in perceptions, decision-making and access to information in Nyando and Wote

	Nyando			**Wote**		
Variable	**Men**	**Women**	**Sig**	**Men**	**Women**	**Sig**
Innovative (index score, 1-5. 5 being more innovative)	3.96	4.00		3.46	3.52	
Tradition (index score, 1-5, 5 being more traditional)	2.47	3.14	***	1.97	1.79	***
Female (percent)	50	50		50.1	49.9	
Contact with extension officer (percent)	57	68	**	97	94	
Access to information from NGO (percent)	64	68		68	84	***
Access to information from community meetings (percent)	63	38	***	99	97	
Access to information from farmer organizations (percent)	13	36	***	11	30	***
Access to information from religious groups (percent)	32	42	*	44	55	**
Access to information from agri-service providers (percent)	7	16	***	18	67	***
Access to information from family members (percent)	79	93	***	99	97	*
Access to information from neighbors (percent)	94	82	***	99	99	
Access to information from radio (percent)	99	96	**	100	99	
Access to traditional knowledge (agriculture and weather) (percent)	93	81	***	90	91	
Age	42.5	43.4		45	44	
Assets (index score)	68			63	61	
Education (number of years)	7.8	5.6	***	8.3	6.8	***
Maize dairy system (percent)	30					
Mixed crop and livestock system (percent)					51	

Variable	Men	Women	Sig	Men	Women	Sig
Sugar cane cross system (percent)	30					
Land owner (percent)	52	18	***	27	11	***
Other income (percent)	91			99		
Credit access (percent)	83	67	***	89	92	
Community "trust others" (index score, 1-5, 5 showing more trust)	4.1			3.42		
Difference "trust others" (trust others- community averaged trust others)	0.05	-0.09	*	-0.16	0.16	***
Work together (index score, 1-5, 5 showing more willingness to cooperate)	3.8	3.85		3.5	3.4	
Memberships (number)	0.77	1.4	***	3	4	***
Self decisionmaker (percent)	65	63		78	63	***
Female credit access (percent)	46	46		81	90	***
Female percent assets (percent)	12	12		9	10	
Gender decisionmaking (index score, 1-5)	4.76	4.28	***	3.8	3.9	
Access to information on drought, flood, or extreme event (percent)	85	70	***	91	44	***
Access to forecast on start of rains (percent)	91	91		97	98	
Access to seasonal weather forecast (percent)	80	40	***	88	92	
Crop shock (percent)	81	73	*	99	90	***
Water shock (percent)	64	62		98	90	***
Soil erosion shock (percent)	19	7	***	5	5	
Drought impact (percent)	48	43		97	89	***
Flood impact (percent)	17	50	***	0	1	
Total farm area	4.1	4.1		5.3	5.2	
Income (USD)	809			1398		
Household size	6.5			5.7	5.9	

Source: CCAFS/IFPRI/ILRI Gender Survey 2012, author's calculations

"*" = significant at the 10% level, '**'= significant at the 5% level, and '***'= significant at the 1% level.

Nyando

Women in Nyando are more likely than men to report having access to, and contact with, extension agents (contrary to what was expected), and are also more likely to be in contact with farmer organizations, religious groups, agri-service providers, and family members. Men are more likely to access information via community meetings, neighbors, radio, and traditional forecasting/indigenous knowledge. In terms of types of climate-related information, women have less access than men to forecasts of extreme weather-related events and seasonal weather forecasts.

Regarding perceptions of the importance of women participating in household decision-making, males in Nyando ranked this higher than did females. Men and women scored nearly identically in terms of considering themselves the main decisionmaker for agricultural plots, however, women were much less likely to consider themselves the owner of any land. Men were more likely to report household access to credit and women reported more group memberships.

Men's ranking of shocks they had experienced that resulted in crop loss and soil erosion were higher than women's perceptions of such events in Nyando. Men are also more likely to predict being impacted by droughts in the future, while women are significantly more likely to anticipate experiencing more frequent or more severe floods in the future.
In terms of personal values, women place higher importance on/belief in traditional approaches to agriculture than men do. Women's scores on the "trust other" indices were lower than the community averages, while men's scores were higher.

In terms of socio-economic and household variable, households report an average land size of 4.1 hectares and an average income of $890. For production system, 30% of households practices were identified as falling in the improved maize and dairy system, while 30% were classified as sugar cane cross. The remaining 40% of households employ a production system that mixes maize, sorghum, and local livestock.

Wote

Wote farmers reported higher rates of contact with extension agents compared to Nyando, and rates were slightly higher for men than for women. Women reported having higher rates of access to information from NGOs, farmer's organizations, religious groups, and agri-service providers. Nearly everyone received information from neighbors and the radio, and both men and women relied heavily on traditional knowledge.

Similar to Nyando, men were more likely than women to receive information on extreme events. Wote men reported higher rates of access to long-term weather forecasting, which is a new pilot project in the area. Both men and women reported high and equal access to information on the start of the rains. Overall, access to information seems more gender equitable in Wote than in Nyando.

Men have higher education levels compared to women in both sites and education levels are higher in Wote compared to Nyando. Women, however, had more memberships in community groups and, unlike Nyando, more access to credit. Rates of land ownership were low; only 27% of male respondents considered themselves owners, although this was

significantly more than the 11% of women that said they owned land. Males were more likely to consider themselves the main decision-maker on agricultural plots.

Nearly all men reported experiencing crop or water-related shocks, a proportion slightly higher than that of women. Equal numbers reported experiencing soil erosion shocks. Men were significantly more likely to believe that droughts would impact them seriously in the future.

In terms of personal values, men, as opposed to women, were much more likely to have higher scores on the traditional index, but scores were lower than in Nyando, possibly due to proximity to Nairobi. Men and women reported equal innovation index scores in Wote. Women were significantly more likely to score higher on the difference in "trust others" indices. We see higher rates of group membership than in Nyando, and within the site, women participate in a larger number of groups than men.

Households in Wote reported owning, on average, between 5.1- 5.2 hectares of land and earning $1398. The average household size is 5.3/5.2.

Factors influencing CSA awareness

Tables 6a and 6b present a summary of the results of the Heckman models that analyze what factors help to explain variations in awareness of CSA practices in these sites (full regression results are available from the authors).

Innovative versus traditional orientation

Tables 6a and 6b show that in both sites respondents with higher innovation scores are more likely to be aware of the practices of pasture management and planting pits. For Wote, self-reported innovativeness is also strongly associated with the following livestock practices: manure management, improved feed management, drought tolerant breeds, and destocking. And in Nyando, individuals with higher innovation scores are more aware of agroforestry, cover cropping and composting practices.

For those seeing themselves as more bound to cultural traditions in Nyando, we see a lower awareness of planting pits, composting, high yielding varieties, improved feed management, and destocking, and to a lesser extent, awareness of stress tolerant crops and livestock manure management. In Wote, however, we see that those scoring higher in terms of following tradition have higher awareness of planting pits, composting, efficient fertilizer use, switching to drought tolerant livestock breeds and cover cropping, and less awareness of livestock manure management, no till, high yielding varieties, and improved feed management practices.

Awareness of Practices	Agroforestry	Terraces	Leaving crop residue	Composting	No till	Cover cropping	Water harvesting	Irrigation	Planting pits	Livestock manure management	Improved feed management	Destocking	Drought tolerant animal species	Pasture management	More efficient fertilizer use	Improved HYVs	Improved STVS
Innovative	++			+++		++			+++					+++	---		
Traditional				---					---	-	---	---				---	--
Female	---	---	+++	---	--	+++	---						+	+++		+++	+++
Spouse aware	+		++			+++		+++	++	+				++	---	++	++
Information from extension agent				-													
Information from NGO						+											
Information from community meetings											+				++		
Information from farmer organizations	-	--															
Information from religious groups	+	++		+++	++		+++			+++	+++	+	+++			--	+
Information from agri service providers										---							
Information from family members				+	+					++							
Information from neighbors									++								
Information from radio				+++					+++				+++	+++		+++	+++
Information from traditional forecasters	-			---	+++						--				---		
Age					+++						+	+					
Age2				+	---						-						
Asset Score											+	+++					
Education years	+++	+++	+	+++		++	+++	+++			+++	++	+		+++		
Sugarcane and crossbreed livestock (Nyando)	---	---	++	---		---	--		---			-	---		+++		--
Mixed crop and improved livestock (Wote)																	
Maize and dairy (Nyando)		---	+		---	---	---		--		++		---		+++	+++	---
Constant			-		--	---		--				--			++		
Mills																	
Lambda			-														

Source: CCAFS/IFPRI/ILRI Gender Survey 2012, author's calculations

Table 6a: Awareness of CSA Practices in Nyando. For each variable that is positively (negatively) correlated, we denote with a '+' ('-') if it is significant at the 10% level, a '++' ('- -') if it is significant at the 5% level, or by '+++' ('- - -') if significant at the 1% level.

Awareness of Practices	Agroforestry	Terraces	Leaving crop residue	Composting	No till	Cover cropping	Water harvesting	Irrigation	Planting pits	Livestock manure management	Improved feed management	Destocking	Drought tolerant livestock	Pasture management	More efficient fertilizer use	Improved HYVs	Improved STVs
Innovative					++	---			+++	+++	++	+++	++	+++			
Traditional				+++	---	++			+++	---	--		+++		+++	--	
Female				---	---	+++			+++			++	+++	+++	---	--	
Spouse aware								--	++		++	++					
Information from extension agent				--			++	++			+++	+++				+	
Information from NGO						++								--			
Information from community meetings																	
Information from farmer organizations						---					+++	+++	+++	+++			
Information from religious groups								-	-		---		--	---	---		
Information from agri service providers						+						---					
Information from family members										++							
Information from neighbors								++						--			
Information from radio				+++				+++	++		+++		+++				
Information from traditional forecasters			+++					+++				---		---		++	
Age																	
Age2									+								
Asset Score				--									++				
Education years			++						++					-		++	
Sugarcane and crossbreed livestock (Nyando)																	
Mixed crop and improved livestock (Wote)					--	++				+							
Maize and dairy (Nyando)																	
Constant																	
Mills																	
Lambda								+++		-	--			-			

Source: CCAFS/IFPRI/ILRI Gender Survey 2012, author's calculations

Table 6b: Awareness of CSA Practices in Wote. For each variable that is positively (negatively) correlated, we denote with a '+' ('-') if it is significant at the 10% level, a '++' ('- -') if it is significant at the 5% level, or by '+++' ('- - -') if significant at the 1% level.

Gender

Even after accounting for other factors, being female in Nyando is negatively associated with awareness of the practices of agroforestry, terracing, no till, composting, and water harvesting but positively associated with awareness of leaving crop residues, cover cropping, and improved high yielding varieties, stress tolerant varieties, pasture management, and switching to drought tolerant livestock. Awareness of soil conservation practices and seed and fertilizer-related practices had strong associations with being female (positive for soil conservation practices and negative for input-related practices). In Wote, women farmers are less aware of composting, more efficient fertilizer use, high yielding varieties, and no till, but more aware of options such as planting pits, cover cropping, drought tolerant livestock, pasture management, as well as destocking. In both cases, we see a positive connection between being female and being aware of several livestock management-related practices as well as cover cropping.

Having a spouse that is aware of a given practice does not automatically mean that information will be available to both primary decisionmakers. In Nyando, spousal awareness is significantly associated with higher awareness of the practices of irrigation, cover cropping, planting pits, leaving crop residue, improved high yielding varieties, stress tolerant crop varieties, pasture management, and agroforestry. On the other hand, in Wote, spousal awareness does not seem to be as strongly associated with awareness of various practices, although it is positively associated with planting pits, destocking, and improved feed management. It is interesting that while spousal awareness is both positively and negatively associated with increased awareness of practices across the sites, the impacts of spouse awareness in awareness of the various livestock practices are all positive.

Access to information

For Nyando, contact with an extension agent was not associated positively with awareness of any of the listed CSA practices, and in fact was negatively associated with composting. In Wote, contact with an extension officer proved to be associated with awareness of improved feed management, destocking, water harvesting, irrigation, and high yielding varieties. It was negatively associated with awareness of composting.

Access to different information sources has varying impacts on awareness of CSA practices. In Nyando religious groups are associated with increased awareness of a number of practices, in particular soil conservation and livestock management practices. Surprisingly, NGOs and farmer groups appear to have little impact on awareness of most practices in Nyando, and in the case of farmer groups, are actually negatively associated with the awareness of agroforestry and terracing. Agri-service providers are associated with lower rates of

awareness of livestock manure management (perhaps because they are promoting more chemical intensive fertilizer options). Of the most popular options, friends and family have a relatively limited impact on the awareness of CSA, while radio seems to have a more positive effect, being strongly associated with awareness of planting pits, composting, improved high yielding varieties, and stress tolerant seeds. Relying on one's own knowledge was negatively associated with agroforestry, composting, more efficient use of fertilizers, and improved feed management.

In Wote, a semi-arid area, perhaps not surprisingly, farmer groups were more likely to be associated with awareness of livestock practices, such as improved feed management destocking, switching to drought resistant livestock, or pasture management practices. They were negatively associated with cover cropping. Contrary to Nyando, access to religious groups was negatively associated with awareness of six CSA practices, including irrigation, planting pits, more efficient use of fertilizers, improved feed management, switching to drought tolerant livestock, and pasture management. Radios are associated with greater awareness of several practices (irrigation, planting pits, composting, improved feed management and drought tolerant varieties). Traditional knowledge is associated with improved awareness of some practices, including irrigation, crop residue management, and using high yielding varieties.

Age and education

Across both sites, the age of the respondent did not seem to have much association with higher awareness. The role of formal education in relation to awareness of CSA practices is mixed. In Nyando, education is fairly consistently related to improved awareness of CSA practices (in particular soil conservation, livestock, and water related practices), while in Wote, there is less association and education is negatively associated with awareness of pasture management, possibly because more educated farmers move out of pastoral systems or because proximity to Nairobi makes pasture management a less promising strategy.

Wealth

In Nyando, the measure of wealth calculated from a list of household assets was positively associated with destocking and improved feed management. However, from the literature, one would expect that a higher asset score, including both agricultural and non-agricultural goods, would be generally correlated with less reliance on livestock assets (Little et al. 2009). Here we see households with greater assets being more aware of opportunities to invest in and improve these assets. In Wote, having more assets was associated with less awareness of composting, but a greater awareness of drought tolerant varieties.

Production system

In terms of production systems, farmers in Nyando involved in sugarcane production (a cash crop), or the maize-dairy production system (with steady income stream from milk sales) were less likely to be aware of many practices including terracing, water harvesting, planting pits, stress tolerant varieties, and cover cropping practices. On the other hand, they were more likely to be aware of leaving crop residues on the fields and more efficient use of fertilizer. In addition, sugarcane farmers were less likely to be aware of agroforestry, destocking, and composting, while maize-dairy farmers were more likely to be aware of improved high yielding varieties. In Wote, those with crops and improved livestock were more likely to be aware of livestock manure management and cover cropping.

Factors influencing adoption of different CSA practices

Tables 7a and 7b summarize key factors influencing adoption behavior in Nyando and Wote.

Innovative versus traditional orientation

In Nyando, higher innovation scores are associated with adoption of water harvesting and no till practices, but not irrigation or a switch to drought tolerant livestock breeds. In Wote, innovativeness is associated with adoption of destocking practices and terracing, but negatively related to more efficient use of fertilizer (Table 7a/7b). Willy and Holme-Muller (2013) found similar results for the role of social norms in shaping the participation and likelihood of adopting soil conservation practices in Kenya. In Nyando, traditional behavior and attitudes are associated with more efficient use of fertilizers, drought tolerant livestock, and no till practices and less use of stress tolerant varieties and improved feed management. In Wote, on the other hand, traditional orientation supports adoption of destocking but not improved rangeland management or cover cropping.

Gender

Among those who know about CSA practices, women in Nyando are more likely than men to adopt more efficient use of fertilizer, stress tolerant varieties, no till and improved feed management practices (Table 7a). If they identify themselves as landowners, women are also more likely to take up improved high-yielding varieties, but less likely to compost. In Wote, women are less likely to adopt crop residue management practices, but are more likely to take pasture management actions. Women who identify as landowners are less likely to adopt composting in Wote, but the number of observations for this practice was low.

Ranking the importance of women participating in household decisions higher is positively related to uptake of more efficient use of fertilizer but negatively related to pasture

management and water harvesting in Nyando. In Wote, this variable is positively associated with pasture management in Wote and negatively associated with leaving crop residues.

In Nyando households where women have access to credit, are more likely to adopt more efficient use of fertilizers and switch to drought tolerant livestock breeds, but are less likely to adopt terracing. The higher the percentage of female assets in relation to total household assets, the lower the adoption of more efficient use of fertilizer, terracing, and uptake of improved high yielding varieties in Nyando.

In Wote, women accessing credit is associated with uptake of water harvesting, irrigation and livestock manure management, but negatively associated with composting and terracing. A higher share of female assets is positively associated with composting and leaving cover crops, but negatively associated with irrigation and livestock manure management.

Table 7a. Factors explaining variations in adoption in CSA practices in Nyando

	Nyando						Nyando			Nyando					Nyando		
Adoption of CSA Practices (Nyando)	Agroforestry	Terraces	Leaving crop residue	Composting	No till	Cover cropping	Water harvesting	Irrigation	Planting pits	Livestock manure management	Improved feed management	Destocking	Drought tolerant animal species	Rangeland management	More efficient fertilizer use	Improved high yielding varieties	Stress tolerant varieties
Land owner			--			--				--			---				
Other income								---					---				
Credit access					---								---		---		-
Community "trust others"				+			--			++	++		--	-			
Difference "trust others"							-						---	--			
Work together				+++		+				---	-		++	+++			--
Memberships				+++													
Innovative					+		++	--					---				
Traditional					+++						-		+++		+		--
Self decisionmaker													---				
Female					+						+				+		+
Female Land owner				---								-	-			++	
Female gender decisionmaking											-				--		
Female credit access		--											+++		+		
Female percent assets															---	---	
Gender decisionmaking							---							---	+		
Access to forecast of extreme events					--						+		+++				---
Access to forecast of the start of the rains													+++		--		--
Access to seasonal weather								-						---	+	++	
Crop shock	---																
Water shock				++									--	+			
Soil erosion shock	-									---	---		+++				++
Drought impact		--		++									---		--	---	
Flood impact	+++	+++					++	++		+++	+++		+++				
Total area farm												-	---				
Sum income	+++										+++		+		+++		
Household size								+++					+++				+
Education				-		--									+++	++	
Age	++									--							
Age2	-									++			+				
Sugarcane and crossbreed livestock (Nyando)	---				-			--			---		+++		+++	+++	-
Mixed crop and improved livestock (Wote)																	
Maize and dairy (Nyando)	---	---			-			---					+++		+++	+++	--
Sample Size	255	282	364	126	256	128	221	297	50	353	145	110	128	50	273	293	58

Source: CCAFS/IFPRI/ILRI Gender Survey 2013, author's calculations

For each variable that is positively (negatively) correlated, we denote with a '+' ('-') if it is significant at the 10% level, a '++' ('- -') if it is significant at the 5% level, or by '+++' ('- - -') if significant at the 1% level.

Table 7b Factors explaining variations in adoption in CSA practices in Wote

	Wote						Wote			Wote					Wote		
Adoption of CSA Practices (Wote)	Agroforestry	Terraces	Leaving crop residue	Composting	No till	Cover cropping	Water harvesting	Irrigation	Planting pits	Livestock manure management	Improved feed management	Destocking	Drought tolerant animal species	Rangeland management	More efficient fertilizer use	Improved high yielding varieties	Stress tolerant varieties
Land owner																	
Other income																	
Credit access					---		--										
Community "trust others"		+				-	--										
Difference "trust others"		++			---												
Work together					---					+			++				
Memberships											++			+++			
Innovative		++										++			---		
Traditional						---						++		-			
Self decisionmaker			-		++										--		
Female			--											+++			
Female land owner				-													
Female gender decisionmaking			+		+						++			---		--	
Female credit access				-			++	+++		+							
Female percent assets		-	+	++				---		--							
Gender decisionmaking			-											+++			
Access to forecast of extreme events		+	+				+					---	--				
Access to forecast of the start of the rains															---		
Access to seasonal weather														++			
Crop shock						--											
Water shock						++	-					++		++			
Soil erosion shock						---	+++							+++	-		
Drought impact		-			---										---		
Flood impact														-			
Total area farm							+			++	+			+++			
Sum income							+++	+		+++	+				+++		
Household size			+	+				---		-	-				-		
Education												+					
Age															+		
Age2																	
Sugarcane and crossbreed livestock (Nyando)																	
Mixed crop and improved livestock (Wote)				---			-	---		+++			---				
Maize and dairy (Nyando)																	
Sample Size	348	351	338	132	71	31	330	310	108	311	247	233	145	59	82	339	349

Source: CCAFS/IFPRI/ILRI Gender Survey 2013, author's calculations

For each variable that is positively (negatively) correlated, we denote with a '+' ('-') if it is significant at the 10% level, a '++' ('- -') if it is significant at the 5% level, or by '+++' ('- - -') if significant at the 1% level.

Land ownership

Whether and how security of land tenure, and in particular, land ownership (i.e. with a title deed) is related to adoption is debated in the literature, as traditional land tenure arrangements can be strong and important in many places, particularly for grazing and forested areas (Place 1995; Fortmann, Antinori, and Nabane 1997; Kiptot and Franzel 2012; Place, Roth, and Hazell, 1994, Otsuka and Place 2001). We did not find a strong relationship between perceived plot ownership and adoption of CSA practices (Table 7a/7b). In Nyando, self-identifying as the owner of a plot is negatively associated with leaving crop residues on the field, cover cropping, livestock manure management, and use of drought tolerant livestock breeds – not surprisingly perhaps, as these are all practices relating to crop-livestock interactions which may relate more to livestock ownership and control than land ownership per se. In Wote, we see no significant relationships between land ownership and adoption of any CSA practices. However, in Wote, we also find low share of land ownership; the land is instead under another family member's name.

Access to credit and off-farm income

Access to credit and other income sources should provide resources for long-term investments in CSA and are two proxies for market orientation. Surprisingly, in Nyando access to credit and off-farm income are negatively associated with the adoption of CSA practices (Table 7a). Credit access is negatively associated with more efficient use of fertilizer, use of stress tolerant varieties, no till, improved feed management, and switching to drought tolerant livestock; other income sources are associated negatively with irrigation and drought tolerant livestock. For Wote, credit access is also negatively associated with the adoption of no till and water harvesting. Our evidence therefore does not support the often-reported constraint of 'lack of cash' as a key constraint to adoption of new technologies (Zeller et al 1998; Lambrecht el al 2014) We find results similar to recent studies (Kassie et al 2015), in which credit is not uniformly associated with all technology adoption. Rather, other sources of cash, especially credit, may orient farmers away from agriculture. (Nagler and Naudé 2014)

Social capital

Here we consider various social capital proxies, including the indices measuring the degree of working together, trusting others (community level variables and the difference between respondents' scores and community scores), and group memberships (Table 7a/7b).

In Nyando, we found that those with higher scores for the 'work together' indicator are more likely to adopt the following practices: cover cropping, composting, drought tolerant livestock breeds, and improved pasture management. But these farmers are less likely to adopt stress tolerant varieties, livestock manure management, or improved feed management strategies. In

Wote, those who value working together are more likely to adopt livestock manure management, and switch to drought tolerant livestock species, but are less likely to adopt no tillage practices.

For both of the trust indices, we found a largely negative association in Nyando with the uptake of improved practices, including water harvesting, drought tolerant livestock, and pasture management. However, community trust was positively associated with composting, livestock manure management, and improved feed management at that site. For Wote, trusting others is negatively associated with the adoption of no till and cover cropping, but positively associated with terracing. This is true for both the trust variables (the community level and the difference between individual and community scores).

Group membership is positively associated with the adoption of composting in Nyando, and with improved feed management and pasture management in Wote.

Access to weather-related information

Access to information about extreme events contributes to adoption of improved feed management and drought tolerant livestock breeds in Nyando, and to water harvesting and terracing in Wote. It is negatively associated with no till, use of stress tolerant varieties in Nyando, and destocking and drought tolerant livestock in Wote. Information on the timing of the start of the rains is positively related to adoption of drought tolerant livestock in Nyando and terracing in Wote. Access to seasonal weather predictions is related to uptake of high yielding crop varieties and more efficient use of fertilizer in Nyando and improving pasture management in Wote.

Weather shocks

Experiencing weather related shocks that result in crop loss or damage in Nyando is negatively associated with agroforestry adoption and with cover cropping in Wote. Contrary to expectations, experience with weather shocks that have impacts on water availability and access shocks in Nyando is negatively related to uptake of drought tolerant varieties of livestock, but positively related to adoption of composting and pasture management. This makes sense, as households are not likely to adopt drought tolerant livestock if they experience floods. The other practices have the potential to mitigate against drought and drying patterns. In Wote, water shocks are negatively associated with water harvesting practices (against expectations), but positively associated with pasture management, destocking, and cover cropping practices.

Respondents' experience in relation to soil erosion shocks is negatively associated with the uptake of agroforestry, livestock manure management, and improved feed management

practices, but is positively associated with the adoption of stress tolerant seed varieties and drought tolerant livestock breeds in Nyando. Soil erosion shocks have a strongly significant association with the uptake of water harvesting and pasture management (positive) in Wote, and a negative association with the adoption of more efficient fertilizer and cover cropping.

In Nyando, respondents who feel that floods will have a substantial impact on their livelihoods in the future are more likely to adopt water harvesting and irrigation, while expected drought impacts generally reduces adoption of CSA practices. This is also seen in Wote, where experiences with droughts, contrary to our hypothesis, is negatively associated with use of water harvesting, terracing, no till, and more efficient fertilizer practices.

Farm and household characteristics

In Nyando, we see little effect of farm size on adoption of CSA practices—it is negative for destocking and drought tolerant varieties. For Wote, farm size increases adoption of water harvesting, livestock manure management, improved feed management, and pasture management practices.

Higher income has a positive impact on the adoption of agroforestry, more efficient use of fertilizer, improved feed management, and switching to drought tolerant livestock in Nyando. In Wote, household income is positively associated with uptake of water harvesting, irrigation, livestock manure management, improved feed management practices, and more efficient use of fertilizer.

Household size (i.e. labor availability) appears to be important for the adoption of irrigation, stress tolerant varieties, and drought tolerant livestock breeds in Nyando; in Wote, larger household size supports adoption of crop residue management and composting, but reduces adoption of irrigation, more efficient use of fertilizer, livestock manure management, and improved feed management.

In Nyando, education is correlated with increased adoption of more efficient use of fertilizer and high yielding varieties, but with decreased adoption of composting and cover cropping. In Wote, education is only positively associated with destocking practices.

Production system

We see some influence of the different production systems for adoption of CSA practices – in Nyando, sugarcane and crossbred livestock and maize-dairy systems both increase the probability of more efficient use of fertilizer and improved high yielding varieties and

switching to drought tolerant livestock, but are negatively associated with uptake of agroforestry, irrigation, and improved feed management practices. Maize-dairy systems are associated with a lower likelihood of adopting terraces and stress tolerant varieties.
In Wote, the mixed food crops, fruits, and improved livestock production system is positively associated with adoption of livestock manure management, but negatively associated with adoption of irrigation, composting, and drought tolerant breeds.

Discussion and Conclusions

The results of this analysis indicate that CSA awareness and adoption differ substantially between the two sites due to both cultural and biophysical differences. Moreover, the determinants differ considerably by practice. Revisiting our over-arching hypotheses, based on the literature, we anticipated finding that: 1) Practices for which the benefits are accrued after years rather than months will require special attention to property rights and tenure security issues; 2) Practices requiring cooperation (either through community bylaws, joint work, or enforcement) will require higher levels of community social capital; 3) Women will be more likely to adopt practices that are of special interest to them – for example, those that provide food security without being overly labor or cash intensive. Here we explore which of these hypotheses is supported by our evidence.

We found little evidence that being a self-identified plot owner had much of an influence on adoption of CSA practices. In terms of the interaction between gender and land ownership, we saw little impact on those practices that we hypothesized to be more 'women friendly'. Only in Nyando was being a female land owner connected with increased adoption of use of improved seeds. However, field staff noted that many people in Wote do not consider themselves the owner of the land, as it is still in the name of their parents, so it is likely that this question was unable to capture what was intended, given the complexities of land tenure.

With respect to cooperation, social capital and collective action memberships, trusting others, and working together have varying influences on the adoption of CSA practices reported in these sites. Overall, these factors seemed to have more of a positive influence in Nyando than in Wote. Our regression results indicate more explanatory power of social variables for the awareness of various practices, rather than for the adoption of the practices, suggesting that the gender, household, and institutional aspects that shape and drive the adoption of CSA practices still need more attention. Western Kenya is characterized by significant free grazing post-harvest, which make concerted community action necessary to protect agricultural investments from neighbors' livestock. It is interesting to note that despite the long presence

of agroforestry projects in the area and the considerable effort dedicated to establishing group-based tree planting programs, group membership does not seem to be correlated with agroforestry adoption.

Because we asked the same questions of men and women within a household, we have learned what differs between them in terms of awareness and adoption of different agricultural practices. In Nyando, being a female farmer is associated with greater awareness of practices that contribute to food security, such as cover cropping, HYVs, and STVs. Food security is largely a woman's responsibility, as in many rural villages across Africa. In Wote, we found that being a female farmers was associated with greater awareness of several livestock-related practices, confirming the large responsibility women have in livestock production.

A key conclusion from our results is that, while there is a gendered disparity in access to information, at least for some of the CSA practices, gender itself does not seem to be a factor that necessarily prevents or impedes adoption of CSA, among those who know of the technologies. In Nyando, more so than in Wote, if women are aware of a given practice, they are just as likely, or more likely, to adopt the practice than are men. In Nyando, the practices that women are more likely to adopt are what we hypothesized as being 'women friendly' CSA practices, including more efficient use of fertilizer (as it is resource conserving), no till (also resource conserving, although it may increase women's labor requirements for weeding), and finally the practice of cover cropping (because it may provide additional food crops).

Across both sites, the age of the respondent did not seem to have much association with higher awareness, nor with adoption. However, it is worth further exploration to see if certain types of information are more effective in reaching different ages, especially given recent attention to the need to reach out to young people in rural areas with information regarding lucrative agricultural opportunities. This could be done, for example through cellphones and internet, as their rural access and affordability has now increased substantially in Kenya and many other countries. The finding that education is significant with respect to awareness of many CSA practices is promising, in light of higher education levels among the younger generation. However, especially in Wote, we found little evidence that education was linked with higher rates of adoption of these practices.

We explored whether having one spouse that is aware of a practice meant that the other spouse would be too. In Nyando, spousal awareness of some practices increased the likelihood that the other decisionmaker would know of it, but this was not the case in Wote.

This may suggest that the dynamics of information sharing in the household vary between regions; training in agricultural practices and sharing of weather and agricultural information that is accessed by only the man or woman may therefore fall short of desired outcomes in terms of enhanced and widespread uptake of CSA interventions.

In terms of the predicted relationship between sources of information and increased awareness, it is perhaps more telling to describe what we did not see. For example, we did not see extension officers having much influence in Nyando, while receiving climate and agricultural information through religious groups was very signficiant. Farmer groups are only related to increased awareness of livestock-related practices in Wote, but do not show up as significant in awareness of other practices. Extension has had an impact on awareness of improved agricultural practices in Wote but not in Nyando. Individuals reported high levels of access to information from friends and family, and a reliance on indigenous knowledge; however, these do not seem very effective at increasing knowledge of key CSA practices. Our data show that radios are a key source of information for a number of practices in both sites. Income matters for both awareness and adoption, so initiatives leading to higher incomes (e.g. through improved market access or value chains) will also likely have an impact on uptake of CSA practices.

In terms of more traditional versus innovative orientations, our hypotheses were supported for the most part in Nyando, at least in terms of awareness. However, in Wote, we found that many of those identifying more strongly with traditional values were also aware of and adopting improved agricultural practices. This may relate to the long history of extension work in this area (e.g. terracing practices were widely supported as of 30 years ago), so that such practices are thought of as being traditional. Since higher scores in innovation and tradition (based on self-perceptions) do not necessarily correlate strongly with higher levels of adoption of CSA practices, it supports the contention in recent literature that other constraints, such as those related to institutions and policies (Meinzen-Dick et al. 2012) need more attention. It is also the case that some of the practices queried may actually not be considered new and 'innovative', but instead may be strongly related to practices that have a long history of trial and adoption by individuals and communities in these areas.

We do see that some practices may appeal to both more innovative and more traditional farmers, such as the case with no till and more efficient fertilizer use in Nyando. This may be because these practices have several reasons for being adopted—one which relates to conserving resources (less labor, water, etc), and another related to higher benefits (e.g. increased income). We think that these practices and behaviors are interesting, and look

forward to the opportunity to study this rich dataset in more depth in future papers exploring how these motivations shape individual decisions.

We found that access to credit by households does not increase adoption of CSA, suggesting such credit is not often being used for investment in improved farming techniques. Many of these households are supplementing agricultural activities with off-farm businesses, typically seen as more profitable than farming. Our evidence also suggests that access to off-farm income is not associated with greater adoption of CSA technologies—even those technologies that require greater investments.

However, when credit is being accessed by women in particular, we see that in both sites, women's access to credit was positively associated with adoption of CSA practices. In Wote, we found that when women access credit, they are more likely to invest in irrigation, water harvesting and improved livestock manure management practices. In Nyando, we saw changes to drought tolerant livestock and more efficient use of fertilizers when women have access to credit. As women's assets increase as a share of total household assets, we see less investment in livestock manure management practices, using fertilizer more efficiently, and in improved high-yielding varieties in Nyando. In Wote, more assets under female control leads to similarly lower rates of adoption of high-yielding varieties, livestock manure management practices and irrigation, but is associated with investment in improved use of crop residues.

Planned future analyses will look more closely at the impacts and outcomes of joint decision-making. We hypothesize that greater equality in decision-making within the household helps to pool resources; we are seeing evidence of this in Wote for composting, where more equality allows men and women to discuss composting together and allows women to access crop residues, which had previously been used by men for livestock feed. We may similarly find that increased gender decision-making scores (and increased jointness of decision-making) means that men and women jointly discuss and decide that the activity is too much work to do—such as is the case, for example, with water harvesting in Nyando. In terms of other income, we see very little relationship between that and the adoption of CSA practices. In Nyando, off-farm employment is very prevalent and it seems that few may use these resources to invest in their farms.

Weather-related shocks do not affect CSA adoption. Serious land degradation and soil erosion, such as the large gullies seen in Nyando, are paradoxically related to low adoption of certain practices—even those that may prevent these events in the future. These include investments in agroforestry, livestock manure management, and improved feed management practices. It may be that serious land degradation reduces interest in investing further in the

land. Having experienced water-related extreme events did have a positive influence on adoption of cover cropping, improved feed and rangeland management in Wote, but oddly, a negative effect with respect to water harvesting.

Anticipated future impacts from severe weather events matter. Flood impacts in Nyando led to an increased likelihood of adoption of a number of CSA practices, including agroforestry, terraces, water harvesting, irrigation, livestock manure management, improved feed management, and switching to drought tolerant livestock breeds.

In both sites, the predicted impact of future droughts is negatively associated with the adoption of CSA practices (terracing, no-till and efficient fertilizer use in Wote, and terraces, drought-tolerant livestock species, more efficient fertilizer use, and high-yielding varieties in Nyando), which is contrary to what we expected, as many of these practices are aimed at lowering the negative impacts of droughts. This points to the need for more attention to the risks and investments (in cash, labour, water, land) involved in these practices in different environments.

It is promising to see that information regarding weather forecasts, particularly those of extreme events, is positively influencing CSA adoption in some cases (terracing, crop residue management and water harvesting in Wote). Availability of seasonal weather forecasts have a limited positive impact on adoption, but are associated with more efficient fertilizer use and uptake of higher-yielding varieties in Nyando. We find little impact of any weather-related information on adoption of soil and water conservation practices that will contribute to increased resilience to climate change for these households.

This paper demonstrates that gendered CSA adoption is highly complex. Our findings suggest that women are constrained in awareness of CSA practices. Yet, beyond gender, a whole host of institutional, attitudinal, social, economic, and contextual factors influence the adoption of CSA practices.

Some of these factors, such as improving information channels, are amenable to interventions that can increase awareness and adoption of CSA. However, the fact that many of the commonly-identified interventions such as extension services, agri-service providers, farmers' organizations, and credit, do not have a broad positive effect, whereas the orientation of people toward innovation and toward trust in each other also plays an important role, indicates that there are not necessarily clear and mechanistic "policy levers" that will lead to universal adoption. Rather, there is a need to understand the role of agriculture in people's current and future livelihoods in order to improve the saliency, legitimacy, and credibility of information

and CSA interventions for women, youths and disadvantaged individuals and groups (Cash et al. 2003).

References

Adger, W., S. Dessai, M. Goulden, M. Hulme, I. Lorenzoni, D. Nelson, L. Naess, J. Wolf, and A. Wreford., 2009. Are there social limits to adaptation to climate change? *Climatic Change* 93, 335–354.

Agrawal, A. 2010. Local institutions and adaptation to climate change. Chapter 7 in *Social dimensions of climate change: Equity and vulnerability in a warming world*, R. Mearns and A. Norton, eds. Washington, D.C.: World Bank.

Agarwal, B. 1997. Bargaining and gender relations: Within and beyond the household. *Feminist Economics* 3 (1): 1–51.

Aker, J. C. 2011. Dial "A" for agriculture: a review of information and communication technologies for agricultural extension in developing countries. *Agricultural Economics* 42.6: 631-647.

Alkire, S., R. Meinzen-Dick, A. Peterman, A. Quisumbing, G. Seymour, and A. Vaz. 2013. The women's empowerment in agriculture index. *World Development*, *52*: 71-91.

Amin, S. 1997. The poverty–purdah trap in rural Bangladesh: implications for women's roles in the family. *Development and Change*, *28*(2): 213-233.

Arora-Jonsson, S. 2011. Virtue and vulnerability: Discourses on women, gender and climate change. *Global Environmental Change*, *21*(2):744-751.

Asfaw, S., F. Di Battista and L. Lipper. 2014. Food security impact of agricultural technology adoption under climate change: micro-evidence from Niger. ESA Working Paper No. 14-12. Rome, FAO.

Becker, G. S. 1965. A Theory of the Allocation of Time. *Economic Journal* 75: 493-517.

Becker, G. S. 1981, A Treatise on the Family. Cambridge, Mass: Harvard University Press.

Budlender, D. 2003. The Debate about Household Headship. *Social Dynamics: A Journal of African Studies* 9 (2) (Special issue: Households and Families in Southern Africa): 48–72.

Buvinić, M., and G. R. Gupta. 1997. Female-headed Households and Female-maintained Families: Are They Worth Targeting to Reduce Poverty in Developing Countries? *Economic Development and Cultural Change* 45 (2): 259–280.

Carr, E. R. 2008. Men's crops and women's crops: The importance of gender to the understanding of agricultural and development outcomes in Ghana's Central Region. *World Development*, *36*(5): 900-915.

Cash, D. W., W. C. Clark, F. Alcock, N. M. Dickson, N. Eckley, D. H. Guston, J. Jäger, and R.B. Mitchell. 2003. Knowledge systems for sustainable development. *Proceedings of the National Academy of Sciences* 100 (14): 8086-8091.

Chaudhury, M., P. Kristjanson, F. Kyagazze, J. Naab, and S. Neelormi. 2012. Participatory gender-sensitive approaches for addressing key climate change-related research issues: Evidence from Bangladesh, Ghana, and Uganda. CCAFS Working Paper 19. Copenhagen: CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS).

Croson, R. and U. Gneezy. 2009. Gender differences in preferences. *Journal of Economic literature*. 448-474.

de Jalón, S. G. , S. Silvestri, A. Granados, and A. Iglesias. 2014. Behavioural barriers in response to climate change in agricultural communities: an example from Kenya. *Regional Environmental Change*:1-15.

Deere, D.C., G.E. Alvarado, and J. Twyman. 2012. Gender inequality in asset ownership in Latin America: female owners vs household heads. *Development and Change*, *43*(2): 505-530.

Deressa, T., R. M. Hassan, R. M., and C. Ringler. 2011. Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *The Journal of Agricultural Science*, *149*(01): 23-31.

Di Falco, S. and E. Bulte. 2013. The impact of kinship networks on the adoption of risk-mitigating strategies in Ethiopia. *World Development*, *43*: 100-110.

Di Gregorio, M., K. Hagedorn, M. Kirk, B. Korf, N. McCarthy, R. Meinzen-Dick, and B. Swallow. 2008. Property rights, collective action, and poverty: The Role of institutions for poverty reduction. CAPRi Working Paper No. 81. Washington, D.C.: International Food Policy Research Institute.

Djoudi H, and M. Brockhaus. 2011. Is adaptation to climate change gender neutral? Lessons from communities dependent on livestock and forests in northern Mali. *International Forestry. Review* 13(2):123–35

Doss, C. 2013. Intrahousehold bargaining and resource allocation in developing countries. *The World Bank Research Observer* 28 (1): 52–78.

Doss, C. R. 1996. Testing among models of intrahousehold resource allocation. *World Development*, *24*(10): 1597-1609.

Doss, C. R., and M. L. Morris. 2000. How does gender affect the adoption of agricultural innovations? *Agricultural Economics*, *25*(1), 27-39.

Elmhirst R. 1998. Reconciling feminist theory and gendered resource management in Indonesia. *Area* 30(3):225–35.

Fafchamps M, and A. Quisumbing. 2003. Social roles, human capital, and the intrahousehold division of labor: evidence from Pakistan. *Oxford Economic Papers.* 55(1):36–80

Farnworth C, P. Kristjanson, and E. Rijke. 2013. 'Climate smart' agriculture and beyond. Pp 107-120 in: Farnworth C, Fones Sundell M, Nzioki A, Shivutse V, Davis M. Transforming gender relations in agriculture in sub-Saharan Africa. Swedish International Agricultural Network Initiative, Stockholm Environment Institute and SIDA. Stockholm, Sweden. http://www.siani.se/book/gender_relations

Feder, G, R. Birner, and J.R.. Anderson. 2011. The private sector's role in agricultural extension systems: potential and limitations. *Journal of Agribusiness in Developing and Emerging Economies* 1.1: 31-54.

Food and Agriculture Organization of the United Nations. 2010. "Climate-Smart" Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation. Rome.

Food and Agriculture Organization of the United Nations. 2013. Climate-Smart Agriculture

Sourcebook. Rome.

Förch W, Sijmons K, Mutie I, Kiplimo J, Cramer L, Kristjanson P, Thornton P, Radeny M, Moussa A, Bhatta G, 2013. CCAFS Site Portfolio. Core Sites in the CCAFS Regions: East Africa, West Africa and South Asia, Version 3. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Online at www.ccafs.cgiar.org

Fortmann, L., C. Antinori, and N. Nabane. 1997. Fruits of Their Labors: Gender, Property Rights, and Tree Planting in Two Zimbabwe Villages1. *Rural Sociology*, *62*(3): 295-314.

Giller, K. E., E. Witter, M. Corbeels, and P. Tittonell. 2009. Conservation agriculture and smallholder farming in Africa: the heretics' view. *Field crops research 114*(1): 23-34.

Gilligan, D. O., S. McNiven, N. Kumar, J. V. Meenakshi, and A. Quisumbing. 2013. "Who Decides to Grow Orange Sweet Potatoes? Bargaining Power and Adoption of Biofortified Crops in Uganda." GAAP Note. Washington, DC: International Food Policy Research Institute. http://www.ifpri.org/publication/who-decides-grow-orange-sweet-potatoes

Goh, A. H. 2012. "A literature review of the gender-differentiated impacts of climate change on women's and men's assets and well-being in developing countries." Capri Working Paper No. 106. Washington, DC: International Food Policy Research Institute (IFPRI). http://www.capri.cgiar.org/pubs.asp#wp

Gong, B., and C.L. Yang. 2012. Gender differences in risk attitudes: Field experiments on the matrilineal Mosuo and the patriarchal Yi. *Journal of Economic Behavior & Organization*, *83*(1): 59-65.

Hansen, J.W., W. Baethgen, D. Osgood, P. Ceccato, and R.K. Ngugi. 2007. Innovations in climate risk management: protecting and building rural livelihoods in a variable and changing climate. Journal of Semi-Arid Troprical Agricultural Research 4: 1–38.

Heckman, J. J. 1976. The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. *Annals of Economic and Social Measurement* 5, 475–492.

Herrero, M, E. González-Estrada, P.K. Thornton, C. Quiros, M.M. Waithaka, R. Ruiz, G. Hoogenboom 2007. IMPACT: Generic household-level databases and diagnostics tools for integrated crop-livestock systems analysis. *Agricultural Systems* 92: 240-265.

ICRAF. 2008. Baseline Report Nyando River Basin. Western Kenya Integrated Ecosystem Management Project. World Agroforestry Center (ICRAF), Nairobi.

Jacobs, K., S. Namy, A. Kes,, U. Bob and V. Moodley. 2011. Gender Differences in Asset Rights in KwaZulu-Natal, South Africa. Gender, Land, and Asset Survey Report. Washington, DC: International Center for Research on Women. http://www.icrw.org/publications/gender-land-and-asset-survey-south-africa

Johnson, N., J. Njuki, E. Waithanji, M. Nhambeto, M. Rogers, and E. H. Kruger. 2013. The gendered impacts of agricultural asset transfer projects: Lessons from the Manica Smallholder Dairy Development Program. CAPRi Working Paper No. 115. Washington, DC: International Food Policy Research Institute. http://dx.doi.org/10.2499/CAPRiWP115.

Kaliba, A. R., H. Verkuijl and W. Mwangi. 2000. Factors affecting adoption of improved maize seeds and use of inorganic fertilizer for maize production in the intermediate and lowland zones of Tanzania. *Journal of Agricultural and Applied Economics, 32*(1): 35-48.

Kassie, M., H.Teklewold, M. Jaleta, P. Marenya, and O. Erenstein. 2015. Understanding the adoption of a portfolio of sustainable intensification practices in eastern and southern Africa. *Land Use Policy* 42: 400-411.

Kes, A., K. Jacobs, and S. Namy. 2011. Gender differences in asset rights in central Uganda. Gender, Land, and Asset Survey Report. Washington, DC: ICRW http://www.icrw.org/publications/gender-land-and-asset-survey-uganda.

Kiptot, E., and S. Franzel. 2012. Gender and agroforestry in Africa: a review of women's participation. *Agroforestry systems, 84*(1): 35-58.

Kristjanson P., A. Gordes, R. Sessa, A. Braimoh, S. Vermeulen. 2013. Local Institutions. Module 12 in Sourcebook on Climate-Smart Agriculture, Forestry and Fisheries. FAO, Rome. http://www.fao.org/docrep/018/i3325e/i3325e00.htm

Lambrecht, I., B. Vanlauwe, R. Merckx, and M. Maertens. 2014. Understanding the process of agricultural technology adoption: mineral fertilizer in eastern DR Congo. *World Development, 59*, 132-146.

Little PD, J. McPeak, C. Barrett, and P Kristjanson. 2008. Challenging Orthodoxies: Understanding Pastoral Poverty in East Africa. *Development and Change* 39 (4): 585-609.

Magnan N, D. Spielman, K. Gulati, and T. Lybbert. 2013. Gender dimensions of social networks and technology adoption: evidence from a field experiment in Uttar Pradesh, India. GAAP Note, Washington, DC: International Food Policy Research Institute http://www.ifpri.org/sites/default/files/publications/gaapnote10.pdf

Mango, J., A. Mideva, W. Osanya, and A. Odhiambo. 2011. Summary of Baseline Household Survey Results: Lower Nyando, Kenya. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Manser, M. and M. Brown. 1980. Marriage and household decision-making: A bargaining analysis. *International economic review*: 31-44.

McBride, W. D., and S. G. Daberkow. 2003. Information and the adoption of precision farming technologies. *Journal of Agribusiness*, *21*(1): 21-38.

McCarthy, N., C. Dutilly-Diane, B. Drabo, A. Kamara, J.-P. Vanderlinden. 2004. *Managing resources in erratic environments: An analysis of pastoralist systems in Ethiopia, Niger, and Burkina Faso*. Research Report 135. Washington, D.C.: International Food Policy Research Institute.

McCarthy, N., L. Lipper, and G. Branca. 2011. Climate-smart agriculture: Smallholder adoption and implications for climate change adaptation and mitigation. Mitigation of Climate Change in Agriculture Series No. 4. Rome: FAO.

McCarthy, N., B. Swallow, M. Kirk, and P. Hazell, eds. 2000. *Property rights, risk, and livestock development in Africa*. Washington, D.C.: International Food Policy Research Institute and International Livestock Research Institute.

Meinzen-Dick, R. S., Bernier, Q., Haglund, E. 2013. The six" ins" of climate-smart agriculture: Inclusive institutions for information, innovation, investment, and insurance. CAPRI Working Paper 114. Washington, DC: International Food Policy Research Institute (IFPRI).

Meinzen-Dick, R., A. Knox, F. Place, and B. Swallow, eds. 2002. *Innovations in natural resource management: The role of property rights and collective action in developing countries*. Baltimore: Johns Hopkins Press and International Food Policy Research Institute.

Meinzen-Dick, R., C. Kovarik, and A. Quisumbing. 2014. Gender and Sustainability. *Annual Review of Environment and Resources*, *39*:29-55.

Meinzen-Dick, R., A. Quisumbing, J. Behrman, P. Biermayr-Jenzano, V. Wilde, M. Noordeloos, C. Ragasa, and N. Beintema. 2011. *Engendering agricultural research, development, and extension.* Washington, D.C.: International Food Policy Research Institute.

Meinzen-Dick, R., H. Markelova, and K. Moore. 2010. The role of collective action and property rights in climate change strategies. CAPRi Policy Brief, *7*, 1-4.

Mwangangi M, Mutie M, Mango J. 2012. Summary of Baseline Household Survey Results: Makueni, Kenya. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org.

Nagler, Paula, and Wim Naudé. 2014. Patterns and Determinants of Non-Farm Entrepreneurship in Rural Africa: New Empirical Evidence. Paper presented at the 9th IZA/World Bank Conference on Employment and Development in Lima, Peru.

Nam, P. K. 2011. Social capital and private adaptation to climate change: Evidence from the Mekong River Delta in Vietnam. Paper presented at the Institute for International Economic Policy (IIEP) conference on the "Economics of Adaptation to Climate Change," at George Washington University, Washington, DC.

Nelson, J. A. 2014. Are women really more risk-averse than men? A re-analysis of the literature using Expanded Methods. *Journal of Economic Surveys*.

Nelson, G. C., M. W. Rosegrant, J. Koo, R. Robertson, T. Sulser, T. Zhu, and C. Ringler. 2009. Climate change: Impact on agriculture and costs of adaptation. Washington, D.C.: International Food Policy Research Institute.

Neufeldt, H, M. Jahn, B. Campbell, J. Beddington, F. DeClerck, A. De Pinto, J. Gulledge, J. Hellin, M. Herrero, A. Jarvis, D. LeZaks, H. Meinke, T. Rosenstock, M. Scholes, R. Scholes, S. Vermeulen, E. Wollenberg, and R. Zougmore. 2013. "Beyond climate-smart agriculture: toward safe operating spaces for global food systems." *Agricultural Food Security* 2 (12): 6.

North, D. C. 1990. Institutions, institutional change and economic performance. Cambridge: Cambridge Univ. Press.

Otsuka, K. and F. M. Place. 2001. *Land tenure and natural resource management: A comparative study of agrarian communities in Asia and Africa*. Washington, DC: International Food Policy Research Institute.

Pandolfelli, L., R. Meinzen-Dick and S. Dohrn. 2008. Gender and collective action: motivations, effectiveness and impact. *Journal of International Development, 20*(1):1-11.

Peterman, A., A. Quisumbing, J. Behrman, and E. Nkonya, E. 2011. Understanding the complexities surrounding gender differences in agricultural productivity in Nigeria and Uganda. *Journal of Development Studies*, *47*(10): 1482-1509.

Place, F., 1995, 'The Role of Land Tenure in the Adoption of Agroforestry in Burundi, Uganda, Zambia, and Malawi: A Summary and Synthesis', Madison, WI: Land Tenure Center, University of Wisconsin.

Place, F., M. Roth, and P. Hazell. 1994. Land tenure security and agricultural performance in Africa: Overview of research methodology. *Searching for land tenure security in Africa*, 15-39.

Place, F. and K. Otsuka. 2001. Population, tenure, and natural resource management: The case of customary land area in Malawi. *Journal of Environmental Economics and Management*, *41*(1): 13-32.

Quiros, C., M.C. Rufino, M. Herrero. 2011. Developing generic tools for characterizing agricultural systems for climate and global change studies. International Livestock Research Institute, Nairobi, Kenya. Report of Activities 2011. Submitted by ILRI to the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) 31st January 2011.
https://cgspace.cgiar.org/bitstream/handle/10568/42065/Rufino_Report.pdf?sequence=1.

Quisumbing, A. R. and J. A. Maluccio. 2003. Resources at Marriage and Intrahousehold Allocation: Evidence from Bangladesh, Ethiopia, Indonesia, and South Africa. *Oxford Bulletin of Economics and Statistics*, *65*(3): 283-327.

Quisumbing, A. R. and J. A. Maluccio. 2000. *Intrahousehold allocation and gender relations: New empirical evidence from four developing countries*. FCND Discussion Paper No. 84. Washington, DC: International Food Policy Research Institute.
http://www.ifpri.org/publication/intrahousehold-allocation-and-gender-relations

Quisumbing, A. R., L. Pandolfelli. 2010. Promising approaches to address the needs of poor female farmers: Resources, constraints, and interventions. *World Development*, *38*(4): 581-592

Quisumbing, A R., S. Roy, J. Njuki, K. Tanvin, and E. Waithanji. 2013. "Can Dairy Value-Chain Projects Change Gender Norms in Rural Bangladesh?" IFPRI Discussion Paper 01311. Washington, DC: International Food Policy Research Institute.

Ragassa, C. 2014. Improving Gender Responsiveness of Agricultural Extension. Pp 411-430 in A. Quisumbing, R. Meinzen-Dick, T. Raney, A. Croppenstedt, J. Behrman, and A. Peterman (Eds.), *Gender in agriculture and food security: Closing the knowledge gap*. Dordrecht, The Netherlands: Springer and FAO.

Rakib, M. and J.A. Matz. 2014. The impact of shocks on gender-differentitaed asset dynamics. Evidence from Bangladesh. In Ringler, C., A.R. Quisumbing, E. Bryan and R. Meinzen-Dick. Enhancing women's assets to manage risk under climate change: Potential for group-based approaches. Washington, DC: IFPRI.

Reimer, A., A. Thompson, L. Stalker Prokopy, J. G. Arbuckle, K. Genskow, D. Jackson-Smith, G. Lynne, L. McCann, L. Wright Morton, and P. Nowak. 2014. People, place, behavior, and context: A research agenda for expanding our understanding of what motivates farmers' conservation behaviors. *Journal of Soil and Water Conservation* 69 (2): 57A-61A.

Resurreccion B. 2006. Gender, identity and agency in Philippine upland development. *Development and Change* 37(2):375–400.

Roncoli, C., B. S. Orlove, M. R. Kabugo, and M. M. Waiswa. 2010. Cultural styles of participation in farmers' discussions of seasonal climate forecasts in Uganda. *Agriculture and Human Values* 28 (1): 123–138.

Rosegrant, Mark W., J. Koo, N. Cenacchi, C. Ringler, R. D. Robertson, M. Fisher, C. M. Cox, K. Garrett, N. D. Perez, and P. Sabbagh. 2014. *Food security in a world of natural resource scarcity: The role of agricultural technologies*. Washington, DC: International Food Policy Research Institute.

Rosenzweig, M., and C.R. Udry, C.R. 2013. Forecasting Probability. National Bureau of Economic Research NBER Working Paper No. 19334.

Scherr, S. J., S. Shames, and R. Friedman. 2012. From climate-smart agriculture to climate-smart landscapes. *Agriculture & Food Security*, *1*(12): 1-15.

Smith, L. U. Ramakrishnan, A. Ndiaye, L. Haddad, and R. Martorell. . 2003. *The importance of women's status for child nutrition in developing countries*. Research Report 131. Washington, DC: International Food Policy Research Institute. http://www.ifpri.org/publication/importance-womens-status-child-nutrition-developing-countries.

Tambo, J. A. and T. Wünscher. 2014. Building farmers' capacity for innovation generation: what are the determining factors? Paper presented at 88th Annual Conference, April 9-11, 2014, AgroParisTech, Paris, France.

Tucker, C. M., H. Eakin, and E.J. Castellanos. 2010. Perceptions of risk and adaptation: coffee producers, market shocks, and extreme weather in Central America and Mexico. *Global Environmental Change*, *20*(1), 23-32.

Twyman J, M. Green, Q. Bernier, P. Kristjanson, S. Russo, A. Tall, E. Ampaire, M. Nyasimi, J. Mango, S. McKune, C. Mwongera, and Y. Ndourba. 2014. Adaptation Actions in Africa: Evidence that Gender Matters. CCAFS Working Paper No. 83. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

Udry, C. 1996. Gender, agricultural production, and the theory of the household. *Journal of political Economy*: 1010-1046.

Van den Bold, M., A. Pedehombga, M. Ouedraogo, A.R. Quisumbing, and D. Olney. 2013. "Can Integrated Agriculture-Nutrition Programs Change Gender Norms on Land and Asset Ownership?" IFRPI Discussion Paper 01315. Washington, DC: International Food Policy Research Institute.

van Koppen, B., L. Hope, and W. Colenbrander. 2012. Gender aspects of small-scale private irrigation in Africa. IWMI Working Paper 153. Colombo, Sri Lanka: International Water Management Institute.

van Rijn, F., E. Bulte, and A. Adekunle. 2012. Social capital and agricultural innovation in Sub-Saharan Africa. *Agricultural Systems*, *108*: 112-122.

Vermeulen, S.J., P. K. Aggarwal, A. Ainslie, C. Angelone, B. M. Campbell, A. J. Challinor, James W. Hansen, J.S.I Ingram, A. Jarvis, P. Kristjanson, C. Lau, G.C. Nelson, P.K. Thornton, and E. Wollenberg. 2012. Options for support to agriculture and food security under climate change. *Environmental Science & Policy* 15 (1): 136-144.

Vermeulen, S.J., B. M. Campbell, B.M., and J.S.I. Ingram, J.S.I. 2012. Climate change and food systems. *Annual Review of Environment and Resources*, *37*(1), 195.

Villamor, G. B., M. van Noordwijk, U. Djanibekov, M.E. Chiong-Javier, and D. Catacutan. 2014. Gender differences in land-use decisions: shaping multifunctional landscapes? *Current Opinion in Environmental Sustainability*, *6,*: 128-133.

Wik, M. T. A. Kebede, O. Bergland, and S.T. Holden. 2004. On the measurement of risk aversion from experimental data. *Applied Economics* 36 (21): 2443-2451.

Willy, D. K., and K. Holm-Müller. 2013. Social influence and collective action effects on farm level soil conservation effort in rural Kenya. *Ecological Economics* 90: 94-103

Zeller, M., A. Diagne and C. Mataya, C. 1998. Market access by smallholder farmers in Malawi: Implications for technology adoption, agricultural productivity and crop income. *Agricultural Economics*, *19*(1), 219-229.

Ziervogel, G. and P.J. Ericksen. 2010. Adapting to climate change to sustain food security. *Wiley Interdisciplinary Reviews: Climate Change*, *1*(4), 525-540.

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