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Addressing gender in agricultural research for development in the face of a changing climate: where are we and where should we be going?

Patricia Kristjanson [a], Elizabeth Bryan[b], Quinn Bernier[c], Jennifer Twyman[d], Ruth Meinzen-Dick[b], Caitlin Kieran[b], Claudia Ringler[b], Christine Jost [e] and Cheryl Doss[f]

[a]World Agroforestry Centre, Washington, DC, USA; [b]International Food Policy Research Institute, Washington, DC, USA; [c]Department of Sociology, Brown University, Providence, RI, USA; [d]International Center for Tropical Agriculture (CIAT), Cali, Colombia; [e]World Agroforestry Centre, Nairobi, Kenya; [f]Department of International Development, Oxford University, Oxford, UK

ABSTRACT

Agricultural development efforts that do not address persistent gender gaps miss opportunities for greater impact. This synthesis reflects on key findings from integrated quantitative and qualitative analyses at the nexus of gender, agricultural development, and climate change. Linked farm household-, intrahousehold-, community-, and institutional-level data highlight significant and nuanced gender differences in adaptive capacity of individuals and communities to respond to climate change. The gender gap is also substantial in exposure to climate change and its impacts, and uptake of new practices that lower vulnerability. Women in agriculture will remain largely neglected by information and service providers unless their differing needs, access to, and control over resources are considered at policy and project design stage. Yet clear guidelines for addressing the needs of both men and women in different environments and agricultural systems are still lacking. Participatory 'action research' approaches with a focus on co-learning, and using innovative cell phone or social media-based approaches offer exciting new opportunities. Agricultural development decision-makers and project designers need to 'design with gender in mind'. Equipping them with tools and knowledge of innovative gender-transformative practices and intervention options and creating accountability for serving women and men will be key.

KEYWORDS

Gender gap; agricultural development; climate change; development; adaptive capacity; resilience; vulnerability

1. Introduction

Researchers, policy-makers, and development practitioners increasingly acknowledge the importance of more effectively including gender in their work aimed at addressing climate variability and change (Bernier et al., 2015; Beuchelt & Badstue, 2013). One reason is because investments in research, policy, and development actions have not yielded the widespread, beneficial impacts expected. The evidence is growing on the substantial cost of neglecting the large 'gender gap' that persists in agricultural productivity and development in most countries (Ali, 2015; FAO, 2011; Peterman et al., 2014; UNWomen, 2015; World Bank & ONE, 2014).[1] This cost is reflected not only in terms of persistent inequality, but also in missed opportunities to improve development outcomes. In the context of climate change, it is particularly important to understand how gender mediates opportunities and challenges to increase agricultural productivity and livelihoods.

The gap in agricultural productivity between plots managed by men and women varies across countries and crops, but ranges from 4% to 25% when measured as the value of agricultural production per hectare across Sub-Saharan Africa (Aguilar, Goldstein, & Kilic Oseni, 2015; Backiny-Yitna & McGee, 2015; Oseni,

CONTACT Patricia Kristjanson p.kristjanson@cgiar.org

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Corral, Goldstein, & Winters, 2015; World Bank & ONE, 2014). However, this measure of agricultural productivity is narrow, missing important activities typically carried out by women, such as food processing and preparation and livestock raising (Doss, 2013). Furthermore, it does not account for joint farm management systems where husbands, wives, and other family members all contribute to production and their individual contributions cannot be measured separately.

Women's unequal access to key agricultural inputs such as land, labour, knowledge, fertilizer, and improved seeds and seedlings contributes to the persistence of this gap (FAO, 2011; Farnworth et al., 2016; Wambugu, Place, & Franzel, 2011; WB, 2014). Women also tend to have less decision-making authority and face additional social, cultural, and institutional barriers to accessing and adopting agricultural technologies (Deere & Doss, 2006; Doss, 2001; Doss & Morris, 2001; Peterman et al., 2014; Peterman, Quisumbing, Behrman, & Nkonya, 2011; Perez, Kristjanson, Förch, Thornton, & Cramer, 2015).

To date, much of the analysis of gender gaps in resources or productivity in the context of climate change has been limited to comparisons of households with and without adult men. For example, a recent study of six countries in Sub-Saharan Africa found that female-headed households apply, use, and own significantly less improved or purchased agricultural inputs compared to male-headed ones (Sheahan & Barrett, 2014). However, this approach confounds gender and household structure (presence or absence of a man) and ignores the situation of the majority of women who live in dual adult households – usually referred to as 'male-headed' (Budlender, 2003; Buvinic & Gupta, 1997).

Evidence points to widespread adoption of incremental changes in agricultural practices in developing countries, but relatively little uptake of transformative practices that make agricultural households more resilient and able to deal with increasing rainfall variability and higher temperatures (Bryan et al., 2013; Kristjanson et al., 2012; Meijer, Catacutan, Ajayi, Sileshi, & Nieuwenhuis, 2015). These include improved soil and water management techniques, agroforestry, stress-tolerant seeds and animal breeds, and small-scale irrigation, among others. Moreover, the institutions and policies supporting climate-resilient agricultural systems are severely lacking in many low-income countries (Meinzen-Dick, Bernier, & Haglund, 2013).

In 2011, researchers from CGIAR and partner institutions involved in the global CGIAR Program on Climate Change, Agriculture and Food Security (CCAFS) developed and implemented an integrated and comprehensive approach to measuring gender and climate change issues (www.ccafs.cgiar.org). Qualitative, quantitative, and mixed methods studies on gender and climate change, both at the farm household and community-levels, across a range of countries, provide a rich understanding of these issues. This research has produced a wide range of open access tools and data.[2]

This paper both synthesizes the initial research findings and reflects on the methodological challenges that are raised by this work. While there are other research initiatives related to the study of gender and agricultural development,[3] the CCAFS body of work is unique in its focus on the nexus of gender, agricultural development, and climate change. This paper focuses on gender dimensions (differences between men and women), but the intersectionality with age, ethnicity, race, class, and other social factors is also important, even though these factors are not elaborated on explicitly.

The structure of the paper is as follows: we first situate the key gender-focused research questions addressed by the CCAFS program within a broader conceptual framework. In the research design stage, these broad questions were broken down into specific questions, summarized here with key findings from the initial analyses. We then discuss the extent to which the findings can serve as a useful guide for implementation of gender-sensitive resilience and adaptation programs. Do these research questions and gender-responsive tools address the needs of implementing partners? What are the remaining critical research gaps? And what else can be done to achieve the desired outcomes? This analysis aims to inform programs, projects, and investments to better address climate change concerns and meet the needs of the most vulnerable segments of society.

2. Research agenda

The CCAFS program initially identified several broad research questions related to gender through consultations with leading researchers in the areas of gender, agriculture, and climate change: [4]

1. How do gender relations affect vulnerability to different levels of exposure to climate stress and adaptation to progressive climate change among individuals, households, and communities?

2. What are the characteristics and causes of gender differentials in access to and use of climate-related information?
3. What are promising institutional arrangements enabling women as well as men to benefit from incentives for delivering environmental services?
4. What gender-differentiated patterns can be identified in the trade-offs poor men and women make between adaptation and mitigation options for dealing with climate change in agriculture?
5. How are risks arising from climate change or variability distributed among men and women with different resource endowments and assets?

Table 1. CCAFS gender methods, studies, sites, analyses, and publications.

Tool/method used	Sites/countries where implemented (year)	Analytical methods applied and related publications (to date)
CCAFS gender survey (intrahousehold questionnaire)[11]	Rakai, Uganda (2013); Nyando, Kenya (2013); Wote, Kenya (2013); Kaffrine, Senegal (2010-13); Cauca, Colombia (2014); Tuma la Dalia, Nicaragua (2014); Bagerhat, Bangladesh (2013); Satkhira, Bangladesh (2013) Nwoya, Uganda (2014)	Descriptive analysis (Kristjanson et al., 2015a, 2015b, 2015c), Twyman et al., 2014); Principal components, logit (Bernier et al., 2016; Probit (Bernier et al., 2016; Quisumbing et al. in press)
CCAFS/FAO Gender and CC Training Guide[12]	Rakai, Uganda; Upper West region Ghana; Southwest region, Bangladesh (2011)	Descriptive analysis (Jost et al., 2015; Naab & Koranteng, 2012)
CCAFS/CARE Gender and CC toolbox[13]	Nyando, Kenya; northern Ghana	Descriptive analysis (Jost, Ferdous, et al., 2014; Jost, Kristjanson, & Ferdous, 2014)
Household and plot-level farm characterization (IMPACT Lite)	East Africa (4 countries) and West Africa (5 countries) CCAFS sites	Logit, generalized linear model (Douxchamps et al., 2015; Silvestri et al., 2015)
CCAFS Baseline Surveys[14] – household-level, village/community-level, and organizational level	CCAFS sites in: Kenya, Uganda, Ethiopia, Tanzania, Senegal, Mali, Burkina Faso, Ghana, Niger, Colombia, Honduras, Guatemala, Laos, Cambodia, Vietnam, India, Bangladesh, Nepal	Descriptive analysis (Cramer et al., 2016; Förch et al., 2014; Perez et al., 2015)

An initial review of the literature on these issues revealed a reliance on household-level data, ignoring the voices and experiences of individual men and women (Doss, 2013; FAO, 2011; Quisumbing, 2003). In particular, women's voices in households with men were often not heard. CCAFS aimed to move beyond cursory treatment of gender and climate change issues to approaches facilitating the assessment of differences in men's and women's experiences with climate shocks and change, their preferred approaches to respond to those changes, and the barriers they face in adapting. The studies employed mixed methods, both qualitative and quantitative (Bernier et al., 2015; Förch, Kristjanson, Cramer, Barahona, & Thornton, 2014).

This CCAFS gender research builds on the broader CCAFS research agenda at the community, household, and organizational levels across all CCAFS sites in 21 countries,[5] covering different agro-ecologies and livelihood systems. The project conducted a subsequent farm characterization survey at the plot level (Douxchamps et al., 2015; Silvestri et al., 2015). These efforts aim to measure broader development/well-being outcomes such as agricultural productivity, income, food security, nutrition/health, and education that occur over the long-run (10–15 years), by revisiting the same households and villages. The sampling frame was not intended to be representative at a country level (Förch et al., 2014).

The gender-focused work was implemented in a purposively selected set of CCAFS sites. Key criteria for the selection of these sites included availability, capacity, resources, and commitment of international and local NGO collaborators and implementers. They were designed to facilitate comparisons across sites in different biophysical environments, agricultural systems, cultural, and socio-economic environments (Förch et al., 2014).

Table 1 summarizes the gender-focused CCAFS studies examined in this paper, including the methods used, and sites and countries where they were jointly implemented with local partners. Data collection and analysis is ongoing in several additional sites. The CCAFS initial gender intrahousehold survey collected information in 2012 from an adult male and female decision-maker in each of the sampled households in four sites in Africa: Nyando and Wote in Kenya, Rakai in Uganda, and Kaffrine in Senegal. Bangladesh, Colombia, and Nicaragua sites were added over the next few years. This survey built

upon an earlier farm characterization survey (IMPACTLite) and used the same sample of 200 farm households in each site, which encompass a 10 km^2 block of land. The sample was chosen to represent the different agricultural production systems in each site (Rufino et al., 2012).

The quantitative surveys were complemented with in-depth qualitative research, at the village and organizational levels (Perez et al., 2015). In addition, work developing and testing methods were done in collaboration with FAO and CARE International in Kenya, Ghana, and Bangladesh resulted in a practical training guide for research and development partners (Jost, Ferdous, & Spicer, 2014).

3. Conceptual framework

This paper elaborates on the conceptual framework presented in Behrman, Bryan, and Goh (2014), which links gender, agricultural development, and climate change (Figure 1). This framework provides a way to understand farmers' adaptation decisions in response to climate change by bringing together components of the Sustainable Livelihoods Framework (Department for International Development [DFID], 2001), the Institutional Analysis and Development framework (Ostrom, 2005), the IFPRI and ILRI Gender, Agriculture & Assets Project (GAAP) framework (Meinzen-Dick et al., 2011), and the climate change framework of the Third Assessment Report of the IPCC (IPCC, 2001). These frameworks all shaped an initial theory of change for the CCAFS global research program (Thornton et al., 2017).

Figure 1 captures the key drivers of adaptive change that are explored further below. Exposure to climate change is represented by the climate signal. Adaptive capacity from the IPCC framework is represented by the 'vulnerability context', made up of user characteristics, information and technology, biophysical characteristics of the context in which adaptation decisions are made (e.g. characteristics of the soils, rainfall patterns, etc.), and the institutional context. The adaptation arena is where actors use resources and their own decision-making authority to respond to perceived climate changes or future climate risks. The resulting well-being outcomes, in turn, affect the vulnerability context (Bryan & Behrman, 2013).

The literature provides strong evidence that the impacts of climate change are mediated by the context in which climate change occurs. Gender intersects with the vulnerability context in multiple ways – for example, men and women, of different ages, ethnic groups, etc. have different user characteristics, access to information and technology, relationships with institutions, and access to natural resources such as land and water. This context also influences men's and women's capacity to adapt to climate change. Women often have less bargaining power and fewer assets and other resources identified as essential for adaptation. Moreover, given gender differences in resources, assets, decision-making authority, and roles within the household and community, we would expect that men and women have different preferences, needs, and priorities for adaptation. The linkage between CCAFS results and the framework is explained for each component.

3.1. Climate signal

The climate signal includes long-term, average changes in temperature and rainfall, as well as changes in the frequency of extreme weather events, such as droughts and floods. While short-term climate shocks are not considered indicative of long-run climate change, changes in the frequency and severity of these shocks are. Men and women may experience climate change differently, even when they live in the same household. Gender-differentiated factors and adaptation decisions made in a given context determine the ways in which different individuals, groups, and communities experience and are affected by climate change. Studying the differential perceptions of exposure to climate shocks by men and women from agricultural households is a first step to understanding the potential differential impacts of long-term climate change on men and women. Recent literature examining the impact of climatic shocks on gender-differentiated asset dynamics shows that the impacts of shocks are nuanced, often unexpected, and depend on the type of shock and the local context (Rakib & Matz, 2014; Quisumbing, Kumar, & Behrman, in press). Section 3.2.1 further describes climate change perceptions as the interplay between the climate signal and user characteristics.

3.2. Vulnerability context

The vulnerability context comprises factors that affect exposure, sensitivity, and adaptive capacity of

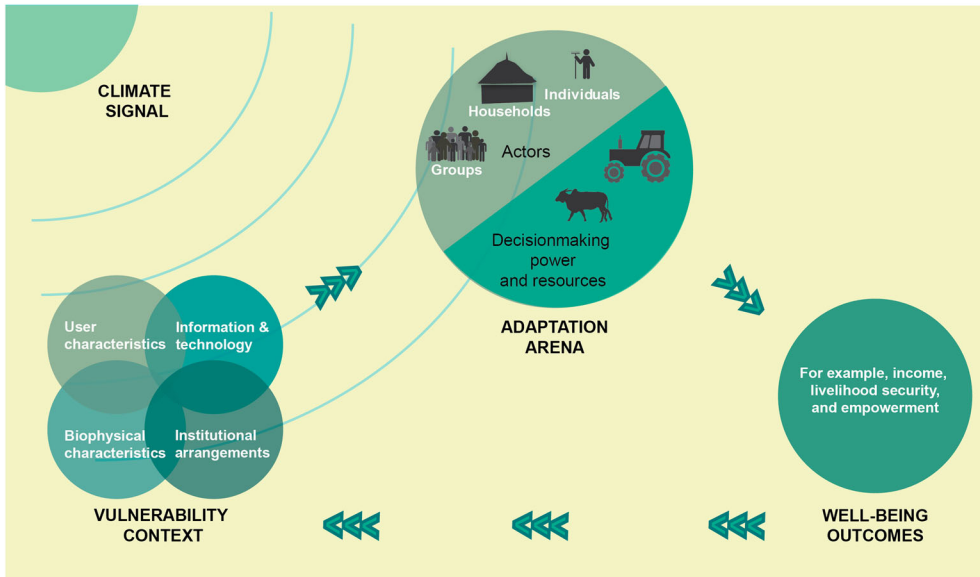

Figure 1. Framework on gender, agricultural development, and climate change. Source: Behrman et al. (2014).

individuals and communities to various climate change risks or hazards. Biophysical characteristics influence exposure and sensitivity to climate risks as well as adaptive capacity. The institutional context and user characteristics impact sensitivity to climate risks and adaptive capacity; and access to information and technology affect adaptive capacity. While the biophysical and institutional context may be the same for men and women in a household, they may affect men and women differently. Moreover, the sub-components of the vulnerability context are interlinked and influence one another. For example, access to information and the institutional context affect perceptions of climate change, that is, the climate signal, and awareness of adaptation strategies (the user characteristics) (Bernier et al., 2015). These factors combine to influence the range of response options that are available for individuals, households, and groups to adopt in the adaptation arena. Given high vulnerability to climate change and limited adaptive capacity, certain individuals or groups may be limited to coping with climate changes rather than adapting to these changes to increase their resilience over the long term.

Most micro-level adaptation studies have focused on particular aspects that influence the vulnerability context, such as social or cultural norms (Di Falco & Bulte, 2013; Nielsen & Reenberg, 2010), risk preferences (Grothmann & Patt, 2005), or the most salient factors influencing adaptation, such as access to extension services, information, and credit (Bryan, Keressa, Gbetibouo, & Ringler, 2009, 2013; Deressa, Hassan, Ringler, Alemud, & Yesuf, 2009; Nhemachena & Hassan, 2008). Rather than assessing differences between household members, these studies include individual characteristics of the household head, such as their level of education, access to information, age, and risk preferences. While limited in their usefulness for gender analysis, these studies show that the sex of the household head influences adaptation decisions and most find that female-headed household are less likely to adapt to climate change given that they face more barriers (such as fewer assets, lack of access to information, or less access to credit) (Bryan et al., 2013; Deressa et al., 2009; Nabikolo, Bashaasha, Mangheni, & Majaliwa, 2012).

3.2.1. User characteristics

User characteristics refer to the characteristics of individual decision-makers or groups of decision-makers, such as their ability to perceive climate change and climate risk (and other aspects of their cognitive capacity), their values and beliefs, and other individual attributes such as livelihood activities, asset holdings, age, marital status, or level of education. A user's perceptions of climate changes and climate risk are particularly important as adaptation is often seen as a two-step process where farmers must first perceive

climate changes and then adapt (Deressa et al., 2009; Maddison, 2007).

Gender differences in perceptions relate to differential exposure to climate shocks and change based on livelihood activities, roles within the household and community, and perceptions of the same climate signal, all of which may differ for men and women (Perez et al., 2015; Quisumbing et al., in press). Again, the CCAFS work goes beyond previous studies, which only identified perceptions and other characteristics influencing the behaviour of the main decision-maker in the household (usually the male head), to include user characteristics of multiple household members (young and old).

3.2.2. Information and technology

Farmers possess a number of traditional strategies for predicting weather patterns and agricultural production practices. However, unprecedented changes in climate can often render traditional methods for predicting the climate ineffective (Roncoli, Ingram, & Kirshen, 2001). Scientific information and new technologies are, therefore, important for successful adaptation to climate change.

Access to climate information and appropriate technologies for adaptation is an essential determinant of climate change adaptation (Bryan et al., 2013; Deressa et al., 2009; Nhemachena & Hassan, 2008; Tambo & Abdoulaye, 2012). To adopt the appropriate strategies to mitigate future climate risk, smallholder producers need access to information on how the climate is projected to change and which technologies and practices are available to address these challenges. Integrating climate information into adaptation decision-making is difficult given the challenge of communicating often uncertain scientific information, the lack of context-specificity, and ineffective channels of communication (Patt & Gwata, 2002; Roncoli et al., 2001; Vogel & O'Brien, 2006; Ziervogel, Johnston, Matthew, & Mukheibir, 2010; Ziervogel, Bithell, Washington, & Downing, 2005). Furthermore, much of the information being communicated does not meet the needs of local communities, which suggests that farmers must be involved in generating climate information at the local level and communicating what scientific information is needed. Similarly, farmers' innovation should be tapped to contribute to the development of appropriate adaptation strategies in response to the climate threats they face. Differences in men's and women's information needs and access to information sources and agricultural technologies further complicate this – requiring deeper gender and social analysis to differentiate the needs and preferences of different groups (Meinzen-Dick, Quisumbing, & Behrman, 2014; Peterman et al., 2014; Ragasa, Berhane, Tadesse, & Taffesse, 2013). Communication strategies that support a two-way exchange of climate information and learning between extension agents and communities, including different social groups within communities, appear to be more effective and equitable approaches (Tall, Kristjanson, Chaudhury, McKune, & Zougmore, 2014).

3.2.3. Institutional context

The institutional context in Figure 1 refers to the social, cultural, political, and economic structures that govern human interaction (Klein, 2000). These structures can be both formal (e.g. organizations such as NGOs or farmer cooperatives) and informal (e.g. social and cultural norms of behaviour) (North, 1990; Ostrom, 2005). Such formal and informal structures influence how men and women can adapt to climate change. Formal institutions, such as local organizations, influence how climate risks and resources needed for adaptation (such as credit and agricultural inputs) are distributed across different social groups within a community (Agrawal & Perrin, 2008; Agrawal, 2010). Not all community members have equal access to and ability to participate in decision-making in formal institutions (Agrawal, 2010; Cleaver, 2001, 2009). Lack of access to and participation in formal institutions, therefore, can constrain the adaptive capacity of these disadvantaged groups.

Informal institutions such as social networks and ties can both help and hinder adaptation (Adger, 2003; Adger et al., 2009). Informal institutions can promote cooperation in resource management and income diversification, thereby contributing to livelihood and ecological resilience, as evidenced by a case study in Tanzania (Rodima-Taylor, 2012). Institutions such as property rights and collective action also influence the adoption of many agricultural technologies and practices that are important for addressing climate change, such as agroforestry, rangeland management, and livestock feeding practices (Meinzen-Dick, Knox, Place, & Swallow, 2002). Social and cultural norms shape the extent to which men and women can participate in and benefit from adaptation. For example, social norms often prohibit women from adopting certain practices, such as

agroforestry (Kiptot & Franzel, 2012) and irrigation using treadle pumps (Njuki et al., 2014).

3.2.4. Biophysical characteristics

Biophysical characteristics relate to natural resources, such as land, water, and trees, and the critical ecosystem services they provide, as well as the sensitivity of these resources to climate change. The link between biophysical factors and gender differences in adaptive capacity is not always recognized. Yet there is growing evidence that women tend to have less access to land (both in terms of quantity and quality) in sub-Saharan Africa and Asia, which may put them at a considerable disadvantage with respect to the options that are available for adaptation (Kieran, Sproule, Doss, Quisumbing, & Kim, 2015; Doss, Kovarik, Peterman, Quisumbing, & van den Bold, 2015; Doss & Morris, 2001; Perez et al., 2015; Peterman et al., 2011).

Moreover, there is reason to believe that changes in the availability of water resources may affect women more than men in many places where women are responsible for domestic water collection (Codjoe, Atidoh, & Burkett, 2012; Goh, 2012). Therefore, it is important to consider how changing availability of natural resources due to climate change and differences in the quality of these resources between men and women may affect the adaptive capacity of men and women farmers.

3.3. Adaptation arena

The adaptation arena in Figure 1 is where (and when) actors (whether individuals, households, groups, or communities) make use of resources and their own decision-making authority to respond to perceived climate changes or future climate risks. As mentioned above, adaptation occurs in, and is influenced by, an institutional context that includes norms, policies, and other formal and informal rules that regulate interactions between actors and access to goods and services (Meinzen-Dick et al., 2013). Strong linkages between institutionally determined decision-maker powers and user characteristics modulate access to the goods and services meant to help actors reduce vulnerability and improve adaptability. Other factors in the vulnerability context, such as the availability of agricultural technologies, also influence the response options available to individuals, households, and groups. These response options range from coping responses to more transformative approaches that increase resilience to future climate changes.

The temporal dimension is another important element that applies here. Adaptation is an ongoing process as individuals, households, and groups continuously respond to changing climate conditions under different conditions of vulnerability. These decisions have implications for subsequent well-being outcomes and the future context of vulnerability. For example, deciding to sell assets in response to a climate shock to smooth consumption may leave the household more vulnerable to future shocks and changes.

3.4. Well-being outcomes

Whether or not individuals, households, and communities adapt to climate change and the types of adaptation options chosen will affect the welfare outcomes of households, such as their food and livelihood security, income, and asset holdings. These outcomes then influence the vulnerability of the individual, household, or community to future climate change and shocks. That is, the circular nature of the framework indicates that adaptation is an ongoing, iterative process and that vulnerability, adaptive capacity, risk, and well-being are never constant but dynamic and changing over time as climate conditions continue to change and decision-makers continue to respond to those changes.

Some studies are beginning to examine the impacts of adopting climate-smart practices on outcomes such as productivity, resilience, and GHG emissions (Rosenstock, Lamman, Arslan, & Richards, 2015). However, there are no studies that explicitly examine how welfare impacts differ when women participate in the adaptation process. The literature on the gender gap in assets suggests that outcomes related to education, nutrition, and health are strongly influenced by women's role in the household (Johnson, Kovarik, Meinzen-Dick, Njuki, & Quisumbing, 2016; Quisumbing, 2003).

4. Key findings from the CCAFS studies

This framework was used to revise the gender research questions of the CCAFS program and report on key findings as follows:

- *Climate signal*: What are the implications of exposure to climate stress (both climate shocks

and climate change) for men and women and their ability to adapt to those changes?

- *Vulnerability context*: What are the characteristics and causes of gender differentials in vulnerability to climate-related risk, that is, the factors influencing adaptive capacity? (1) *User and biophysical characteristics:* How are risks arising from climate change or variability distributed among men and women with different resource endowments? (2) *Information and technologies*: What are the characteristics and causes of gender differentials in access to and use of climate-related information and technologies? (3) *Institutions*: What are promising institutional arrangements enabling women as well as men to benefit from environmental services?
- *Adaptation arena*: Are there systematic differences in the choices and trade-offs poor men and women make in selecting options for adaptation and mitigation to deal with climate change in agriculture?
- *Well-being outcomes*: How do adaptation strategies impact men and women?

4.1. The climate signal: gender differences in exposure to climate change and impacts of climate shocks

The CCAFS gender surveys use intrahousehold questionnaires, which ask men and women within the same household about their perceptions of climate change and how climate shocks and climate change affect them. Analyses reveal gender differences in the responses. For example, in Nyando (Kenya), men are significantly more likely than women to report having experienced a drought in the last five years, while in Rakai (Uganda), more women than men report experiencing drought. In general, fewer women perceive long-run changes in weather patterns, although, in Rakai and Nyando, significantly more women than men report a perceived increase in temperatures in their lifetime (Twyman et al., 2014). Since these men and women live in the same households, it is interesting that their subjective experiences of climate change differed.

Although many men and women report similar impacts of climate shocks, some differences exist. For example, men are significantly more likely to report that shocks resulted in soil erosion, while a higher percentage of women recall impacts relating to flooding in Nyando, Kenya (Bernier et al., 2015).

4.2. Gender differences in the vulnerability context

Using data from the intrahousehold survey, several studies examine the influence of *user characteristics*[6] in relation to the vulnerability context.

Intrahousehold data facilitated analysis of how personal values and beliefs of men and women affect uptake of improved agricultural practices (Bernier, Kristjanson, & Meinzen-Dick, 2016). Similar to Wheeler, Zuo, and Bjornlund (2013), farmers were categorized as 'innovative' or 'traditional'[7], based on their reported beliefs and values concerning their attitudes towards commerce (commercial orientation), tradition, environment, and technology. Farmers characterized as innovative have a higher probability of water harvesting (Nyando), terracing (Wote), and adopting stress-tolerant varieties (Kaffrine) and irrigation and terracing practices (Rakai). Innovative farmers might be viewed as 'positive deviants' whose successful early adaptation through the use of improved practices will influence other members of their communities to make similar changes, resulting in higher overall rates of climate adaptation over time (Marsh, Schroeder, Dearden, Sternin, & Sternin, 2004).

Those with more traditional outlooks are associated with an increased probability of adopting no-till and fertilizer practices in Nyando (Kenya), and irrigation, manure management, and leaving crop residues on the field in Kaffrine (Senegal). Conversely, in Rakai (Uganda), those with a traditional outlook are less likely to adopt water harvesting, agroforestry, and composting. Farmers who value working together are more likely to adopt various climate-smart agricultural (CSA)[8] practices, including composting, water harvesting, and leaving crop residue (Bernier et al., 2015).

The village-level baseline studies find that across the diverse sites, men and women engage in different livelihood activities and have different resources supporting adaptive changes. Women typically have fewer assets and less access to capital, extension, inputs, and resources for agricultural production (Perez et al., 2015). Analyses of the intrahousehold data confirm the importance of asset ownership. Women's asset ownership was found to be

significantly and positively related to uptake of some CSA practices in Wote (Kenya), Rakai (Uganda), and Kaffrine (Senegal) (Bernier, Kristjanson, Bryan, Meinzen-Dick, & Ringler, 2016).

4.2.1. Information

Given that access to and ability to use information is essential for adaptation, the CCAFS studies explore gender differences in access to information and technologies for climate change adaptation, particularly with respect to weather and climate information, but also regarding agricultural advice on adaptation. The results of a descriptive analysis show that across the African sites, women farmers often have significantly less access to many types of agricultural (e.g. CSA practices) and climate-related information than men (Kristjanson et al., 2015a, 2015b, 2015c; Twyman et al., 2014). However, in some cases, women have greater access to certain types of information. For example, in the two Kenyan sites (Nyando and Wote), women report higher levels of access to crop and livestock production and post-harvest handling information than men (Twyman et al., 2014).

Numerous sources of information are available, but across the diverse sites, men and women tend to access different and fewer sources than men. In the African sites, women generally rely more on personal connections and informal sources and men are more likely to receive information through extension, private sector, and other formal sources. Radio reaches both men and women widely. Cell phones are reaching relatively few men or women with this information (Kristjanson et al., 2015a, 2015b, 2015c; Twyman et al., 2014). In the Colombian site, most men and women receive information from technicians, radio, TV, neighbours, extension agents, and family members. However, a higher percentage of men than women reported access to each of these sources of information (Twyman, Muriel, & Clavijo, 2016). In Nicaragua, radio and NGOs are the primary sources of information for agriculture and climate-related information. Men have slightly higher rates of access to these sources (J. Twyman, personal communication, 10 April 2017).

Qualitative focus-group approaches explored if men and women have different preferences for sources and types of climate information and the extent to which they use it differently. For example, in Senegal, women, unlike men, request forecasts of dry spells and timing of the cessation of the rains, given that they plant later than men owing to their lack of control over means of production (Tall et al., 2014). Use of CCAFS's new gender social inclusion tools[9] in Uganda and Ghana also revealed gender differences in preferences for both the sources and uses of information. Men in Uganda prefer radio, and women prefer receiving information through megaphones or from village leaders and other community groups. In Ghana, men use climate information for planning farming activities while women use this information for planning household tasks such as fuelwood collection (Jost et al., 2016).

4.2.2. Institutional issues

CCAFS studies also explored how formal and informal institutions influence the vulnerability and adaptive capacity of men and women. With respect to what institutional factors influence climate change adaptation options for men and women, the participatory research teams in Ghana, Uganda, and Bangladesh found that women's restricted mobility, due to social norms, lack of access to transportation, and heavy domestic responsibilities (e.g. childcare), limit their options for adaptation, whereas men have a wider range of adaptation options (Jost et al., 2016; Naab & Koranteng, 2012).

The baseline study of organizations intervening at different geopolitical levels revealed that women generally have access and links to local village-level institutions, while men have greater access to institutions and services coming from outside their own communities (Cramer, Förch, Mutie, & Thornton, 2016; Perez et al., 2015). The village-level baseline analysis also shows that women and men typically value different types of organizations. Women place a higher value on savings and credit groups than do men, although there is some variation across regions (Cramer et al., 2016). Qualitative work in Nwoya, Uganda, using organizational mapping, found that women report participating in fewer organizations than men (Mwongera et al., 2014).

Analyses of the intrahousehold data addressed whether group membership increases the likelihood that men and/or women will adopt CSA practices. The findings suggest that for both men and women, group membership increases the likelihood of adopting CSA practices in the African sites. For women, participating in groups that share labour increases the probability of making transformative (as opposed to incremental) changes, while for men, groups focused on mobilizing resources are key (Bernier et al., 2016). Women's access to credit is positively associated

with the uptake of some CSA practices in the African sites (Bernier et al., 2016).

4.2.3. Access to and control over natural resources

The village-level baselines explored what access women and men have to natural resources. Even within the same communities, women typically have less access than men to productive resources and opportunities. Women usually tend fields and natural resources located near their homes, while men's fields and areas of influence are further away. In Tanzania, for instance, men, but not women, have access to forests that are a three-hour walk away from the community. In two sites (Ethiopia and Tanzania), participants reported that men and women have their own and separate water pans. Women's are typically smaller, with poorer water quality. In the Ghana site, men's plots are located adjacent to the main, permanent river, while women's plots are near a seasonal river (Perez et al., 2015).

4.3. Gender differences in the adaptation arena

How different are men's and women's climate change agricultural adaptation strategies? CCAFS research has asked this in several different ways, using both qualitative and quantitative approaches. The intrahousehold surveys provide the following insights:

1. Women in CCAFS sites in Kenya, Uganda, Senegal, and Bangladesh are less aware than men of climate-smart agriculture practices/options. Encouragingly, in the Kenya sites, if they are aware, they are just as likely to adopt CSA practices as men;
2. Few women are harvesting rainwater or investing in soil and water management, food storage, or planting trees due to their specific climate experiences;
3. More men, but not a majority, are adopting soil and water conservation practices and agroforestry due to climate change;
4. The most common adaptations made by men and women are related to crop production adjustments and include implementing soil and water conservation practices, changing crop variety, changing the type of crop, changing planting date, and planting trees (Bernier et al., 2016; Twyman et al., 2014).

In Kenya, Uganda, and Bangladesh, qualitative, participatory work suggest financial and food security incentives for change are equally important as those related to climate. Women adopt changes less frequently than men, citing financial and resource limitations. New tasks that are more labour-intensive, such as composting and vermiculture, generally fall on women, suggesting the well-being outcomes for men and women may differ following adoption of particular strategies. Women say that increased labour requirements are a disincentive to changing agricultural practices. This research concluded that 'changes in agricultural practices are occurring mainly within existing gender roles' (Jost et al., 2016).

In Ghana, gender-responsive participatory approaches reveal that men focus more on changing staple crop varieties, introducing new tree crops, intercropping and rotation with legumes, changing livestock types and breeds, and increasing application of fertilizers and other agricultural chemicals. Women prioritize growing vegetables, planting cash crops near the home, composting, mulching, fallowing, and row planting (Naab & Koranteng, 2012).[10]

4.4. Well-being outcomes

The theory of change behind most of the research in the climate change agricultural development-gender nexus is that modifications in the behaviour of women and men in the agricultural sector (e.g. adoption of CSA practices), and the institutions supporting them (e.g. extension), will have multiple benefits. These include improved productivity and more food output per unit of land and/or labour, higher incomes, greater food and/or nutrition security, enhanced stocks, and flows of ecosystem services, among others. These impacts, in turn, lower the vulnerability of the individual, particularly women, their households, and communities, making them more resilient to future climate change and shocks. However, measuring well-being outcomes, such as reduced vulnerability and increased resilience, resulting from long-run climate change and the adaptation options taken by decision-makers is extremely challenging, which is why researchers tend to measure perceived impacts of climate shocks and change instead.

The large literature on welfare impacts, such as agricultural production outcomes, education, health, etc., resulting from the gender gap in assets and resources (Quisumbing, 2003) suggests that this gap

has a negative influence on many measures of individual and household welfare. Many studies examine the adoption of specific technologies or practices and their impacts, but seldom include gender differentials in impacts following technology adoption. However, the costs and benefits associated with adopting new climate-smart technologies and practices are not likely to be evenly distributed among household members. For instance, Beuchelt and Badstue (2013) find that conservation agriculture, which is often touted as an important climate-smart practice, increases the amount of time women spend weeding, adding to their overall time burdens. This suggests that increasing women's empowerment cannot be assumed to be an expected result of agricultural development without sustained attention and gender-sensitive implementation approaches. Few, if any, studies examine outcomes across a range of strategies or look at differences in welfare outcomes when men, women, or both men and women are actively pursuing climate change adaptation strategies. This is an area that requires considerably more research.

The initial CCAFS baseline surveys, together with the subsequent farm characterization (called IMPACT Lite) surveys and the intrahousehold gender survey, aim to measure broader development and well-being outcomes, such as agricultural productivity, income, food security, nutrition/health, education and women's empowerment, that occur over a longer period (10–15 years). Measuring changes in these outcomes will require revisiting the same households and individuals over time to see what changes when men, women, or both adopt CSA practices or adapt to climate change through other means. This presents an opportunity to use innovative ICT-based approaches, as discussed below.

5. Discussion

5.1. State of knowledge on gender and climate change

It is too early to assess thoroughly the long-run impacts of the research summarized here, but it is timely to ask which questions we are addressing well with the methods implemented, which have proved especially difficult, and what critical research gaps and method design needs remain. We discuss this in terms of 'what, why, where, and how'. Research has answered many of the key 'what' questions, at least for one point in time, through analysis of quantitative surveys. The findings raise new questions about how to develop policies and programs based on this information, but also point to the need for more investment in 'gender-transformative' approaches (Kantor, Morgan, & Choudhury, 2015). Gender-transformative approaches examine, question, and influence gender norms and power imbalances, through an enhanced awareness among men and women of gender roles, enhancing the position of women and changing the distribution of resources and roles played by men and women (Morgan, 2014).

Overarching questions relating to the adaptation arena in Figure 1 for CCAFS in the early stages were 'What are men's and women's adaptation options and strategies (individual, household, or collective)? What are the differences in their capacity to adapt?' Analyses of the intrahousehold gender survey data shed light on which CSA practices men versus women adopt in a particular context. Some practices appear to be generally preferred by women or men across diverse environments. For example, women are more likely than men to take up improved stoves, water harvesting, and small-scale irrigation, while men are more likely than women to adopt stress-tolerant varieties and animal breeds and agroforestry practices. The gendered patterns of uptake of other practices, such as mulching, composting, terracing, and improved feed management, vary considerably across sites.

The other overarching 'what' question was 'What are the characteristics and causes of gender differentials in vulnerability and adaptive capacity to weather-related risk' (including those related to information and technologies, institutions, biophysical characteristics, and user characteristics)? CCAFS results allow us to draw some conclusions regarding the barriers to adoption of CSA practices – namely that differences in perceptions of climate change, access to information on climate change and the appropriate responses, institutional constraints, and access to and control over resources influence men's and women's capacity to adopt a range of climate-smart practices. Again, while there are some general barriers that appear to affect men or women across the various environments, other barriers vary by local context.

These differences identified by the 'what' questions lead us to the 'where' questions. While the data show that there are, in fact, differences between men and

women in terms of the determinants of and preferences for adaptation, these differences must be identified and examined within a particular local environment in order to contextualize these differences. Similarly, answering the 'what' questions does not get us to 'how' to overcome differences in adaptive capacity and rates of adoption of improved, CSA practices and livelihood approaches. Moreover, there is limited understanding of how the barriers to adoption interact with each other. For example, how is access to and control over assets and resources constrained by gender norms? Also, how can policies and interventions overcome the constraints that have been identified? There are substantial differences in how capacities to adapt vary between men and women due to a multitude of reasons. At this stage, a new research question could be reformulated as 'how best can the differing capacities of different groups of men and women (based on race, ethnicity, class, caste, age, etc.) to adapt be supported?' CCAFS's current strategy focuses more broadly on issues of gender and social inclusion to better account for these intersectional issues. This question of 'how' to support adaptation also relates to the enabling policy and institutional environment and how research can be better oriented to contribute to development outcomes. These issues are discussed further below.

Regarding the 'why' questions, if women's empowerment in the agricultural sector is a key priority, agricultural research-for-development efforts need to benefit women, and potentially transform gender relations to close the gender gap in agriculture. The theory of change (implicit or explicit) in CGIAR-wide research programs such as CCAFS is that agricultural sector actors, including women, will have to transform existing farming and food systems through the uptake of a wide range of new practices, technologies, management approaches, and policies. It is clear that there are no 'silver bullets'. Therefore, addressing issues of gender in research, policies, and interventions related to climate change is essential to both reduce gender inequalities and to maximize broader development gains such as increased resilience and food security of smallholder producers in developing countries. Intrahousehold research highlights that women must be part of the solution to the climate challenge and that research and development communities should seek to overcome the barriers to women's adoption of new innovative technologies and practices.

5.2. Lessons for future research

Mixed qualitative–quantitative approaches are powerful tools for learning across a range of environments and farming systems, thus addressing questions of 'where'. Their value will increase over time, as many of the same households are revisited, providing an opportunity to investigate how households obtain new knowledge and engage in new agricultural practices. Long-run panel datasets are a way to rigorously assess what is sustainably working, where, and how. However, they must continue to be paired with complementary in-depth qualitative work, particularly to address why things work.

Quantitative intrahousehold surveys that ask the same questions of a man and a woman in the same household are time consuming, relatively expensive, and often challenging to implement. Ideally, they collect plot-level data, as did the CCAFS intrahousehold studies. They play an important role in addressing questions regarding differential access to and use of information and resources, as well as gender differences in outcomes, such as agricultural production. But when do the benefits of investing in this type of research outweigh the costs? The costs include both the direct research costs and those borne by the respondents who contribute considerable time. Initial analyses should identify a subset of key indicators to monitor for the same households and individuals over 5–10 years or longer, but project funding is usually allocated on a much shorter time scale and does not allow for this.

The studies reviewed here demonstrate that comprehensive quantitative surveys, especially those collecting information from multiple household members, often raise more questions about the 'where, how and why' than they can answer. For example, women are largely not engaged in practices such as rainwater harvesting that would save time collecting water, and might well improve the productivity of their homestead gardens. There is likely a wide range of reasons for this, varying by location. This is where qualitative, focus-group-based work adds value (ideally in conjunction with, or linked to, the quantitative approaches). Such qualitative work must be based on rigorous sampling frames and quality standards to limit biases (e.g. random selection of participants instead of the village head's selection of participants) (Perez et al., 2015).

Action research such as the qualitative approaches developed by CCAFS with development partners FAO

and CARE have generated valuable evidence regarding changing gender cultures and norms. This facilitates analysis of the 'what' questions about gender barriers. The aim of this body of research was to see development partners 'scaling out' these participatory, largely qualitative approaches in a wide range of sites globally. This research is both diagnostic in nature (e.g. what practices are you pursuing), as well as action-oriented (e.g. understanding the impacts on women of practices being tested as they occur). The scaling out that will make these approaches more valuable is starting to happen. For example, in the Peruvian Andes, the gender inclusion toolbox was applied in a study that compared the benefits to men and women from various agroforestry practices as options for adaptation to climate change (Mathez-Stiefel, Ayquipa-Valenzuela, Corrales-Quispe, Rosales-Richard, & Valdivia-Valdes, 2016). In Colombia, a local partner NGO of CCAFS called EcoHabitats recently implemented an approach called 'Participatory Local Adaptation Planning with a Gender Focus' that initially added the gender focus for CCAFS sites, but are now expanding to other (non-CCAFS) sites in northern Colombia. They use community workshops divided by groups of men and women to discuss climate change and agricultural production systems (including gender roles and responsibilities) and discuss how different adaptation actions might impact production, labour of men and women, and other challenges.

This kind of action research that takes a joint learning approach (with development partners and communities in the driver's seat) overcomes some of the drawbacks of purely diagnostic approaches that are seldom able to answer the question 'so what?' A drawback of the qualitative, focus-group-based approaches, however, lies in its reliance on a strong partnership between the local organizations and communities and the research team. The true strength of these approaches is realized if the learning that occurs is translated into local actions that help people overcome some of the challenges identified during the participatory research process.

Given the huge investments that CGIAR and others have made in collecting baseline data in many sites and countries, there is also an opportunity to complement the qualitative and quantitative approaches being used with shorter-term, larger waves of lower cost data collection, such as mobile phone text questions, linking these to the existing baseline datasets. Several CGIAR centres and other partners are now using such tools, as well as testing innovative crowdsourcing through online citizen science approaches (Van Etten, 2011).

5.3. Linking research with development outcomes

This review not only helps us identify potential future research areas and approaches but also provides insights on how research might better contribute to development outcomes. An important step towards assessing the extent to which the research is contributing to development outcomes was made in 2013 when researchers from across CCAFS developed a gender theory of change (Jost, Kristjanson, & Ferdous, 2015). It states:

> Women can be vulnerable to climate change. Women are also powerful agents of change, and often have unrealized solutions for adaptation and mitigation. Gender norms change, and can change quickly; this is a key part of the "transformative change" we support.

This mandate encouraged innovation in terms of the development of tools such as the Gender and Inclusion Toolbox that are specifically formulated to tie research outputs to development outcomes, as well as the design of such tools in collaboration with development partners from the very beginning to ensure that they are outcome oriented.

Tied to its gender theory of change, CCAFS identified a gender and social differentiation impact pathway that aimed to integrate capacity development and research activities, so each activity contributed to both new knowledge and new capacity. As a result, in addition to the original gender-focused research questions considered early in the program, two questions that challenged gender norms and targeted transformation were identified:

- 'How do we best target climate-smart practices and knowledge to women?
- Can the capacity of stakeholders to implement gender transformative climate change, agriculture and food security programs be increased by using participatory methods?' (Jost et al., 2015).

Targeting women and vulnerable groups with climate-smart solutions increases the likelihood of achieving not only positive gender-related outcomes, but also reducing poverty and increasing sustainability. To achieve the greatest overall impact, we need to take

the lessons learned from sex-disaggregated documentation and diagnostic research, and use it to formulate research aimed at informing, catalyzing, and better targeting adaptation and mitigation solutions to those that represent a missed opportunity to date. Societal norms and beliefs regarding gender must be addressed in order to achieve a 'healthy, food and nutrition secure world free of poverty and hunger, with sustained and regenerating natural resources' (Jost et al., 2016).

A Monitoring, Learning and Evaluation (ML&E) plan was developed as an integral part of the impact pathway. Critical indicators to measure early progress towards outcomes were identified. These include measuring outputs such as the number of views and downloads of papers, briefs, training materials, etc. Follow up research on outcomes, such as a recent knowledge, attitudes, and practices survey carried out by IFPRI (Bryan, Bernier, Espinal, & Ringler, 2017), and similar studies in Latin America (Espinal & Witkowski, 2015; Mathez-Stiefel et al., 2016) focus on what approaches stakeholders are using to integrate gender into their work, how research materials are being used, and what knowledge and capacity gaps remain. This research shows that greater collaboration between and among research organizations and implementing partners is needed to share knowledge, tools, and approaches; and build capacity on gender within key organizations, such as government agencies, to ensure that gender is integrated in climate change adaptation and resilience programs. Providing tools alone may not be sufficient, unless there are incentives for implementers to use the tools. Creating accountability for serving women as well as men can help strengthen these incentives. To do this, key questions from gender diagnostic tools can be used to monitor progress over time, as has been done with the Women's Empowerment in Agriculture Index (see www.ifpri.org/topic/weai-resource-center). Building capacity for such diagnosis, program formulation, and monitoring will require nurturing long-run, strong partnerships over many years.

6. Conclusions

From this synthesis of select research aimed at the intersection of gender, agricultural development, and climate change, it is evident that much progress has been made in the last few years on identifying gendered research questions and developing new research approaches for addressing them. Yet many gaps remain.

The evidence demonstrates that men and women are exposed to different climate shocks and experience different impacts. Clear guidelines on how to address the needs of both men and women in different environments and agricultural systems are still lacking. More 'action research' with a focus on co-learning is needed. Women and men farmers are both vulnerable to negative impacts of climate change, but women are less likely to act to reduce vulnerability (e.g. by taking up CSA practices). Key opportunities are lost as very few farmers have taken up new practices that will make them more resilient to future climate changes. Women's lower adoption levels may relate to high labour requirements and/or the fact that such investments are long term in nature (i.e. requiring relatively high up-front costs but the benefits only accrue in the long-term). Since women typically have less access to resources, including labour and money, and less secure tenure to assure them that they will benefit from the investments, it stands to reason that such practices are harder for women to adopt. Research to relieve such constraints has potentially high benefits.

Access to information is critical. Information needs differ for men and women; while neither are receiving sufficient access to agricultural and weather/climate-related information in many places, women are particularly neglected. Many of the 'climate-smart' agricultural practices and interventions, for example, actually have the potential to substantially increase women's workloads (e.g. composting and vermiculture, Jost et al., 2016; conservation agriculture, Beuchelt & Badstue, 2013). Gender differences in adaptive capacity (user characteristics, information and technology, biophysical characteristics, and institutional context) comprise the overall set of capacities that will enable individuals and communities to respond to climate change; the CCAFS research highlights that there continues to be a stark gender gap. Work is needed to link biophysical (e.g. soil health mapping) and socio-economic approaches to address the relative influences of land quality and institutional factors in determining food security levels.

Quantitative research methods are often viewed as more 'rigorous' and less biased than qualitative approaches. Yet, the qualitative approaches included here are equally rigorous and provide findings that are essential to understand patterns found in the

quantitative data. Both approaches are crucial to better understand the complex nexus of gender, agricultural development, and climate change.

While both quantitative and qualitative research under CCAFS has begun to shed more light on these issues, a key question remains: how can understanding the nexus of gender, agricultural development, and climate change contribute to development outcomes on the ground? More people accept that gender is a key piece of the puzzle that has been neglected for too long, but many are still seeking practical advice as to how to successfully integrate gender into their programs to increase their efficacy and equity. Here, the social learning process used by CCAFS to develop the participatory Gender and Inclusion Toolbox has been particularly effective for generating capacity of partners and users in gender awareness and transformative approaches (Jost, Ferdous, et al., 2014).

Lessons from this synthesis point towards a continued need to invest in these participatory 'action research' approaches, testing new technologies, strategies, policies, tools, and approaches and co-learning with partners on the ground. Such efforts can further enhance understanding of gender and climate change issues, while, equally importantly, build capacity in local partners for climate change appropriate gender research and development in agricultural systems and communities. This will be especially valuable with an added focus on *transforming our quantitative research approaches* from extensive household-based surveys to more efficient survey tools that are designed to rapidly characterize a series of standardised indicators across the spectrum of agricultural production and market integration, nutrition, food security, poverty, and GHG emissions (Hammond et al., 2017). Given the huge investments that CGIAR and others have made in collecting baseline data in many sites and countries, there is also an opportunity to complement the qualitative and quantitative approaches we have been using with other data collection methods, such as mobile phone text questions, and linking these to the existing baseline datasets. Several CGIAR centres and other partners are now using such tools, as well as testing innovative crowdsourcing in online citizen science approaches (Van Etten, 2011).

In terms of addressing the gender research questions identified with respect to climate signal, vulnerability context, adaptation arena, and well-being outcomes, this body of work has contributed new evidence showing many nuanced differences between men and women. However, there is more work to be done in order to better understand differences among women, or the specific needs of traditionally under-represented groups, for example. This will require not only more participatory and integrated qualitative–quantitative work, but also linking it to innovative ICT-based action research and gender-transformative approaches.

The implications for policy and programming are that women will remain largely information-starved and neglected by service providers and development interventions unless their differing needs, preferences, and constraints are considered right from the beginning. Better integrating research and practice, and designing information, tools, practices, and interventions with gender in mind can accelerate progress towards achieving many development objectives, while enabling women to become agents of their own empowerment.

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Notes

1. For a detailed discussion on conceptualizing and measuring women's agricultural productivity, see Doss, in press.
2. See https://dataverse.harvard.edu/dataverse/CCAFSbaseline
3. These include International Food Policy Research Institute studies of gender, assets, and resilience (http://gaap.ifpri.info/), women's empowerment in agriculture (http://www.ifpri.org/publication/womens-empowerment-agriculture-index), climate change, collective action, and women's assets (http://womenandclimate.ifpri.info/),

and a new gender focus of the World Bank's Living Standards Measurement Study surveys (http://go.worldbank.org/EKQ8VQVPK0).

4. The process of developing the research agenda was broadly participatory. In the first year of the program, CCAFS research leaders consulted widely and hired a gender in agricultural development expert to jointly develop a gender research strategy (Ashby et al., 2012).
5. See https://ccafs.cgiar.org/resources/baseline-surveys#household for more details on CCAFS baselines and sites.
6. The surveys also covered the typical user characteristic variables such as farm size, household size, gross income, education, and age. The findings show that all of these are associated with uptake of some climate-smart agriculture practices in some sites. In particular, farm size, household income, and household size were often significant, but this information relates to the household and not to individuals.
7. Some of the innovations described involve the adoption of what might be considered traditional practices (in an improved manner). Thus a term such as conventional or conservative may be preferred by some.
8. CSA is defined by FAO as agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances achievement of national food security and development goals (FAO, 2010).
9. https://ccafs.cgiar.org/publications/gender-and-inclusion-toolbox-participatory-research-climate-change-and-agriculture#.VwLCQHDWRek
10. While the studies cited focus on agricultural systems, this is a potential limitation as some important adaptation strategies/opportunities may be outside of agriculture; see Meinzen-Dick et al. (2013).
11. https://dataverse.harvard.edu/dataverse/CCAFSbaseline
12. http://www.fao.org/climatechange/micca/75949/en/
13. https://ccafs.cgiar.org/publications/gender-and-inclusion-toolbox-participatory-research-climate-change-and-agriculture#.VwLCQHDWRek
14. https://dataverse.harvard.edu/dataverse/CCAFSbaseline%3bjsessionid=4aa3b98e3c03e9377f3d2d2590b0

ORCID

Patricia Kristjanson http://orcid.org/0000-0001-6059-4187
Christine Jost http://orcid.org/0000-0003-1911-975X

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