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Engendering Agricultural Research

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Notices

[1] Effective January 2007, the Discussion Paper series within each division and the Director General's Office of IFPRI were merged into one IFPRI–wide Discussion Paper series. The new series begins with number 00689, reflecting the prior publication of 688 discussion papers within the dispersed series. The earlier series are available on IFPRI's website at http://www.ifpri.org/publications/results/taxonomy%3A468.

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ABSTRACT

This paper makes a case for gender equity in the agricultural R&D system. It reviews the evidence on exactly why it is important to pay attention to gender issues in agriculture and why it is necessary to recognize women's distinct food-security roles throughout the entire value chain—for both food and nonfood crops, marketed and nonmarketed commodities. The authors examine whether women are factored into the work of research institutions, and whether research institutions effectively focus on women's needs. In short, are these institutions conducting research by and for women? The paper's conceptual framework demonstrates the need to integrate gender into setting agricultural priorities; conducting the research itself; designing, implementing, and adopting extension services; and evaluating their impacts. It concludes with recommendations regarding how to make these suggested changes.

Keywords: gender, agriculture, R&D, priority setting, value chains

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ABBREVIATIONS AND ACRONYMS

CIAT	Centro Internacional de Agricultura Tropical
MDG	Millennium Development Goal
OPV	open-pollinated varieties
R&D	research and development
CGIAR	Consultative Group on International Agricultural Research
FFS	farmer field schools
NGO	Nongovernmental organizations
FAO	Food and Agriculture Organization of the United Nations
NTFP	nontimber forest products
GHI	Global Hunger Index
GFAR	Global Forum for Agricultural Research
PRGA	Participatory Research and Gender Analysis
NARS	National Agricultural Research System
CIP	Centro Internacional de la Papa
ILRI	International Livestock Research Institute
ICRW	International Center for Research on Women
S&T	science and technology
ASTI	Agricultural Science and Technology Indicators
ICT	Information and Communication Technologies
FBO	Farmer Based Organizations
CBO	community-based organizations
ATMA	Agricultural Technology Management Agency
NAADS	National Agricultural Advisory Services
SEWA	Self Employed Women's Association

1. INTRODUCTION

Successful development interventions are, by nature, transformative—whether through creating opportunities, new commodities, and services or changing the way people do things and the way they perceive and react to change. One might argue that changing agricultural research and development[1] from male-dominated to gender-equitable is a matter of political correctness or ideology. However, we argue that paying attention to gender is not ideology but a matter of development effectiveness: We will not be able to meet the food needs of the future population or ensure that productivity translates into improved welfare for the poor unless we take gender into account more seriously in agricultural research and development.

Gender differences matter in agricultural production in various farming systems all over the world, where the ownership and management of farms and natural resources by men and women are often defined by culturally specific gender roles. Gender differences are also obvious in the staffing and conducting of agricultural research and extension, with most agricultural scientists and extension agents being male. While progress has been made in developing extension systems that are more gender-sensitive, unless the source of new crop, fish, and livestock varieties and agricultural technologies takes women's different needs into account, the product that is being disseminated by extension systems may not meet different needs and preferences. A gender-responsive agricultural research and development system therefore needs to address women as well as men as both the clients and actors in agricultural research.

We must keep in mind that gender relations are culture and context specific. Women's roles in food and agricultural systems and involvement in agricultural research depends on the region in which the women live. Because gender and cultural issues are inseparable, involving women in agricultural research issues should take into account existing gender roles and how these can be transformed through education and capacity building.

Whereas the fields of health and education have long acknowledged that explicitly addressing gender issues is one of the most effective, efficient, and empowering ways to boost development and address poverty, the field of agriculture research has lagged. In the world of national and international agricultural research, women continue to be underrepresented and underserved, and their contributions are not fully tapped. It is time to catch up.

This paper aims to make a case for a more gender-equitable agricultural research and development system. It reviews evidence on whether women are factored into research institutions and whether research institutions effectively focus on needs of women, that is, research by and for women. It begins by reviewing the evidence on why it is important to pay attention to gender issues in agriculture. It develops a conceptual framework linking various actors in the agricultural innovation cycle and discusses the need to integrate gender into agricultural priority setting, the conducting of research and development, the design and implementation of extension systems, and the adoption and evaluation of new agricultural technologies. It then argues that our development paradigm in agriculture and food security needs to move beyond production and toward a broader view of agriculture and food systems, one in which women's distinct role in ensuring the food security of their households is better recognized. This involves recognizing women's role throughout the value chain for both food and nonfood crops and for both marketed and nonmarketed commodities. The paper concludes by providing recommendations regarding what needs to change in the way we think about and conduct agricultural research.

[1] Throughout this paper, agricultural research and development refers not only to crops but also to livestock, fishing, forestry, and natural resource management.

2. WHY PAY ATTENTION TO GENDER IN AGRICULTURE?

The rationale for considering gender in agricultural research relates to agricultural productivity, food security, nutrition, poverty reduction, and empowerment. In all of these cases, women play a critical, but often underrecognized, role and face greater constraints than men. Recognizing this sets the stage for identifying ways that the agricultural research system can redress these problems and contribute to productivity and equity.

Considerable evidence exists that households do not act in a unitary manner when allocating resources (Alderman, Haddad, and Udry 1996; Haddad, Hoddinott, and Alderman 1997). This means that men and women within households do not have the same preferences nor pool their resources. This has important implications for productivity; several empirical studies have found that redistributing assets between men and women in the household has the potential for increasing productivity (Udry 1996).[2] Not only do gender disparities in control over assets exist, but increasing women's control over assets has positive effects on a number of important development outcomes, including food security, child nutrition, and education (Quisumbing 2003).

Improving Agricultural Productivity and Profitability

Women are important in agriculture, and agriculture is important to women.[3] Women around the world play important roles in planting, weeding, postharvest processing, food preparation, and so forth. FAO (2007) estimates that Southeast Asian women provide up to 90 percent of the labor involved in rice cultivation and that sub-Saharan African women produce up to 80 percent of basic foodstuffs for household consumption and sale. However, in many instances, the roles women play in farming and production are not formally recognized (Dixon 1982). For example, in sub-Saharan Africa, women and girls are responsible for transporting fuel and water supplies for domestic use (World Bank 2009)—an arduous and time-consuming task that plays an invaluable, though unacknowledged, role in agriculture-related activities. Women are also engaged in fisheries and fish farming to a greater extent than acknowledged. Available evidence points to at least 47 percent of fisheries-related activities being performed by women.[4] In many Asian countries, women are engaged in aquaculture-related activities such as fry collection; feed preparation; feeding of stock; and the sale and processing of the catch from fish cages, pens, and ponds.

Given the important role women play in agricultural production around the world, focusing on the unique challenges women face and the resources they lack is key to increasing overall agricultural productivity. Extensive evidence from the 1990s (Quisumbing 1996) and a review of more recent literature (Peterman, Behrman and Quisumbing 2009) have documented gender inequalities in agricultural inputs that disadvantage women as agricultural producers. Studies from Africa find that not only do female-headed households use land much less productively than their male-headed counterparts (Holden, Shiferaw, and Pender 2001), but they also tend to rent out their land to tenants with much lower productivity because of lack of alternatives (Bezabih and Holden 2006; Holden and Bezabih 2007).

[2] A critique of this study (O'Laughlin 2007) maintains that one—perhaps counterintuitive—implication of this finding would be to give all of the land to men in order to maximize productivity.

[3] In reviewing evidence on women's labor force participation, Doss (2009) finds that the oft-cited figures of women producing 60–80 percent of the world's food (often attributed to FAO, nd) is not supported by the data, especially official data on the percentage of the agricultural labor force that is female, although careful time-use studies from selected countries in Africa indicate women do contribute more than 60 percent of the total time spent in agricultural activities, although still not 60–80 percent overall. However, Doss (2009:20) also notes that if we look at the importance of agriculture to women, "Of those women in the least developed countries who report being economically active, 79 percent of them report agriculture as their primary economic activity. Overall, 48 percent of the economically active women in the world report that their primary activity is agriculture."

[4] According to the Big Numbers Project (FAO, WorldFish, and World Bank 2008), women account for 48 percent of fisheries-related employment in nine major fish-producing countries. Other available studies also point to a larger involvement of women in the fisheries and aquaculture sector than previously estimated (Weeratunge and Snyder 2009).

To understand why agricultural productivity is often lower for women, we need a broader understanding of the obstacles women face. For example, Udry (1996) found productivity on female-managed plots in Burkina Faso was 30 percent lower than on male-managed plots within the same household because labor and fertilizer were more intensively applied on men's plots.

Despite the important role women play in agricultural production, they remain disadvantaged in numerous respects. On one hand, women have limited access to a wide range of physical assets including agricultural inputs, technological resources, land, and so forth. In addition, women often lack the capacity needed to deploy these assets. For example, women may have access to land but lack access to the fertilizer needed to farm the land productively or lack the knowledge of how to properly apply fertilizer. Furthermore, many non tangible assets, such as social capital, human capital, rights, and decisionmaking power, are more difficult for women to access. Examples of asset disparities include the following.

Land: Studies from South Asia and Africa demonstrate that women are disadvantaged in both statutory and customary land tenure systems (Agarwal 1994; Lastarria-Cornhiel 1997; Kevane 2004; Peterman, Quisumbing, Behrman and Nkonya 2009). Even when legislation aimed at strengthening women's property rights is enacted, women often lack the legal know-how or enforcement mechanisms to ensure these rights are maintained.

Human capital: In addition to well-documented gender disparities in education in many countries, studies from throughout Africa and South Asia find that women routinely have less access to agricultural extension than their male counterparts (Gilbert, Sakala, and Benson 2002; World Bank and Government of Malawi 2007; World Bank and IFPRI 2010). Women are also disadvantaged with respect to labor because they have less access to labor-saving technology and to hired labor needed for lucrative, labor-intensive cultivation.

Box 1.Feedback from G-FAR Consultations – 1

According to the Africa Regional Review, "Successful extension must involve women, youth and the most vulnerable people in the rural communities."(Mokwunye 2009, 20).

Technological resources: Women are disadvantaged with respect to access to important technological resources, such as fertilizer, improved seed, clean water, insecticide, and mechanical power. In a recent review of differential gender access to non land inputs throughout the developing world, Peterman, Behrman and Quisumbing (2009) reviewed 24 empirical studies and found that when input indicators are provided, 79 percent find that men have higher mean access and 21 percent find that women have higher mean access to the given technology.

Box 2. Feedback from G-FAR Consultations -2

According to the E-Consultation Report from the Asia-Pacific Region, "Technological breakthroughs that may be generated through advanced research can interface the resource poor and women through simple facilitating processes. And this needs to be in-country."(APAARI Stakeholders 2009, 4)

These gender asset gaps are a hindrance to agricultural productivity and poverty reduction. A wide-ranging body of empirical work suggests that increasing resources controlled by women could promote increased agricultural productivity (Saito, Mekonnen, and Spurling 1994; Udry et. al. 1995; Quisumbing 1996). Alderman, Haddad, and Udry (1996) estimate that reducing inequalities in human capital, physical capital, and current inputs between male and women farmers in sub-Saharan Africa could potentially increase agricultural productivity by 10–20 percent Thus, agricultural research and development can play an important role in reducing gender inequality in these key areas when it works to enhance women's assets or improve the productivity of the resources that women do control.

Increasing women's education and other resources is a key way to reduce their constraints and increase agricultural production, which can improve food security at the household and higher levels. Orienting agricultural research to reduce those constraints can make a lasting contribution to this. For

example, where women are labor constrained, affordable mechanization can unleash their productivity. Research to develop effective ways of delivering fertilizer directly to the crop root zone has helped increase women's fertilizer use because it reduced the cost and the difficulty for women to transport large fertilizer bags needed to spread over a whole field (Gladwin 2002).

Gender-inclusive research needs to go beyond quantity of production as its only objective and to include taste, food quality, nutrition, processing, resilience, and other characteristics that are particularly important to women. This can increase the effectiveness of agricultural research by producing crops that reflect the needs not only of farmers but also of processors and others along the value chain (World Bank 2009). For example, in rural India, Paris, Singh, and Luis (2001) note gender-based differences in preferences for rice varieties whereby women give more importance to traits important particularly to females (such as weed-competitiveness, ease of husking and threshing, suitability for food preparation). A study in Rwanda undertaken by CIAT (Centro Internacional de Agricultura Tropical) demonstrates the importance of recognizing the expertise of female farmers and involving women in participatory plant-breeding processes. When 90 Rwandan female farmers evaluated genetic material over a period of four growing seasons, the bean varieties selected by the female farmers increased production up to 38 percent more than breeder-selected varieties and outperformed local mixtures 64–89 percent of the time (Sperling and Berkowitz 1994). Importantly, this study demonstrated the importance of female agricultural knowledge both to researchers and to female farmers themselves. A similar result was found in Kenya where women with less education than men were able to excel at the uptake of soil fertility replenishment technologies that were explained in simple, straightforward terms (Place et. al. 2007). Fish ponds where at least 50 percent of tasks were controlled by women demonstrated higher yields than other ponds in Cambodia (Nadeesha 1994).

Increasing Agricultural Sustainability

Gender-responsive agricultural research can also result in greater sustainability—of the environment and of agricultural development projects. Women and other marginalized groups often hold local knowledge of low-impact, low-cost methods and coping strategies that can prove to be vital in building capacity for resilient farming systems in response to climate change. Tapping into this knowledge and combining it with new research can make significant contributions to environmental sustainability. In Kenya, where cash constraints of many women farmers prevented them from taking measures to improve fertility on poor soils, research on biomass transfers and extension systems that recognized women's low literacy levels led to adoption by women as well as men, and provided not only for higher yields but also increases in organic soil matter (Place et. al. 2007). Recognizing women's roles in seed selection and tending of wild or semidomesticated crops can lead to greater conservation of agrobiodiversity—and retention of the knowledge of how different plants and varieties can be cultivated and used.

Groups of resource users play a critical role in management of water, watersheds, forests, and other commonly pooled resources. Meinzen-Dick and Zwarteveen (1998) found that the involvement of women in water organizations in South Asia can strengthen the effectiveness of irrigation management. Westermann, Ashby, and Pretty (2005), in their study of the natural resource management outcomes of 33 rural programs in 20 countries in Latin America, Africa and Asia, found that collaboration, solidarity, and conflict resolution increase among all program group members when women are members of groups. Similarly, in a study of 104 peasant cooperative institutions in Paraguay, Molinas (1998) found that levels of cooperation increase with increases in women's participation. Conversely, Agarwal (2001) notes that women's exclusion from community forest groups has efficiency implications and may exacerbate gender asymmetries in power relations (see also Pandolfelli, Meinzen-Dick, and Dohrn 2008).

Food Security and Nutrition

Gender differences matter not only for food production but also for how food is used. From a broader perspective of food systems, women are income earners and guardians of household food security.

Women play a crucial role in the distribution of food and nonfood household resources that determine the food security of the household. Increases in the resources that women control have been shown to improve child health and nutrition and increase allocations toward education (Quisumbing 2003).

Women's own nutritional status can itself be viewed as a valuable input to child nutrition and health. A World Health Organization review of nationally representative surveys from 1993 to 2005 found that 42 percent of pregnant women worldwide have anemia, a major hindrance to physical productivity (Kraemer and Zimmermann 2007). In a food policy report on women and food security, Quisumbing and colleagues (1995) link factors related to maternal health—including pregnancy weight gain, diet throughout lactation, and breastfeeding—with birth weight of infants (birth weight continues to be of utmost importance with respect to neonatal and infant mortality and early childhood development). A mother's nutritional status has other important impacts on the household, over and above that related to agricultural productivity.

Poverty Reduction and Empowerment

Empowerment of women is often cited as an essential ingredient for poverty reduction, notably in the third Millennium Development Goal (MDG3), which calls for gender equality and empowerment of women (United Nations 2000). However, as Naila Kabeer (2000) points out, empowerment is a fuzzy term often used in different senses by different actors. Kabeer seeks to clarify the term through a conceptualization of empowerment as "the expansion in people's ability to make strategic life choices in a context previously denied to them" (2000, 29). Such a definition is useful when thinking about the links between empowerment of women and poverty reduction. It becomes important to distinguish between disempowerment common to all poor or marginalized people and disempowerment unique to poor women. For example, poor women might not lack access to schooling, health care, and nutrition solely because they are poor; they are often given limited access to these valuable resources because they are female in societies that prefer to spend available resources primarily on males. Studies from the World Bank (2001) and King, Klasen, and Porter (2007) document the significant societal costs of gender inequalities in women's schooling, health, and nutritional status. According to the estimates of Abu-Ghaida and Klasen (2004), countries that are off track of meeting MDG3 (gender parity in primary and secondary education) will likely lose an average of 0.4 percentage points in annual economic growth between 2005 and 2015.

A number of studies demonstrate the benefits of investing in women's human capital. In a cross-country study of developing countries, Smith and Haddad (2000) attribute more than 50 percent of the reduction in child malnutrition rates between 1970 and 1995 to improvements in women's education (43 percent) and women's life expectancy relative to men's (12 percent). This is higher than increases in national food availability (26 percent) and the health environment (19 percent). Quisumbing and Maluccio (2003) found that the greater a woman's asset holdings at marriage, the larger the share of the household income is spent on children's education. In Bangladesh, when women own a higher set of household assets, their daughters have better health outcomes (Hallman 2000). In addition, global hunger is significantly correlated with gender inequality: Countries that had high gender inequality similarly had high levels of global hunger (von Grebmer et. al. 2009). Among the four components of the gender gap index (Hausmann, Tyson, and Zahidi 2008) used as an indicator of gender inequality, the correlation was strongest with the education inequality sub index, followed by the health and survival sub index. This indicates that gender differences in education and health, not just low levels of women's education per se, contribute to global hunger.

While much of the attention has been given to the role of education in empowering women, agricultural programs can also play an important role. In Bangladesh, fish pond programs that were "gender blind" ended up reaching wealthier men, whereas fish pond and vegetable garden programs that targeted poor women ended up empowering these women (Hallman, Lewis, and Begum 2007). In the long term, these programs that were targeted to women also improved nutritional status of women and children as well as gender asset equality more than untargeted programs (Kumar and Quisumbing 2009).

In Uttar Pradesh, India, Paris and colleagues (2008) demonstrate the advantages of empowering women by giving them increased decisionmaking authority in participatory varietal selection of rice. This strategy improved development of varieties best suited to the environment and increased female confidence in their decisions and opinions. This corresponds with Bartlett's (2005) argument that in an agricultural context, empowerment entails farmers' making their own decisions rather than merely adopting the recommendations of others.

Social capital and collective action also play an important role in the empowerment of rural women. Bantilan and Padmaja (2008) explore adoption pathways using case studies of groundnut production technology from the International Crops Research Institute for the Semi-Arid Tropics in Maharashtra, India. Findings of a mixed-methods study indicate that social capital formation via participation of men and women in mixed-gender groups facilitated adoption and diffusion of seed technology.

Box 3. Feedback from G-FAR Consultations – 3

In the Face-to-Face Workshop in West Africa and North Africa the consensus was "Women have many roles in agriculture: farm production, marketing, food preparation, etc. Evidence shows that empowering women will result in [lower] child mortality, school enrollment and declines in child malnutrition. Women also have a better track record in collaboration and sustaining social capital. Based on evidence from micro-finance schemes, investments used by women have shown higher returns as those used by men" (Smets 2009, 13).

Potential of Agricultural Research and Development

As noted above, a number of empirical studies document the multifaceted potential of agricultural research to improve women's role in agriculture systems and to increase agricultural productivity. For future agricultural research to produce meaningful changes, the differential needs, preferences, and constraints of female farmers must be recognized. Because women often have access to fewer resources, they are better suited to adopt high-value crops that do not require large initial investments. For example, in Zimbabwe, women were more likely to adopt open-pollinated varieties (OPVs) of maize that did not require fertilizer and permitted for marketing through women's informal networks, whereas men, who had access to formal marketing institutions and assets, were more likely to adopt high-yielding varieties (Bourdillon et. al. 2007).

In a review of recent agricultural research and interventions geared toward women, Quisumbing and Pandolfelli (2010) identify a number of promising approaches to increase poor female farmers' access to and control over productive resources in sub-Saharan Africa and South Asia. These include the following:

1. Strengthening women's land and water rights and investing in girls' schooling
2. Promoting divisible technologies or smaller input packages that are more affordable as well as opportunities for groups to achieve economies of scale
3. Adapting program design or service delivery to client needs
4. Considering interaction among inputs rather than treating each input in isolation
5. Taking gender roles into account when designing and implementing projects

Such approaches should be taken as a starting point for researchers and practitioners alike as the perspectives and positions of women become integrated in research and development agendas. We examine a general framework for this in the following section.

Box 4. Feedback from G-FAR Consultations – 4

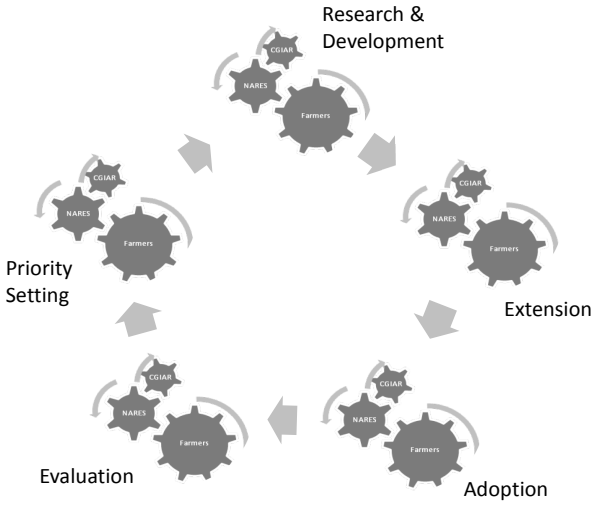
G-FAR regional consultations from Africa, Latin America and the Caribbean, and central Asia all cite increasing the voices and presence of women in agricultural research and development as a key priority. According to the Africa Regional Review, because research is not woman-oriented, "the 'poorest of the poor' [African women, the youth, the disabled, and others] are unlikely to be reached by the products of the current slate of research themes" (Mokwunye 2009, 25).

3. WHEN TO PAY ATTENTION TO GENDER: THE AGRICULTURAL RESEARCH AND DEVELOPMENT CYCLE

A more gender-responsive agricultural research and development (R&D) system calls for a comprehensive look at the system: who are the actors, who are the users of the technology, and whose needs are addressed at each stage, from priority setting, through implementation, to evaluation and impact assessment. In this section we provide a framework for considering these issues, which will be followed in subsequent sections of this paper.

Many conventional analyses of agricultural research and development have used a pipeline analogy with upstream (basic) research feeding in to downstream (adaptive) research to develop technologies, which are then passed on to extension systems to be disseminated and adopted by farmers, possibly followed by impact assessments to assess the payoffs to the research. The implicit image associated with this process is an improved staple crop variety being adopted by a male farmer. Although in recent years some attention has been given to involving women in adaptive research and to examining gender differences in impacts of technologies, relatively little attention has been given to gender in the upstream priority setting and decisionmaking. In order to fully meet the needs of women and men as agricultural producers and consumers, it is imperative to go beyond mechanistic approaches and recognize that innovation systems are composed of multiple actors and linkages; these actors and linkages need to be considered at each stage of the R&D process. Instead of a unidirectional flow between basic research, adaptive research, and end users, a more farmer-, consumer-, and gender-responsive agricultural research system would allow feedback from end users of the technology, both farmers and consumers, thereby creating an effective feedback loop (Figure 1).

Figure 1. Components of a gender-responsive agricultural research system



Source: Created by authors
Note: CGIAR, Consultative Group on International Agricultural Research; NARES, National Agricultural and Research Extension Systems

The following are key elements of this process and examples of critical questions that are needed to evaluate the extent to which gender issues are being integrated.

Priority setting: The first question to ask is who makes the decisions regarding the kinds of agricultural R&D that will receive investment. This leads to consideration of the representation of women

in management of the Consultative Group on International Agricultural Research (CGIAR) or national agricultural research centers. The second key question in this area is whether there are mechanisms to take the needs of women and men as producers and consumers into account (see Section 4).

This relates even to the way agricultural research is defined. Conventional definitions have been gender biased, focusing on the production of field crops, which are more likely to be male activities, and relatively neglecting homestead gardens, postharvest processing, supply chains, and consumption and nutrition outcomes, which are often of greater salience to women. Indeed, instead of focusing on agriculture, thinking in terms of food is likely to lead to a more gender-balanced picture. Although crop research is important, and women are also involved in producing nonfood crops, the food sector—which is more relevant to this paper—is broader, also including fish, livestock, garden production, water, trees, soil, and natural resources. In fish and livestock farming, research is centered on high-value, genetically improved varieties that bring high economic returns to male farmers. Varieties valued by women for their nutritional content, taste, or other uses might not receive the same attention. Postharvest processing needs to be considered, not only for reaching high-value markets but also for food safety and reduction of drudgery, which tends to be borne most often by women in the household. As farmers begin producing surpluses to be sold in the market, the distinction between food and cash crops breaks down; therefore, it is important to pay attention to the differential roles of women throughout the value chain, but particularly for nonmarketed crops, which are more often the domain of women subsistence producers.

Research and development: As with priority setting, it is important to consider who is conducting the research and how attuned researchers are to gender issues. A key aspect of this is the gendered staffing patterns of CGIAR and national agricultural research systems. However, it is important to look beyond these public-sector institutions as a source of innovation and to also consider private-sector R&D, as well as the research conducted by farmers themselves, and the extent to which each of these address the needs of women (see Section 5).

Extension: In examining gendered patterns of extension, it is important to consider who delivers extension services (because female extension agents are more likely to reach female farmers, especially in highly sex-segregated societies), who receives the extension services and information (only males or heads of households, or whether women are recognized as farmers and clients of the extension services), and how extension services are delivered (including individual- or group-based approaches, conventional extension, or farmer field schools [FFSs]). As with R&D, it is important to consider not only formal public extension services, but also private-sector and farmer-to-farmer dissemination, and how effective each of these is in recognizing and reaching women as producers and consumers (see Section 6).

Adoption of innovations: All of the foregoing are likely to shape who can and will adopt agricultural innovations and benefit from them. Additional factors also can constrain adoption, such as lack of necessary cash, labor, skills, and property rights, and each of these may differ for men and women. Even after adoption, if particular innovations do not meet the needs or deliver results for women or men, the innovations may be dropped. Section 7 considers evidence on how these are likely to differ by gender.

Evaluation and impact assessment: There are both external studies and participatory processes to assess the costs and benefits of agricultural innovations and how these are distributed, but relatively few have considered gender differences in the outcomes and impacts. Moreover, even the criteria used for evaluation and the impact measures may be implicitly gendered, for example, considering quantitative yields rather than quality of micronutrients or cooking qualities, or focusing only on marketed production and not on home consumption.

Ideally, information from the evaluations and impact assessments should feed into priority setting for future research. One limitation of the "pipeline" model is that this feedback loop remains incomplete. Thus, we suggest that in addition to addressing gender differences in each of the other stages, linking evaluations and impact assessment with the priority-setting process is also important.

All of the aforementioned processes can be seen at different scales, or levels, with different actors, such as the following:

- CGIAR and other international agricultural research institutions
- National agricultural research systems
- Private-sector agricultural R&D (including contract farming)
- Nongovernmental organizations (NGOs) and civil society organizations, including farmers' unions
- Farmers who do their own innovations (which may be disseminated by different approaches) and participate in research and extension

However, none of these entities exists on its own. Rather, we must consider how these different levels and actors are linked and how to promote connections between levels and actors so that, for example, farmer innovations can be picked up and disseminated through national extension systems, or evaluations of programs from NGOs feed into CGIAR priority setting. This would more effectively create a feedback loop from end users to agricultural R&D systems.

Moreover, we need to go beyond the confines of the conventionally defined agriculture sector to address linkages to other sectors, such as nutrition, health, population, and education. Addressing these cross-cutting issues will make it more likely that agriculture can provide a pathway out of poverty for present and future generations.

4. PRIORITY SETTING

A gender-blind priority setting process is not likely to yield a gender-balanced agricultural R&D portfolio. Therefore, the first question to ask is where and how are the differential needs, interests, and priorities of women and men reflected? This requires systematic gender analysis of needs in the field as well as of the balance of women's and men's voices in consultations at all levels of decisionmaking. For example, are women farmers' associations consulted at any point? Do female farmers have a voice in male-dominated farmer associations?

The FAO (Food and Agriculture Organization of the United Nations) Focus paper Women and Food Security sums up the consequences of decades of ignoring women researchers' and women policymakers' critical role: "While rural women are knowledgeable about and use a large amount of traditional technology, they have very little access to modern technology that could benefit them in their farm and household activities. This is due to women's lack of participation in setting research priorities or in generating and disseminating conventional technologies" (FAO 2010).

Priorities of Women and Men

A wide-ranging body of empirical and theoretical literature challenges the commonly held assumption that the household is a unified unit that works together to pool common resources toward a common end (Haddad, Hoddinott, and Alderman 1997; Quisumbing and Maluccio 2003). In place of this unitary model of the household, a collective model has gained prominence in which different household members have different preferences, incomes, resources, and needs, which often vary along gender lines. Recent empirical works highlight gender-based differences in roles, resources, and needs among household members. In agriculture, these differences are relevant to the priorities of men and women as both producers and consumers. Like all gender differences, these differences are contextual and will vary among and within regions, countries, and communities and will change over time. However, we can identify some key questions to ask regarding the roles, resources, preferences, and needs as producers and consumers.

In terms of roles, women often have greater responsibility for family food production and processing, whereas men have greater involvement in market-oriented production. Even where women are engaged in markets, their responsibility for cooking food and serving it to their family is an important factor affecting preferences for certain crops (for example, vegetable production for relishes) or varieties (for example, with certain cooking traits). Men and women also play different roles in natural resource management, local organizations, and links to outsiders, which need to be considered in developing resource management strategies or group- and market-based programs. Moreover, women's responsibilities for child care and domestic work often create labor constraints, affecting the resources at their disposal for farming. However, women are increasingly involved in agricultural production and the labor force as a result of male migration and occupational diversification, as well as with the growth of new agricultural value chains. In the dry forests of northern Mali, women have adopted new income-generating activities such as charcoal production in order to cope with their growing vulnerability to climate change (Brockhaus and Djoudi 2008).

Labor constraints and other differences in resources will affect men's and women's abilities to benefit from different types of agricultural technologies and innovations. Peterman, Quisumbing, Behrman and Nkonya (2009) found that lower productivity is persistent on female-owned plots and in female-headed households in Nigeria and Uganda when accounting for a range of socioeconomic variables, agricultural inputs, and crop choice. Men and women also hold different types of assets, which play different roles within the household. Dillon and Quiñones (2009) found that women's assets grow more slowly than those of men over a long time period in northern Nigeria. Men's assets, primarily livestock, increased greatly in value over time; whereas women's assets, primarily durable goods and jewelry, increased at a much slower rate. In rural Bangladesh, husbands' and wives' asset stocks are

drawn down for different kinds of shocks, with husbands' assets being liquidated to finance dowry and wedding expenses, and wives' assets being negatively affected by illness shocks (Quisumbing 2009).

Gender differences also play a key role in needs of men and women as consumers. Adolescent girls and women have a higher biological need for micronutrients, but culturally they are often prescribed to eat last or to curtail their consumption to ensure that others in the household have enough to eat. This can have long-lasting effects: Not only is women's health affected, but effects are also transmitted to the next generation through low birth weight and malnutrition. For agricultural research to contribute to long-term poverty reduction of both the current and future generations, these differential needs of women need to be considered in the selection of varieties (such as through biofortification), crops (for example, nutrient-rich vegetables), and processing (to preserve nutrients).

Considerable research on trait preferences by gender has been conducted, particularly from participatory research programs that have involved farmers in varietal selection. Although this downstream research is important, it begs the larger question of which crops, why agricultural systems, and which domains of action are addressed through agricultural research systems. In the following we examine each of these.

Trait Preferences

The differential needs of male and female farmers are reflected in their different preferences for maturation periods, yields, tastes, and colors. Horna, Smale, and Von Oppen (2007) document this phenomenon in Benin where the gender of farmers involved in rice production is a statistically significant determinant of how farmers rank rice varieties. Though gender-based differences in preferences are documented in many countries, differences in preference vary with culture and context. In Nepal, Krishna et. al. (2002) report that local women farmers prefer to grow lower-iron, white-grained rice varieties than red varieties with a higher iron content. The underlying reason is related to cultural norms (white rice is more socially prestigious) and pragmatism (white rice requires less labor of women than red rice, which requires spending time revolving red bran with a rice pounder). Sperling, Loevinsohn, and Ntabomvura (1993) discuss the wide range of preferences expressed by female Rwandan bean farmers when they were invited to a research station to assess potential cultivars. Given the heterogeneous, often stressful, growing climate these women face, yield is only one of several factors they consider. Smale (1995) describe that Malawian women responsible for processing maize in a time-consuming, multistage process preferred maize with a flinty grain texture (as opposed to dent grain texture) because it was easier to process and stored well—highlighting the importance of considering postharvest processing as well as yields.

Several studies indicate that gender-based preferences may ultimately impact adoption rates. For example, Bourdillon et. al.'s (2007) study of high-yielding maize adoption in Zimbabwe found that in an area where maize was sold as a cash crop, men did not consider taste as a factor in adoption, although women, who were charged with cooking, did consider taste as a factor of adoption. However, in another area in Zimbabwe where maize was not considered a cash crop, both men and women considered taste as a factor in adoption. Women preferred open-pollinated varieties (OPVs) that can be replanted over hybrid seed, which had to be purchased each year, because they had less control over cash and less reliable access to seed markets compared with men. An agricultural R&D system that provides only hybrids (and indeed removes OPVs from the research and dissemination process) without addressing women's credit and market access constraints does not meet their needs. Although some progress has been made in understanding and responding to gendered trait preference in relation to crops, this is virtually absent in livestock and aquaculture research. This highlights the need for gender assessments in all agricultural sectors, as well as channels for women's voices in priority setting.

Crop, Livestock, and Aquaculture Priorities

Beyond choosing the particular traits of a given crop variety or animal species, addressing gender issues in priority settings also requires examining the varieties and species that are selected for research and improvement. The particular importance that men and women farmers place on different varieties and species is culturally specific, depending on the relative roles and resources of each. Gender differences in aquaculture adoption in Central African Republic revealed that costs of feed, fingerlings, and tight feeding schedules constrained women low on cash, labor, and information from investing in catfish farming; they found the low-input, low-cost tilapia more appropriate to their needs (Van der Mheen-Sluijer and Sen 1994). We often find that women are more heavily involved in vegetable cultivation around the homesteads, although these production systems ("kitchen gardens") are rarely documented in official production statistics or receive the same attention as field crops. For example, researchers from the World Vegetable Center looked at vegetable farming in post tsunami Indonesia and found that women make 70 percent of decisions regarding acreage allocation and have a major stake in harvesting decisions, whereas men are occupied with urban labor tasks (Bhattarai et. al. 2009). A study of gender divisions in Nepal found that women in the sample contributed almost 90 percent of labor in vegetable farming of cauliflower, tomatoes, cabbage, cucumbers, bitter gourds, bottle gourds, and French beans and—with the exception of seed-bed preparation and sowing—also play leading roles in vegetable production and marketing (Upadhyay 2005). The important contributions of vegetables to micronutrients would further argue for investments in R&D for vegetable improvements. In a 2009 survey of scientists to elicit key opportunities for agricultural research, numerous respondents identified important opportunities to work on improving local indigenous greens and vegetable varieties as a means of improving women's production systems, micronutrients, diet diversity, and biodiversity. Unfortunately, formal-sector agriculture often crowds out such production.[5] Although it has sometimes been argued that public-sector investment in vegetables is not as important because of large private-sector investments in fruits and vegetables, the private sector is unlikely to become involved in development of diverse local varieties of fruits and vegetables. Thus, there is an important role for NGOs and national and international agricultural R&D systems to study the value of such plants and to promote and valorize the production and consumption, especially of the highly nutritious or medicinal plants, whether through markets or direct consumption.

Conversely, women are less likely to grow many tree crops because they lack the tenure security that provides incentive and authorization for such perennial investments (Place 1994). In communal areas of Zimbabwe, Fortmann et. al. (1997) found that the potential for loss of land and trees following widowhood or divorce was an important source of insecurity for women that limited tree planting on household land; women and men were equally likely to plant trees on community woodlots because rights over those trees derived from community membership and investment, not marital status, and hence there were fewer gender differences in tenure security. By recognizing this, the World Agroforestry Center developed soil fertility replenishment systems using biomass transfer from hedgerows and other land that women are allowed to use (Place et. al. 2007). Thus, attention to the institutional environment may be necessary to ensure that women can benefit from certain types of agricultural research.

Livestock play a critical role in farming systems, nutrition, and incomes and as a ladder for asset accumulation (Tipilda and Kristjanson 2008). As with crops, gender differences in roles and control of livestock are crucial in shaping who benefits from different types of agricultural R&D. Broadly speaking, the perception is that women are more likely to own small stock than cattle; however, the type of species owned by women may be dynamic. In Asia, a project involving the Grameen Bank contributed to livestock development among women by providing microcredit loans for women. Experience from the project showed a clear investment trajectory, from poultry to small goats and eventually to milk cows. Bullocks were particularly of interest among landless women, who rented them to farmers (Todd 1998). In pastoral and agropastoral areas in the Horn of Africa and the Sahel, women often own cattle and

[5] For example, expansion of modern rice varieties led to reduction in consumption of semiwild leafy greens that often grew on the margins of paddy fields (Hossain et al. 2007).

camels as well as small ruminants (Worley 1991). In East Africa, a study found no significant differences in male- and female-headed households that own small livestock including sheep and goats, although there were more male-headed households that own local poultry than female-headed households (EADD 2008). However, within households, 82 percent, 83 percent, and 80 percent of exotic cattle were owned by men in Kenya, Rwanda, and Uganda, respectively, while 77 percent, 79 percent, and 72 percent of the local cattle were owned by men (EADD 2008). For other livestock species, in Kenya, 75 percent of goats were owned by men. Whether the goats were local breeds or the improved breeds also determined ownership. No improved goats were owned by women, but 21 percent of the local goats were owned by women. There was more ownership of poultry by women compared with men in the country, with 61–85 percent of the poultry in the households being owned by women (EADD 2008). Thus, R&D on poultry and small stock can provide important rungs on the ladder out of poverty, but efforts are also needed to ensure that women have access to improved breeds and larger animals as well.

Men and women may also have different reasons for keeping animals and therefore different preferences for the number and type of livestock they want to keep. Thomas-Slayter and Bhatt (1994) noted that in a Nepalese village, men regarded the acquisition of buffalo as an investment, whereas women were more troubled about management issues such as the increased workload. Heffernan, Nielsen and Misturelli (2001) also found sharp differences between the genders in the perception and role of livestock in Kenya, where women viewed livestock primarily as a means to ensure food security for the family, while men perceived livestock as a longer-term investment.

The responsibility patterns for livestock, however, follow a different pattern, and this has implications for interventions and technologies in livestock production and management. In India, women play a significant role in providing family labor input for livestock keeping. In poorer families especially, their contribution often exceeds that of men (Tipilda and Kristjanson 2008). However, women traditionally have a weak decisionmaking position in the use of income from livestock. In addition, the service and input delivery system is male dominated, which makes most of these services difficult for women to access.

Natural Resource Management

Men and women both play crucial, but different, roles in natural resource management. For too long the agricultural sector has tended to focus on the activities in which men were more heavily involved. To some extent this may have been due to men playing a more prominent role in meetings and as external liaisons in many areas. But it also relates to the lens through which resource management was viewed. For example, focusing only on irrigation in Asia revealed little female involvement in water management. However, when attention was turned to multiple uses of water, a more complex pattern of gendered water uses emerged, with different roles for men and women in domestic water use, livestock watering, aquaculture, fishing, and other livelihood activities; even within crop production, water management strategies differed between rice fields, upland crops, and homestead gardens (Bakker et. al. 1999). This then raises new questions about management priorities and incentives. Similar issues arise in forestry: Focusing on timber generally leads one to see only men involved; but when we look at the whole range of forest resource use, including firewood and a range of nontimber forest products, a more complex gender pattern emerges. Moreover, studies of community forestry in Nepal and India (Agarwal 2001; Agrawal et. al. 2006; Sarin 1995; Acharya and Gentle 2006) have shown that involving both women and men in decisionmaking can help improve rule enforcement (see also Pandolfelli, Meinzen-Dick, and Dohrn 2008).

Where access to a natural resource is predicated on formal access to land, studies tend to focus only on men, who typically have stronger land tenure rights than women. Early generations of watershed programs in India did not adequately address the differential dependence of men and women on watershed resources. As a result, programs to regenerate vegetation often excluded firewood collection or grazing, upon which poor women depended, with the greatest benefits going to (male) farmers with land downstream (Arya 2007). Similarly, fish pond development programs that focused on fish pond owners in

Bangladesh resulted in men from wealthier households benefitting from polyculture fish pond technology, whereas another program was able to reach landless women with the same technology by organizing them into groups and leasing ponds jointly for the group (Hallman, Lewis, and Begum 2007). These examples illustrate the importance of looking closely at the roles and resources of men and women so that natural resource management research and programs can benefit both.

Other Domains of Action

The definitions of "agriculture" and "farmers" typically focus on activities conducted between the planting period and the harvest period, thus overlooking activities such as postharvest processing, where women are key actors. Women often provide the bridge between the productive and reproductive (domestic responsibilities such as child care and nutrition, post-harvest processing, food provisioning and preparation) domains; however, agriculture is often artificially defined as solely in the domain of the productive. A renewed focus on nutrition within the family and a recognition that women are net providers of family food even if they are not always directly agricultural producers points to another need to go beyond these linear definitions of agriculture and farming.

The discussion above hints at some of the ways that the agenda for agricultural research needs to be broadened in order to account for the reality of women's lives and to meet their needs. For example, looking at multiple uses of water for livelihoods, including domestic, animal watering, and so forth, instead of irrigation alone, gives a more accurate picture of gender roles and priorities (see van Koppen et. al. 2009). A shift from thinking about agriculture (especially field crops) to thinking about food (including the processing and cooking) is very important in this regard, as well as getting beyond the divide between food crops and cash crops.

Much more attention needs to be given to postharvest processing to reduce women's labor burdens and to reduce losses of food and nutritional quality. Improvements here are likely to accrue directly to women, because postharvest processing and cooking usually falls to them, and they are most affected by loss of nutritional value. Considering how many billions of hours are spent in husking, milling, and grinding grains at home, relatively little R&D has been devoted to improving the efficiency of these activities. Because the vast majority of this time is unpaid family labor, it is often referred to as "drudgery" but assumed to have a relatively low opportunity cost. However, research on child health finds that child malnutrition (and hence the intergenerational transmission of poverty) is reduced when women have more time for child care (Blau, Guilkey, and Popkin 1996; Popkin 1980). Freeing up women's labor for productive activities, child care, or even leisure plays an important role in increasing household incomes, health, and welfare.

Another benefit of improved postharvest processing is that more food and nutrients would become available with less environmental impact. For example, WorldFish Center (2005) estimates that more than one-fourth of the fish caught in Africa is lost to spoilage and to poor processing and shipping conditions. Improved processing and marketing technologies can slash postharvest losses by more than half, improving fish supplies and their economic and nutritional value, and therefore making more food available with less environmental impact. Because fish processing and marketing is dominated by women, improvements in marketing and market chains will boost the incomes of women's enterprises.

There is increasing attention to agriculture–energy links, especially with the expansion of climate change awareness and biofuels. But this focus on marketed (liquid) biofuels neglects another major type of rural energy need and production: needs for domestic use, especially cooking. These are currently met by firewood (most of which is collected by women and children) and charcoal for many poor people, with women and children being the most exposed to the emissions from burning these sources and to the consequent health problems. Research on rural (domestic) energy diversification, for example, through solar power, biogas, or more efficient stoves, can therefore help millions of poor people save costs, labor, and exposure to pollutants as well as reduce carbon emissions.

Going beyond the commonly held definitions of agriculture leads to greater recognition of the role of agriculture not just in producing more grain but also in nutrition, health, environment, and

livelihoods. One concern will be "mission creep," or becoming over-extended and thus achieving less impact. But rather than avoiding this by staying in narrowly defined boxes, the agricultural R&D system can and should embrace links to other sectors if it is to remain relevant to the needs of the poor. Thus, for example, improving women's literacy as well as knowledge of health issues through formal and informal education can be an important complement to agricultural R&D, increasing women's ability to use new technologies or marketing opportunities.

Value Chains and Food Systems

As agricultural research is expanding from food production to income generation, it is important to recognize the specific roles of women and men in value chains. As with other aspects of gender, these roles will differ between commodities and locations, and over time. In areas of limited female mobility, value chains and cash-oriented production is often dominated by men. In such cases, mobile traders or collection points that buy produce near the homes may provide a means for women producers to increase their involvement in markets. Examples include the dairy cooperatives in India or vegetable collectors in Bangladesh (see Hallman, Lewis, and Begum 2007). In other cases, women may dominate the trading, as with fish marketing or "market mamas" in West Africa. And in relatively egalitarian societies such as the Andes, both men and women are involved in buying and selling in the markets.

Why does this matter? Gender-based constraints affect the structure and relationships of value chains. For example, women often participate in different points of the livestock value chains, often being found more in the informal than the formal systems. Among the Fulani societies in Ferlo, Senegal, milk production is entirely controlled by women, who also control the sale of surplus milk. Fresh milk is very difficult to conserve under the climatic conditions, so it is either sold directly to consumers near the place of production or bartered for cereals (Dieye, Ly and Sane 2005). A study in Guatemala found that marketing of livestock more or less follows the same pattern as livestock ownership: Women might market poultry and smaller animals if such marketing can be done locally. Men market the larger animals, typically at more distant markets (Tipilda and Kristjanson 2009). The study also discovered that when poultry or livestock are marketed further away, the women often lost control over some or all of the income generated. Livestock groups in northern Kenya have demonstrated how spontaneous groups (convened and managed by women) have been successful in accessing markets (Coppock et. al. 2006).

Numerous studies of commercialization have shown that increases in cash income do not necessarily translate into gains for all the household members and can even lead to loss of welfare and nutritional status for some. For example, in Kenya, before the commercialization of milk production and the introduction of high-yielding, high-breed cattle, milk production from local cattle was under the domain and authority of women, and the morning milk (for sale) was divided from the evening milk (for consumption). When production became commercialized, which often accompanied smallholders' entry into tea-growing outgrower schemes, and men took over the cash "crop" domain, all milk became for sale only. This change had a detrimental impact on households' nutritional state—especially for the children—despite increased income. On the other hand, tea production had a different outcome: In those households where women's labor was indispensable for tea production, women's bargaining power in terms of payment for the tea was greater than in households relying on hired labor (Sørensen and von Bülow 1993).

Recent studies on the commercialization of dairy and formalization of milk markets show that women were more likely to receive money from sale of milk if it was sold in the informal markets such as to bicycle traders, in local markets, or to other households than if it was sold through cooperatives. In Kenya, Uganda, and Rwanda, out of all households selling milk to private traders, the money was received by males in 60.7 percent of households, by females in 34.5 percent of households and by either males or females in 3.6 percent of households. With the start of a cooperative-owned chilling plant, the number of households in which women received the money went down to 16.7 percent (EADD 2008). However, the Indian dairy cooperatives have done more to ensure that women receive money, particularly

with local point of sale, and by 1998, 6000 of 7000 dairy cooperatives were women's societies (Tipilda and Kristjanson 2008).

Work on nontimber forest products (NTFPs) in Asia, Africa, and Latin America found that trade in NTFPs created income-generating opportunities at all stages of the production chain from hired laborers for harvesting to independent traders (Kusters and Belcher 2004; Sunderland and Ndoye 2004; Alexiades and Shanley 2004). While this gave women control over part of the household expenditures, NTFP commercialization often resulted in men taking over businesses from women (Kusters and Belcher 2004). Gender was a key factor differentiating business size, product specialization, and market strategies among traders, especially in Africa (Perez et. al. 2002).

Studies on the adoption of nontraditional export vegetables in the highlands of Guatemala found that substantial increases in household incomes had favorable distributional effects, but no detrimental effects on either subsistence production or nutrition (von Braun, Hotchkiss, and Immink 1989; Katz 1992). However, in some cases, men take over women's enterprises when the value of that produce increases. Participating in contract farming or warehouse programs may require using a bank account, which is often held in the man's name. In areas where women may have traditionally controlled income from sales of produce, such formalization of ownership leads to a transfer of control from women to men, changing household financial management practices. A more recent World Bank study of nontraditional agricultural exports found significant income opportunities for women, both as producers and laborers in sectors such as horticulture, floriculture, vanilla, and poultry. In some cases this employment was empowering for women, but it did not always translate into improved welfare and social well-being due to occupational segregation and environmental health issues such as pesticide exposure, which is especially serious for women of reproductive ages (Dolan and Sorby 2003). This indicates the need for greater attention to education about practices as well as enforcement of labor and environmental standards.

Informal food processing and vending is especially an important source of income for women. In South Africa, it is probably the single largest income source in the informal sector (von Holy and Makhoane 2006). In Harare, Zimbabwe, around 9,000 people (81 percent women) are involved in street food vending (Graffham Zulu and Chibanda 2005), including in livestock products. While this is an important avenue for women, it also puts them at risk of zoonotic diseases (Grace 2005). But as formal standards grow, there is a real risk that the poor (and women) will be excluded from markets (Perry et. al. 2005). A focus of research on the formal systems within value chains would also skew research support against women.

The difference in outcomes from these different contexts illustrates the importance of looking closely at gender relations and structural factors when pursuing value chain development. Key questions to ask relate to the degree of gender inequality and separate "purses," or control of income, within households: In those with more pooling, it will matter less who markets the product and receives the cash. Other measures regarding the way payments are made can help to ensure that women do not lose control over products and incomes when they are marketed. Measures such as making payments into a woman's account or increasing transparency on prices paid at market each day can increase trust or ensure that women share in the gains from increased market development.

Agricultural Institutions and Policy Research

Both the CGIAR and national agricultural research systems engage in various forms of institutional and policy research to identify an "enabling environment" for agricultural productivity increases and environmental sustainability. This includes investment policy, property rights, infrastructure, and support services. As noted by the Gender and Governance study: "The perception bias that 'women are not farmers' makes it even more challenging to provide agricultural services to women" (IFPRI 2009, xxv). Agricultural research can help to dispel this perception if it recognizes women's many roles in agriculture.

It is also important to look at governance structures and how they affect access to and control over productive resources, revenues, and also participation in technology development. Each of these

aspects is also gendered. It is therefore important to examine how men and women will engage with each type of institution (such as property rights); how policies will differentially affect men and women; and the governance structures that do (or do not) create accountability of public, private, and community institutions to poor women and men. Thus, for example, policy research on innovative ways to increase land registration in the name of women can increase the uptake and gender-equitable impact of agricultural innovations. Research on governance of community-driven development programs can examine the extent to which women's interests are represented in service delivery, public works employment, and infrastructure creation (IFPRI 2009).

Although institutional change is not easily "engineered," participatory action research offers a means of working with communities to increase tenure security or inclusiveness. Participatory action research in Indonesia resulted in increased participation of women in district budgeting processes in Jambi Province, which in turn led to increased allocations to education and schooling programs. Equally significant, women-led protests resulted in thwarting private companies' taking over of forests (that is, elite capture) for oil palm development, laying foundations for strengthening forest and land tenure security (Komarudin, Siagian and Colfer 2008).

Adaptive collaborative management using participatory action research in 11 countries in Africa, Asia, and Latin America improved the ability of women and other marginalized groups to participate in decisionmaking and to manage conflicts and increased the likelihood and frequency of their negotiation with policymakers (Colfer 2005a). In Nepal in particular, the proportion of women involved in forest management committees increased from 27 to 45 percent, as did their ability to detect and sanction community elites who previously had a free hand in the appropriation of community forest funds (Dangol 2005; Colfer 2005b).

One often-cited constraint to fully integrating gender in policy research is the lack of gender-disaggregated data. Because of the complexity of gender relations and their variability, there are many rich studies of gender relations at the local level, but relatively few that cover large areas, even within a country, let alone across countries. Many official statistics do not report men's and women's participation in programs, productivity for men and women farmers, or even gender-disaggregated data on land tenure. Even most surveys stop at the household level and do not look at the different roles of men and women in production or control over output and income. What often passes for gender analysis is only a comparison between (officially) male- and female-headed households, ignoring the condition of women in male-headed households.

Addressing this requires first improving data availability and then linking this data with analysis and models. There is some progress in this area, notably with new agricultural censuses in Africa that report farm enterprises at the individual, rather than the household, level (FAO 2005). Large-scale, nationally representative surveys such as the Demographic and Health Surveys provide individual-level data on many income and poverty-related variables and are adding more nuanced information about men's and women's assets and spheres of decisionmaking (Doss, Grown, and Deere 2008). But these data are not available on a widespread basis. Much more is needed to have information on such critical variables as crops and animals raised by male or female farmers, incidence of female headship, differences in poverty rates between male- and female-headed households, landownership by men and women, and differential rates of malnutrition between males and females. Moreover, this information needs to be linked to spatial data that is increasingly being used for priority setting in agriculture and natural resource management. Efforts are now underway to incorporate gender-disaggregated data into spatial analysis, but these efforts are in their infancy compared with efforts to map forest resources, watersheds, or agricultural production systems. The underlying data base for such gender-disaggregated spatial analyses simply does not exist for a large number of countries.

In the absence of spatial gender-disaggregated data, it is still possible to conduct important models that can be parameterized or calibrated based on existing gender indexes or gender-disaggregated "stylized facts." Some promising work examines the impacts of gender-focused public investment using IFPRI's IMPACT (International Model for Policy Analysis of Agricultural Commodities and Trade) model (Msangi and Ewing 2009). The IMPACT model incorporates the empirical equation estimated by

Smith and Haddad (2000) that estimates the functional relationship between child malnutrition (percentage and absolute number of malnourished preschool children, 0–5 years old, in developing countries) and four significant socioeconomic indicators: per capita kilocalorie availability; the ratio of female to male life expectancy at birth; total female enrollment in secondary education (any age group) as a percentage of the female age-group corresponding to national regulations for secondary education; and the percentage of the population with access to safe water. Msangi and Ewing (2009) explore two alternative public investment scenarios: increasing female secondary enrollment and providing access to clean water through improvements in water supply and sanitation. Investment in clean water has substantial benefits for women because of the importance of water in domestic use. The authors find that both public investments have high payoffs in terms of reducing global hunger and malnutrition. Increased investment in female secondary education results in a reduction in the number of food-insecure people, leading to a worldwide decline in hunger. When the additional costs of increasing female secondary education are considered, the model finds that a small percentage increase in spending produces a relatively large decrease in malnutrition. Under the scenario conditions, all incidences of malnutrition in children under 5 years of age can be eliminated by 2040 in China by increasing spending per student by 2.6 percent.

The model results also indicate that improving clean water access in the developing world reduces the incidence of waterborne illness and malnutrition. As a result of higher investment and increased coverage, the risk of waterborne illness drops by 30 percent in the worst affected regions of Africa, reducing the exposed population by nearly 21 million by 2050. Similarly, investments that improve access to clean water reduce malnutrition globally, with the greatest impacts taking place in Africa and in the worst-off regions of the Western Pacific. Specifically, by 2030, the number of malnourished children in the Western Pacific Region decreases by 452,000, while the number of malnourished children in the worst-off regions of Africa drops by 637,000. While the simulations suggest that investments in female secondary education bring greater reductions in malnutrition than investments in clean water access, both investments demonstrate widespread human welfare benefits for the world's poor.

These results from the IMPACT model suggests that if the data needed to parameterize the model were available, modeling exercises could be used to examine the gender-differentiated impacts of different types of agricultural investments and of different agricultural research options. This highlights the need to invest in statistical systems that collect gender-disaggregated data, as well as to support modeling work that examines gender-differentiated impacts.

The 2009 Global Hunger Index (GHI; von Grebmer et. al. 2009) is highly correlated with gender inequality—that is, countries that exhibit high levels of global hunger are also those with a high degree of gender inequality. So, to the extent that agricultural research priorities are set based on the GHI, implicitly, some aspects correlated with gender inequality would have been taken into account.

Priority-Setting Processes

Engendering agricultural research and development requires putting a "gender lens" on the entire priority-setting process. Gender analysis can do much to achieve this. However, space is needed for these issues to surface and be taken seriously. This requires examining whether the processes are dominated by conventional thinking or they include space for the needs and voices of women producers and consumers to be heard. In the remainder of this section we examine the experience of the recent Global Forum for Agricultural Research (GFAR) regional dialogues and CGIAR reform processes with regard to their attention to gender.

Regional Agendas

Throughout all of the regional strategy documents, participants called for fundamental changes in the conducting of agricultural research. Global priorities centered on—

- recognition of the important role women play in agriculture;
- increase in the number of female agricultural researchers;
- integration of the needs and preferences of female farmers into current research themes; and
- improvement in linkages between research, extension, and female farmers

A number of additional context-specific regional priority areas emerged. In Africa, where female farmers were referred to as the "poorest of the poor," the priority was on increasing the knowledge of female farmers through increased access to extension, capacity building, and trainings. In central Asia and the Caucasus, a key goal is to change extension systems to focus on smallholder famers (notably female farmers) in light of the disbanding of the collective farms of the Soviet period. In the Asia-Pacific region, regional participants emphasized a need to improve technology transfer to rural women and to develop female-friendly technologies. Several participants noted that village agriclinics have been particularly useful to facilitate technology transfer in this context. Participants also reported that institutional support and participatory policy has an important role to play in rural women's empowerment (for example, the system of quotas for women in local councils in India). In Eastern Europe, regional participants report that a key problem is the exodus from rural areas to urban ones and the resultant social exclusion, which often negatively impacts rural women who are left behind. Regional participants suggested that improvements in economic resources, social services, and public institutions are the best way to deal with this reality. In Latin America and the Caribbean, participants called for institutional innovations as a means to empower rural women.

CGIAR Priority Setting

The CGIAR has had a long but varied history with integrating gender analysis into its research portfolio. At the system level, from 1991 to 1997, the CGIAR had a gender program with two components: Gender Analysis and Gender Staffing. Each component was staffed part-time by an expert in that field, who worked with each CGIAR center to identify the key issues related to gender in staffing or in research. The Gender Staffing program became the Gender and Diversity program in 1999, and the Gender Analysis program was merged into the Participatory Research and Gender Analysis (PRGA) program for Technology Development and Institutional Innovation when it was initiated 1997. PRGA, convened by CIAT, supported gender-mainstreaming efforts in the National Agricultural Research System (NARS), NGOs, and three CGIAR centers: Centro Internacional de la Papa (CIP), International Livestock Research Institute (ILRI), and CIAT. ILRI and CIAT used gender audits as a mechanism, and ILRI used a Challenge Dialogue process with a wide range of stakeholders for identifying the gender dimensions of their research agenda. Outside of the PRGA program, other centers developed research programs addressing gender, either as a focal issue or a component of their work.

At the beginning of the recent CGIAR reforms, an independent review of the system reported the following:

> **Finding 4**: Gender is not adequately integrated into Centers' research mandates and outreach. Centers need to move from advocacy to accountability in their programming to remove unintentional discrimination and to provide incentives in all planning and management instruments. (CGIAR 2009,16)

The response of the 2008 CGIAR Annual General meeting was as follows:

> The recommendation on integrating gender into all programs, monitoring and the results framework was welcomed. The gender dimension will be incorporated into the new strategy and results framework. There was not full agreement on the recommendation to develop a mega-program on gender. A study by IFPRI on gender in the new CGIAR would be valuable input for further consideration of this issue. (CGIAR 2009, 19)

An electronic consultation held in the spring of 2009 included 85 CGIAR center staff and 22 other stakeholders, including NARS, NGOs, donors, and representatives of farmers' groups. After internal consultation in each center, the consultation recommended a systemwide gender-mainstreaming platform that facilitates the uptake of gender analysis throughout all CGIAR centers and new Mega-Programs, and fosters synergies across them as well. This recommendation was taken up by the Strategy and Results Framework team and has recently been endorsed by the CGIAR.

Because of experience of many organizations indicating that without explicit accountability gender often disappears in "mainstreaming" efforts, the consultation was further asked to recommend criteria for selection of Mega Programs and for gender equity in research design.

Results-oriented criteria for each Mega Program

We propose that any potential Mega Program needs to deliver on the following top four indicators to achieve its poverty and gender equality objectives:

- The extent to which women are involved in the crop or sector in terms of production, marketing, or processing has not decreased (or has increased) as a result of the program
- Reduction of gender disparities in access to productive resources and control of incomes as a result of the program
- Improvements in diets or nutritional status of individuals, particularly in areas with marked gender disparities in nutritional status / nutrient adequacy
- The extent to which women are involved in Mega Program delivery

Criteria for gender equity in research design

Since the CGIAR is composed of research centers, attention to gender concerns should be integrated throughout the research design and study protocol of all programs but especially new Mega Programs. Although it may take a while before Mega Programs are in place, setting the criteria early will help ensure that gender considerations are taken into account in the planning stage. … Items 1–4 are crucial; items 5–6 support the achievement of 1– 4:

1. Priority setting based on identification of men's and women's needs, priorities, preferences, and opportunities for technologies, policies, and institutions through consultation with relevant stakeholder groups; gender balance in consultation process
2. Representation of women beneficiaries in proportion to women's role in production and/or postproduction
3. Identification of factors responsible for gender disparities in adoption or impact of new technologies used in the design of the program
4. Gender-responsive monitoring and evaluation system in place
5. Involvement of men and women in the innovation process (participation in identification and testing of promising varieties, use of indigenous knowledge, participation in and access to extension systems) through farmers groups and partner organizations, in proportion to men's and women's share in production and postproduction
6. Women professionals well represented at all levels of the program and research teams

Other parts of the CGIAR priority-setting process used economic models to estimate returns to various investments and spatial analysis to identify priority areas for agricultural R&D. Unfortunately, due to limitations of the data and specification of the models (as discussed above), much of this analysis was gender blind. A survey was also conducted among researchers to identify key opportunities for agricultural research. Respondents were asked to identify the likely gender impacts of their nominated research. Some respondents also provided more specific suggestions on importance of gender analysis and the inclusion of the needs of women and youth in agricultural research. Although many comments were general, underscoring the importance of addressing the needs of women, a number of more specific suggestions were received regarding gender and research opportunities, such as: "Link agricultural research on market performance to small–medium regional units' (municipality, province, and so on.) programs addressed to women." A number of respondents emphasized the need for inclusion of women in decisionmaking processes in natural resource management, strategies for adaptation and mitigation to climate change (as an integral part of agricultural development programs), and agricultural production to recognize the key role that women play in agricultural production as well as the constraints that they face and to direct resources and programs to them, drawing on sociological and anthropological knowledge and understanding of family dynamics.

Although the priority-setting process to date has not included the voices of many grassroots women, high-level support for serious attention to gender, including by donors and management of many centers, has created considerable momentum. Maintaining this and using it to realize change on the ground for the billions of poor women and men is the challenge we now face.

5. CONDUCT OF RESEARCH AND DEVELOPMENT

Why Does It Matter Who Conducts the Research?

A persistent lack of gender balance among scientists and leadership in most agricultural institutions, as well as among agricultural policymakers in the agricultural scene the world over, continues to drive a lack of critically important diversity of insights—insights that can feed into developing the types of agricultural innovations and women-friendly policies needed to ramp up and sustain food production.

The fact that women play a central role in food production in most developing countries stands in stark contrast to the fact that, for example, in sub-Saharan Africa, only one in four of the agricultural researchers is female (Beintema and Di Marcantonio 2009). The situation is not much more encouraging in Latin America, with one in three agricultural researchers being a woman, women holding lower degrees on average than men, and high attrition rates among women (Stads and Beintema 2009).

There is an increasing understanding and appreciation of women's pivotal role as food producers and providers and their critical contribution to household food security. Although male researchers can address the needs of women farmers, the lack of gender balance among agricultural scientists diminishes the likelihood that the specific needs of rural women will be met. Highly qualified women, particularly from countries where women provide much of the farm labor, with an understanding of the conditions faced by their mothers and sisters, should be an essential part of the agricultural research-to-markets equation.

Lack of gender balance among agricultural scientists also means that women's voices are less heard in critical and often male-dominated policy debates and decisionmaking processes. A recent study supported by the International Center for Research on Women (ICRW) found that increases in women's leadership enhance child development, fast-track political change, and encourage economic growth (Gill et. al. 2009).

Appropriately addressing gender disparity and the prevalence of gender stereotypes, especially regarding women's roles as wives and mothers, will provide role models and encourage girls and young women in the developing world to pursue careers in agricultural research and development. A balanced number of women and men leaders nationally, regionally, and globally in research and policy management setting the R&D agendas is the most effective and efficient way to feed the world while ensuring a future for our children and grandchildren.

Women Farmers' Involvement in Innovation

To get the full picture, we need to consider women's roles in agricultural R&D, not only in the formal systems but also as farmers and processors in innovations. An agricultural innovation systems perspective implies that innovation involves a growing number of actors and also new roles and a multiplicity of relationships that can sustain knowledge generation and learning if technical and economic successes, together with social and environmental sustainability, are to be achieved (Birner et. al. 2007). Agricultural innovation systems embrace technology, as well as the actors involved in the process of innovation (World Bank, FAO, and IFAD 2008, Module 7). An innovation, as described here, is neither a research product nor a technology, but rather an application of knowledge to achieve desired social, ecological, or economic outcomes. This knowledge might be acquired through learning, research, and/or experience and may come from a variety of sources and actors; but until applied, it cannot be considered an innovation (Hall, Mytelka, and Oyeyinka 2004). Mapping out actors; assessing their organizational cultures; and creating early opportunities for them to interact, share experiences, and build trust may be a first step in the right direction to boost methodological and institutional innovations (Van Mele and Braun 2005). Rural innovators can be individuals or groups. They can be highly integrated into their communities or rather isolated. They are both women and men, and there is little indication that they can be easily profiled.

The differentiated roles that women and men play in the generation, transmission, and use of knowledge requires additional focus if women are to continue to be critical actors in agricultural knowledge and innovation systems. Innovation, the social and economic process that draws on discovery and invention deals locally with agroecological specificity and is closely linked to sociocultural diversity and gender-differentiated knowledge and skills. Unfortunately, as local knowledge systems gain recognition, their holistic and gendered nature is more often overlooked. Women's and men's generation, adaptation, and use of knowledge and technology are directly shaped by the economic, social, cultural, political, and geographical contexts where they live; however, each gender experiences these contextual issues in a different way. Because the responsibility to carry out different activities is distributed first along gender lines, an understanding of the role of gender is central to innovations in small-scale agricultural systems (Fernandez 2008).

The degree of gender specificity attached to innovation, within a specific social context, depends not only on the way responsibilities are allocated among men and women, but also on the degree of autonomy each has over the areas of production they are active in. The ways in which men and women share knowledge are heavily affected by the cultural norms of the societies where they live and evolve. The degree to which knowledge is shared among women and between women and men is culture specific. Some kinds of knowledge may be complementary in the sense that both female and male knowledge systems are used to understand a particular dimension of production or decisionmaking. Other types of knowledge may be discrete—held exclusively by men or women—or shared. Discrete knowledge is seen in the Andean small-scale, mixed cropping system: Men hold, use, and pass on to their sons complex knowledge of soil types and rotation practices; women manage the livestock and hold, manage, and pass on knowledge of selection, range of species, and traditional veterinary treatments and marketing. But when male out-migration takes place and women take on the responsibility for what has been the male-managed sector, they must find a way to gain knowledge on other issues related to soil qualities, crop rotation, and management. When shared, the knowledge base becomes less complex and therefore possibly less sustainable in practice. However, the degree to which knowledge is shared cannot be assumed. Shared knowledge systems are most commonly found in either less complex production systems or where men and women work together to carry out the same or similar activities.

References in the literature to women as innovators are limited, possibly because although women are often visible in their own cultures and production systems, they become less visible as disconnected bits of their local knowledge become known to and redefined by the outside world. However, it is not uncommon to find researchers and practitioners who have found women to be central to local agricultural innovation systems. Since its inception, the PRGA documented aspects of women's innovation, particularly in relation to participatory plant breeding techniques and end products (new varieties) where the innovation is relevant to their households and communities. Other examples of the role of women in innovation follow.

In 1992, Gordon Prain noted that "it is the observational powers of women who historically have been most associated with seed selection and therefore with noticing 'new varieties' which spontaneously appear in the field" (Prain 1992, 16). In southern Sudan, Berg (1993) found that women were in charge of selecting sorghum seed before harvest and that it is the women, exclusively, who select seed.

Paul Richards (1986) notes that Moguama farmers in northern Sierra Leone consult the women of the household before making the decision to sort planting material for the next season and that the women then supervise the harvest to make sure that the sorting is done well. The same has been found in various parts of the world and for different crops (Bellón 1995; Sperling, Loevinsohn, and Ntabomvura 1993; Padmanabhan 2005).

Realizing that the gender of researchers often affects the type of farmers and information they can interact with, the Indigenous Soil and Water Conservation Program in Tunisia, after experimenting with their usual staff and obtaining information exclusively on male innovators, decided to recruit and train 15 women researchers in order to identify women farmer innovators. Thirty-one women innovators were identified—most were over 40 years of age and illiterate. All of them were farmers but their experiments also encompassed other areas in which they work: animal husbandry, cropping, handicrafts, use of

medicinal plants, efficient use of charcoal and improved stoves and milk processing (Nsar, Bellachheb, and Ben Ayed 2000).

The last example describes how a specific program made major staffing changes that enabled them to gain an in-depth view of the role of women in experimentation and innovation. Women face particular challenges in accessing information, extension, advisory services, and education, as well as in owning or acquiring land and technology. We are aware that women organize to learn, to support each other, and to gain recognition in their communities, even when there is no direct economic benefit. However, we are only beginning to recognize the opportunities to reinforce social support systems such as community organizations; exchange labor groups (such as you care for my animals one week, and I care for yours the next); and extended family networks for enhancing know-how, information, and innovation systems. We are only starting to understand and recognize the role of women farmers in innovation and how their approaches may differ from those of men.

An agricultural innovation system framework focuses on equality in access to technology, inputs, services, and markets as well as on opportunities for participation, leadership, and equal representation as a means of influencing policymaking processes. However, it does not make visible farmer types based on diverse asset portfolios, levels of education, and networks. Hence, although there is a visible space for all types of actors in the system, small-scale, women, and indigenous farmers will continue to be left behind unless they receive effective support to build the organizational, technological, managerial, and investment capacity they will need to engage with the system. It is widely recognized that the most important role agricultural innovation systems have is to improve the livelihoods of the entire community and in particular that of women and other vulnerable groups. From this point of view, the active engagement of women is no longer only right but an imperative to future farming, processing, and marketing systems if livelihoods are to be improved and agribusiness developed.

Gender Balance in Staffing of National Agricultural Research[6]

The beginning of this section emphasized the need for greater representation of women in agricultural research, not only at the researcher levels, but more so at the management level. The number of female scientists working in science and technology (S&T) research in industrialized and developing countries has increased substantially in recent decades, but the participation of women remains low in most countries. Gender-disaggregated data on S&T capacity are scarce, often lack sufficient detail, and focus more generally on S&T rather than on agriculture specifically. The Agricultural Science and Technology Indicators (ASTI) initiative, as part of its overall data-collection activities on agricultural R&D developments, has collected data for more than 50 developing countries.[7]

In a sample of 47 low- and middle-income countries, an average of 22 percent of the agricultural researchers (covering the government, higher-education, and nonprofit sectors) are female. Across regions, average shares of female scientists range from 17 percent for the Middle East and North Africa, 21 percent and 23 percent in Asia-Pacific and sub-Saharan Africa, respectively, to 32 percent in Latin America and the Caribbean (Figure 2). The share of females was higher in the lower-degree qualification levels. An average of 30 percent of the researchers with BS degrees were female, compared with 21 percent and 17 percent with MS and PhD degrees, respectively. By way of comparison, women accounted for 44 percent of total agricultural research staff employed in the government sector in the 27 countries of the European Union in 2006 (EC 2009), considerably higher than the 47-country average for the developing world.

Unsurprisingly, large variations exist across countries within regions (Figure 3). In the 15 sub-Saharan African sample countries, female researchers represented more than 30 percent of all agricultural research staff in Botswana, Mozambique, and South Africa in 2007–2008. In contrast, of the agricultural

[6] This section is based on Agricultural Science and Technology Indicators (ASTI) datasets (www.asti.cgiar.org), Beintema (2006), Stads and Beintema (2009), and Beintema and Di Marcantonio (2010).

[7] ASTI is managed by the International Food Policy Research Institute (IFPRI) and collects and analyzes primary data on agricultural R&D investment and capacity trends in low- and middle-income countries.

researchers employed in Togo, Niger, and Ethiopia that year, only 11 percent, 10 percent, and 6 percent, respectively, were female. The spread was even broader in the Asia-Pacific region. In 2002, female scientists in Pakistan and Nepal constituted only 6 percent and 9 percent of total research staff, respectively, while in Myanmar more than half of the agricultural researchers employed in 2002 were women. In contrast, differences across countries in the Middle East and North Africa are less pronounced—from 13 percent in Jordan to 28 percent in Tunisia—though this is partly due to the low sample size of only five countries. [8]

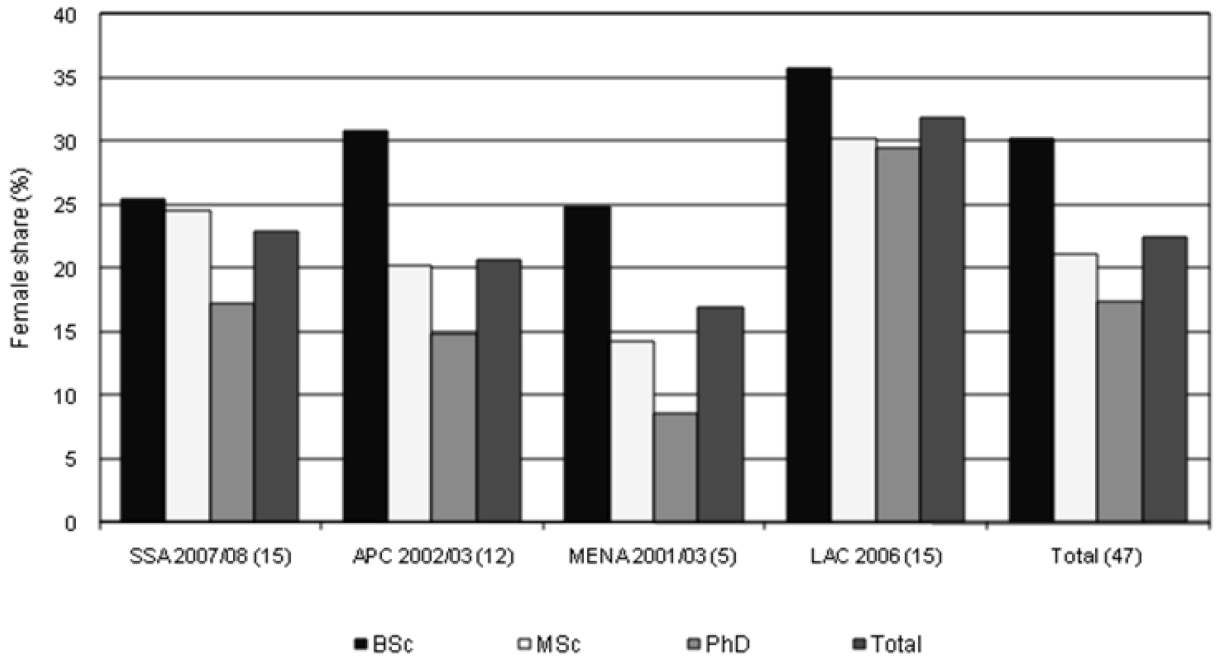
Time-series data were only available for 14 sub-Saharan African countries in our sample.[9] The pool of female professional staff in these sample countries increased by one-half between 2000–2001 and 2007–2008, and four countries doubled their female staff (Botswana, Nigeria, Senegal, and Zambia). In relative terms, the share of women in total professional staff increased from 18 percent in 2000–2001 to 24 percent in 2007–2008. This increase occurred across all three degree levels (BS, MS, and PhD) but varied considerably across the 14 countries under study (Figure 4). The growing shares of professional women employed in agriculture indicate that the gender gap in African agricultural sciences may be narrowing, especially in southern Africa. But the increase in the number of women, as well as men, that enter African agricultural research and higher education is mostly among young staff with relatively lower degrees and at the beginning of the career ladder. On average, more than one-half of the female professional staff in the 15-country sample were younger than 41 years of age, compared with 42 percent of the total male professional staff. Comparably, an average of 31 percent of total female staff and 27 percent of total male staff held BS degrees. These 15-country averages, again, mask a wide variation across countries (see Beintema and Di Marcantonio 2009).

The share of women disproportionately declines on the higher rungs of the career ladder (Figure 5). Only 14 percent of the management positions were held by women, which is considerably lower than the overall share of female professional staff employed in agriculture. Women are, therefore, less represented in high-level research, management, and decisionmaking positions compared with their male colleagues. As a result, women have less influence in policy- and decisionmaking processes, which can further result in biased decisionmaking and priority setting.

[8] The share of female researchers in government agricultural research agencies within Europe varied as well, ranging from 16 percent in Cyprus to more than 50 percent in Bulgaria, Estonia, Lithuania, Malta, and Portugal (EC 2009).

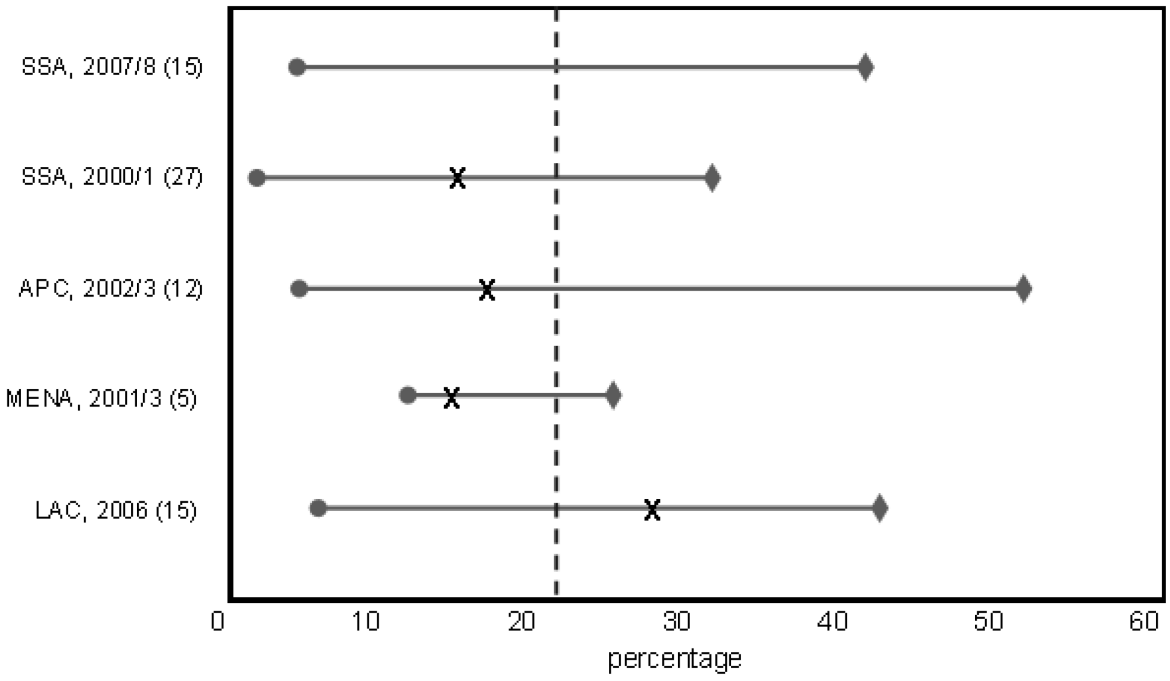
[9] Countries included were Botswana, Burkina Faso, Burundi, Ethiopia, Ghana, Kenya, Malawi, Niger, Nigeria, Senegal, South Africa, Togo, Uganda, and Zambia.

Figure 2. Average female shares in professional staff by degree in 47 developing countries, 2001–2008



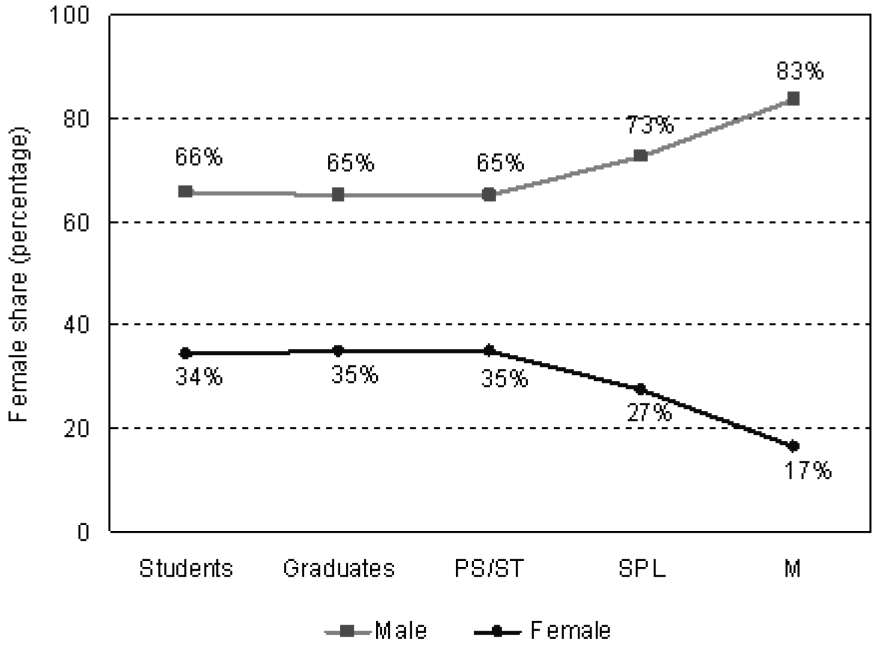
Source: ASTI data (www.asti.cgiar.org) published in Beintema (2006), Stads and Beintema (2009), and Beintema and Di Marcantonio (2010).
Notes: The number of countries included in the regional totals is shown in parentheses. SSA indicates sub-Saharan Africa; APC, the Asia-Pacific region (here excluding China); MENA, the Middle East and North Africa; and LAC, Latin America and the Caribbean. Data are presented in full-time equivalent (FTE) researchers.

Figure 3. National variation in female shares of agricultural research staff by region, 2001–2006



Source: ASTI data (www.asti.cgiar.org) published in Beintema (2006).
Note: SSA indicates sub-Saharan Africa; APC, the Asia-Pacific region (here excluding China); MENA, the Middle East and North Africa; and LAC, Latin America and the Caribbean. Figures in parentheses indicate the number of countries included in each regional sample. X denotes the regional average.

Figure 5. Gender-disaggregated shares of tertiary students and professional staff in agricultural sciences in a 10-country sample, 2007–2008



Source: ASTI data (www.asti.cgiar.org) published in Beintema and Di Marcantonio (2009).
Note: Burkina Faso, Burundi, Ethiopia, Niger, and Togo were excluded because data on student enrollments and graduations were either unavailable or incomplete. When including all 15 countries, the female share in management positions is lower at 14 percent.

Gender Balance in CGIAR Staffing

Between 2003 and 2008, CGIAR centers made strong progress in gender and diversity of their scientist staff group. The number of women scientists went up from 182 to 271, an impressive 49 percent increase, compared with 2 percent for men. As a result, in 2008 women made up 26 percent of the 1,026 CGIAR scientists, compared with 20 percent in 2003. Even more encouraging, this progress was achieved at all scientist levels (from postdoctoral to principal scientist) and at 14 of the 15 CGIAR centers. On the other hand, women made up a more modest 16 percent of center management staff in 2008. At nearly half of the CGIAR centers, women filled fewer than 10 percent of center management positions; four centers had no women in senior management.

Women from developing countries hold particular relevance to the CGIAR mission, as they play a central role in agricultural production in many developing countries. It is therefore of concern that developing country women made up only 6 percent of the center management staff group and had no representation at all among leadership in 9 out of 15 CGIAR centers. Their voice was slightly stronger in the scientist staff group, as women from developing countries accounted for 16 percent of CGIAR scientists in 2008.

The Human Resources Survey 2008 clearly shows positive developments and encouraging progress in staff gender and diversity in the CGIAR overall, but considerable variation among the individual centers remained. For example, despite the improved gender balance among scientists, women's representation ranged from 12 to 41 percent, with six centers reporting fewer than one in five of

their scientists as female. The proportion of women from developing countries ranged from 3 to 36 percent.

Taking stock of the CGIAR's talent profile is especially relevant as it transitions into a new organizational structure to better adapt to and anticipate global changes and more effectively fulfill its mandate to fight poverty and hunger. Rural communities across the developing world are challenged today like never before. They need a CGIAR that delivers relevant innovations and solutions, one whose internal diversity is well suited for its challenging mission

Challenges Women Face in Conducting Research

The glaring gender disparities in agricultural research and development are largely attributable to a range of multifaceted, though often subtle, workplace and societal challenges women routinely face that cut across institutional, social, and cultural dimensions. Taken together, these challenges culminate into a bundle of negative effects that can limit women researchers' movement up the career ladder in agricultural research.

Exclusionary institutional networks: Women researchers face serious challenges in efforts to enter mostly male-dominated formal and informal networks, which are important conduits for integration into collaborative research teams, lobbying with funding agencies for research grants, and improving publication record. In the absence of these fundamental indicators of scientific productivity, women scientists have generally fared less well in gaining promotion to senior research leadership and management positions.

Review and promotion committees—The gatekeeper challenge: Recruitment and promotion committees often lack balanced gender representation owing to the convention of populating such committees with senior professionals—who are often male. This increases women scientists' vulnerability to deep-seated male bias and stereotyping that can work against their chances of winning competitive grants or having objective reviews. While similar patterns are obtained in developed countries, research institutions in developing countries are more closely associated with these deeply entrenched patriarchal notions of women's roles in the public sphere, thus making these environments more challenging for women scientists (Brush et. al. 1995).

Social alienation: Workplace environments have been found to be more challenging for women scientists due to societal attitudes toward the female professional. Studies have shown that covert gender discrimination is rife in institutions where women represent a significant minority. Such discrimination can take the form of higher-than-normal scrutiny and inequitable reward patterns for similar levels of effort in research (Brush et. al. 1995). This is compounded by the lack of role models and mentors, particularly in African research institutions. Without a network of female peers and role models, many women find it hard to survive in a workplace characterized by discrimination and minority dynamics (Rathgeber 2002). On the other hand, if women are pushed too much to fit in with male-dominated approaches to agricultural research, they will not bring the diversity and sensitivity to the needs of women clients that are needed to fully engender agricultural research. Programs such as the AWARD (African Women in Agriculture and Rural Development) leadership and mentoring programs are promising approaches to overcome this.

Work–life balance challenges: Women researchers face more significant challenges balancing the demands of career and family, largely due to deeply entrenched normative notions of women's roles in the public and private sphere. The prevailing perception of a woman's role as a mother and of the family as a woman's domain imposes a double burden on women that severely constrains women's advancement in research institutions (Beoku-Betts 2005; Brush et. al. 1995).

These challenges that women scientists routinely face trigger the "leaking out" of female talent in agricultural research domains. As a consequence, many such institutions lack a critically important diversity of insights that can feed into developing the types of agricultural innovations needed to ramp up production and ensure sustainability. It also diminishes the likelihood that the specific needs of rural women will be met.

But women do not have to—nor can they—do all this on their own. It is essential to involve men also in gender-responsive research, as well as in supporting institutional change to enable women to function effectively in research institutions and farms. Some very influential gender researchers or advocates for gender equity have been men, and some of the strongest champions for making agricultural research institutes more accommodating to women scientists are also men. Measures to improve work–life balance benefit both men and women. Oxfam GB's work to advance gender equality and poverty reduction has focused on incorporating men and boys more fully into its work on gender by encouraging men inside the organization to think about their personal commitment to gender equality and about what that means in practice to their day-to-day work (Esplen 2006). Similarly, the AWARD program has found that senior male mentors for female AWARD fellows have increased their appreciation for the challenges that women staff face, and the program has worked to address these problems.

Implications for Education

There is abundant research on the importance of women's education for economic development and poverty reduction, but most of this has focused on primary and secondary education. Less attention has been given to advanced training, and especially to the fields that girls and women pursue. Considerations include not only whether girls go into the sciences and agriculture, but whether they are supported or mentored once they get in. Another consideration could be attitudes of professors toward students. Even in early grades, stereotypes about what girls can study are already well entrenched. Addressing this requires looking at both attitudinal and structural factors such as whether male professors (and students) are supportive of girls, whether girls are harassed, and whether girls are eligible for scholarships or encouraged to work on exciting topics. And for those who do go into the sciences, it is important that girls are exposed to or encouraged to consider agriculture as a field with opportunities to make a difference. In order to build up the pool of women scientists and agricultural researchers, we need to work on those who feed into the pool of female agricultural researchers—they were once little girls.

6. AGRICULTURAL EXTENSION

Extension services (also known as agricultural advisory services) refers to the range of information, advice, training, and knowledge related to agriculture or livestock production, processing, and marketing provided by governments, NGOs, and other sources that increase farmers' ability to improve productivity and income. Forms of delivery may take the form of individual or group visits; organized meetings; use of Information and Communication Technologies (ICT); or learning through demonstration plots, model farms, or farmer field schools (FFSs). Provision of agricultural extension services is generally poor in rural areas, particularly to women. Evidence of gender bias in access to extension services and adoption of new technologies is numerous and consistent in the literature.[10]

Access to Extension Agent Visits

The commonly used measure of households' access to extension services is contact with or a visit from agricultural extension agents or livestock officers. Using these measures, studies show access to extension services is consistently (and statistically and significantly in the majority of cases) lower for women as compared with men: 19 percent for women versus 81 percent for men in Malawi (Gilbert, Sakala, and Benson 2002); 1.13 versus 2.03 contacts in Uganda (Katungi, Edmeades, and Smale 2008); 20 percent versus 27 percent in Ethiopia, 8-19 percent of female-headed households versus 29 percent of male-headed households in Karnataka, India; and the lowest figures in the recent empirical evidence, in Ghana, 0–2 percent among female-headed households and 0.5-2 percent of female spouses of male-headed households have access to extension agent visits, versus 11–12 percent among male-headed households (World Bank and IFPRI 2010). For livestock-related extension services, results are slightly better: 0–24 percent of female-headed households and 0–15 percent of female spouses have access, versus 5–34 percent for male-headed households in Ghana; and 71 percent of female-headed households versus 78 percent of male-headed households in Karnataka, India (World Bank and IFPRI 2010). In India, the role of dairy cooperatives as an important medium for providing and accessing livestock services accounts for the higher coverage for both women and men in the livestock sector. Dairy cooperatives are slightly more gender-inclusive than other farmer organizations; for example, the male–female ratio of membership in dairy cooperative is 2.6 compared with 4.2 in other Farmer Based Organizations (FBOs) in Karnataka, India, and 11 percent of dairy cooperatives surveyed have female chairs, compared with zero in other FBOs.

Findings by FAO's global survey on extension in 115 countries in the early 1990s showed that women received only between 2 and 10 percent of all extension contacts and a mere 5 percent of extension resources worldwide (Swanson, Farmer and Bahal 1990). Nevertheless, compared with these earlier findings, more recent evidence does not seem to show any substantial improvements in gender equality in extension service delivery, despite decades of gender-mainstreaming efforts. Figures suggest that extension provision is low for both men and women, but more so for the latter, and this has major implications for attaining higher productivity and agricultural development.

With broader definition of extension service access to include community meetings or groups meetings held by extension agents, results remain consistent in terms of gender differences: 0–6 percent for female-headed households and 5–9 percent for female spouses, versus 11–24 percent for male-headed households in Ghana; and 11 percent of women versus 28 percent of men in Ethiopia (World Bank and IFPRI 2010). The differences between female-headed and male-headed households are statistically significant in both countries.

Evidence suggests that access to extension services is a key determinant in the adoption and use of improved technologies and farming practices. For instance, in Ghana, an extension agent visit was the

[10] Empirical studies reviewed here have looked at a wide range of technologies being promoted, from planting techniques, improved seed varieties, use of fertilizer, and disease control to postharvest techniques, group formation, marketing, sanitation, and hygiene.

only variable that was positively and significantly associated with adoption of a new agricultural technique from multivariate analyses (World Bank and IFPRI 2010). This suggests that extension visits, despite new sources of extension, will remain a key medium in bringing in information and knowledge to farmers.

Access to Other Sources of Extension Services

Studies in India, Ghana, Ethiopia, and Kenya indicate that alternative providers of extension still play a rather limited role and that public-sector extension agents were the main source of information. In Ghana, for instance, only one of all sampled farmers had received a visit from an NGO extension provider in the year preceding the survey done by World Bank and IFPRI (2010). Private-sector enterprises did not feature as providers of extension services per se in any of the surveyed regions in Ghana, Ethiopia, and India, although some farmers who buy from private input dealers receive advice related to these inputs.

Other sources of information that were cited include other farmers; female spouses in particular used radio more frequently. A commonly used education and extension approach is the FFS, which has proved important for women's access to extension services. Female membership was 50 percent in FFSs, and gender of the household head did not matter in the participation of FFSs in Kenya, Tanzania, and Uganda (Davis et. al. 2009).

Other potentially important sources of extension service are the community-based organizations (CBOs). Despite their huge potential, the involvement of CBOs in extension services remains low in Ghana, Ethiopia, India, and Kenya; and these organizations are not typically inclusive (World Bank and IFPRI 2010; Davis and Negash 2007). There are considerable gender differences in participation and membership in CBOs. For instance, in Ghana, typically the male head was a member, while only 2–5 percent of female spouses and only 3–7 percent among female-headed households said they belonged to a CBO. In Ethiopia, gender differences exist in services by cooperatives: 24 percent of men and 4 percent of women belonged to some kind of cooperative; 13 percent of men and 2 percent of women belonged to agricultural cooperatives (World Bank and IFPRI 2010). In India, there are gender differences in participation in farmers' and dairy cooperatives: male-to-female ratios in farmers' cooperatives and dairy cooperatives are 4.2 and 2.6, respectively, but multivariate analysis suggests that gender of the household head does not play a significant role in determining the number of memberships in CBOs. However, the type of group joined varied along gender lines: Women in India mainly joined self-help groups or women's groups, and men primarily joined forest groups, cooperative societies, and caste associations. Church groups, parent-teacher associations, and women's groups were the most important forms of social organization in all zones in Ghana, especially for women. Women in Kenya tended to participate more in revolving savings and loan associations, church groups, and women's groups, while men participated more in clan and water groups. These figures suggest that certain groups might be a better vehicle than Farmer Based Organizations (FBOs) for reaching women in rural areas. However, it may be best to work through traditional types of groups or institutions where women and the poor may feel more comfortable participating.

In Mozambique, it has been reported that the husband would typically become a member in a group to represent the household. Consequently, he would sell "his" crops through the group, even if the crops had been grown by the family or by his wife. This is particularly true among groups that allow only one member of the household to become a member; even where both husband and wife are allowed to become members they might not do so, because most groups require members to pay monthly membership fees. In female-headed households, a woman's autonomy increases so that she can join the group in her own name, register, and sell the products as her own. Membership therefore has an inherently gendered subtext: the participation of women in farmer groups depends on their personal circumstances, for example, age, education, and civil status. Because of household and reproductive responsibilities, a wife can hardly participate in a group in her own name and have her own voice in a (mixed) group, but she is likely to be represented by her husband, who as the head of the household becomes a member, sells the joint production, and is the one who takes leadership responsibilities

(Gotschi, Njuki, and Delve 2009). Therefore, attention to the rules governing membership, and even to details such as the timing of meetings, will affect the extent of women's participation.

In terms of leadership positions, gender differences are apparent in the leadership and management of CBOs. In Ethiopia, men are five times more likely than women to hold a leadership position within a cooperative: 3 percent of female and 15 percent of male cooperative members hold such roles (World Bank and IFPRI 2010). In India, women appeared to be underrepresented in the leadership of most organizations: None in farmers' cooperatives and only 10 percent of the dairy cooperatives had female chairpersons, and very few had female secretaries (World Bank and IFPRI 2010). The low prevalence of female chairpersons in most organizations occurs despite the fact that one-fourth of the farmers' cooperatives and more than half of the dairy cooperatives reserved seats for women in executive positions. None of these groups has reserved seats for the chairperson, vice-chair, and secretary. A survey of 73 farmer groups in Mozambique found that women do not enjoy the same chances as men to become president and represent the group, participate in meetings or seminars, and take final decisions: 88 percent of the groups had male presidents, 73 percent had male vice presidents, and 76 percent had male secretaries. Treasurer positions were more likely to be held by women (47 percent of the groups). Women were said to be more trustworthy and not likely to "eat" money belonging to the group and were therefore more likely to be elected as treasurers (Gotschi, Njuki, and Delve 2008).

Gender differences also appear in the type of technology and information disseminated to farmers. In Ghana, the outreach to women farmers is significantly lower than with men (from 0.33 to 0.89 women-to-men ratio) for almost all technology and information disseminated, except on livestock diseases and sanitation and hygiene (1.07 to 1.69 women-to-men ratio) (World Bank and IFPRI 2010). The gender difference is broader for production-related technologies and narrower for information related to marketing, livelihood strategies, and HIV/AIDS.

In terms of the quality of extension services, there is no conclusive evidence about gender differences in the quality of extension services or satisfaction derived from them. In India, households with assets and households with a female head were more likely than other households to report being satisfied with extension service delivery. In Ethiopia, individuals reported being satisfied with extension advice at staggering rates: 92 percent of men and 94 percent of women. Surprisingly, given these satisfaction rates, only 8 percent of respondents stated that they had tried something new in the past two years, making it unclear what these farmers consider satisfaction with extension agents (World Bank and IFPRI 2010). Studies and expert opinion (Davis 2010) suggest that it is the lack of complementary inputs and credit that constrained farmers to try new technologies in Ethiopia, despite having satisfied with the extension services provided or believing that the extension agent knows all the best technologies and farming practices. Nevertheless further research is needed to address methodological issues and probe more deeply into farmers' perception of the quality of their interactions with extension agents."

Factors Contributing to Women's Low Access to Extension Services

Studies on agricultural extension have highlighted a number of challenges in reaching rural women. First, the perception bias that "women are not farmers" persists even though women are engaged in a wide range of agricultural activities. A recent report by World Bank and IFPRI (2010) finds strong evidence for a cultural perception that "women don't farm." In Ethiopia, because extension agents were evaluated on how many farmers they could get to adopt technology packages, they preferred to work with the household decisionmakers, who in a husband-wife household was always the male in this report. Second, there are also perceptions that if extension services are given to a member of the family, then it will trickle down to the household, including female members. However, men do not necessarily discuss production decisions with their wives or transfer extension knowledge to them, and if the extension information is tailored to men's crops or priorities, the information may not help women. There is a clear and compelling need for extension to reach women directly. Third, most extension services have been traditionally devoted to farmers who own land and who are willing and able to obtain credit and invest it in inputs and technological innovations. Since women often lack access to land or to other collateral with

which to obtain credit, extension services unintentionally bypass women. Also, women have lower formal education, and this hampers them from taking part in extension activities requiring reading and arithmetic skills. Women farmers may also not be comfortable dealing with male extension workers or with the time and location of training. Due, Magayane, and Temu (1997) found that in Tanzania, 40 percent of women farmers preferred to work with female extension agents, and 51 percent of the women mentioned that they wanted to receive information on small ruminant production. Almost all the women (94 percent) pointed out that they could only attend demonstrations and training courses if these were carried out at their villages.

Relatively lower provision of extension services to women is also a reflection of the policies, or lack of, at the ministry or service-provider level. In Ghana, a World Bank and IFPRI (2010) study shows that of the 70 agricultural extension agents surveyed, only 10 were female. Although about two-thirds of all extension agents stated that they received training that had a gender component, only 7 percent reported receiving training that was totally targeted to gender issues. Thus a need exists for clear policies and training materials on how to reach women farmers. In Ethiopia, extension agents were overwhelmingly male, and cultural taboos restricted their interaction with women. In Karnataka, India, a survey conducted with front-line professionals responsible for extension service provision show a limited number of women (no female among 41 agricultural extension workers, 1 female out of 41 junior engineers, and 4 females out of 40 veterinary assistants). Lack of staff is the most frequently cited constraint and main problem: More than 70 percent of agricultural extension workers serving the surveyed blocks are over 50 years old.[11]

There were no statistically significant differences between the types of technologies promoted by female and male extension agents, and female agents were just as likely to establish and run demonstration plots as their male counterparts. Female extension workers serve a higher proportion of female farmers than male agents (the average ratio of women to men is 1.3 for female agents and 0.53 for male agents) (World Bank and IFPRI 2010). This suggests that extension services from female extension agents are better targeted to female farmers. Interestingly, the World Bank and IFPRI (2010) study found that in Ghana, when male and female agents were asked about their biggest constraint to achieving their missions, most male agents considered it transportation, while female agents considered it farmer-related problems, such as lack of access to credit. This difference may partly reflect the fact the female extension agents are more likely to work with female workers, who may face more obstacles to adopting new practices.

Although the presence of women professionals in extension organizations and their representation in decisionmaking is critical, the predominant practice continues to direct training and resources to men only. For example, the Sasakawa Africa Fund for Extension Education (SAFE) training program in West Africa set up in universities for midcareer agricultural extension staff of the Ministry of Agriculture has recorded only 21 percent female participation (Akeredolu 2009). The reasons identified for this low female participation include (1) perception bias—the community's low perception of women's talents and potentials and perception of agriculture as a domain of men; (2) limited access to information about opportunities for further education; (3) limited opportunities that target professional women; (4) family concerns and time constraints; and (5) other social, cultural, and religious barriers.

Approaches and Strategies That Worked and Did Not Work

Alternative organizational and institutional arrangements for extension programs are being explored, including restructuring of current systems to be more inclusive, farmer led, market driven, decentralized, and cost effective. Reforms in agricultural extension systems include decentralization (Agricultural Technology Management Agency [ATMA] model in India), privatization (for example, in Chile,

[11] Conversely, with real commitment, it is possible to increase women's involvement in extension. In Gambia, the proportion of female agricultural extension workers has increased from 5 percent in 1989 to more than 60 percent today, paying increased attention to women's livestock information needs, especially regarding small ruminant and poultry production (FAO 2003).

Ecuador, Estonia, Pakistan, South Africa, and Uganda), contracting for extension service delivery (Honduras and Venezuela), private market-oriented extension services, and different forms of public–private partnerships. However, a continuous challenge has been how to increase farmers' engagement, particularly women's, into the program planning and resource allocation and to increase accountability to stakeholders.

There is a dearth of research that looks at how gender issues are integrated and affected by these reform strategies. In some cases, it is assumed that more attention and special provisions to small farmers, given that a majority of smallholders are women, will automatically and equally reach and benefit women farmers. In other cases, special provisions for women farmers have been explicitly incorporated into reform policies and strategies. Numerous gender-responsive strategies have been adopted and can be grouped into the following:

- strategies that specifically target female household members and CBOs, such as creating and strengthening self-help groups and women's associations; adopting affirmative action in user group associations or farmer-based organizations; and promoting political awareness, leadership, and advocacy abilities for women
- strategies that target service providers, such as recruiting and training women extension agents and designing, implementing, and monitoring projects in a gender-sensitive manner
- strategies that target public administration, elected representatives, and political parties, such as reserving seats for women representatives in local councils or committees, gender machineries, sectoral gender focal points, and gender-sensitive training for staff

While a number of these initiatives have some pockets of successes, there are substantial issues on scaling them up, and major gaps in policy and actual implementation persist. Many of these initiatives are superficially done (such as to satisfy donors' requirements) and remain to be supply-driven and far from being transformative. A number of reform processes are described below to provide some indications of the challenges in reaching out to women farmers and being more responsive to their needs.

ATMA Model in India

The ATMA model is often cited as an innovative model for a decentralized extension service delivery in India. An ATMA is a semiautonomous organization composed of a multitude of key stakeholders involved in agricultural activities and is responsible for technology dissemination at the district level. Several gender-specific provisions are included, namely, (1) mandating 30 percent of the resources on beneficiary-oriented programs and activities to be allocated for women farmers and women extension functionaries across 252 ATMAs set up or to be set up in all the major states of the country; (2) introducing gender-sensitization aspects in the trainings of trainers; and (3) mandating representation of women in all committees and groups at the district level. There is a dearth of study in terms of the impact of ATMA on women farmers. Some reports indicate gaps in implementation where the actual allocation and spending is lower than the stipulated. For instance, the actual spending is way below 30 percent of the allocation for various activities under the Women's Component Plans in India (Planning Commission 2007). In Bihar, staff shortage prevented agricultural extension workers from promoting the formation of farmer interest groups foreseen under ATMA. While ATMA guidelines stipulating the participation of women did induce agricultural extension workers to seek women's participation in ATMA-sponsored programs, such efforts or programs were not always geared toward improving agricultural production or the marketing practices of women (World Bank and IFPRI 2010). For example, in a case study in Bihar, a group of landless female members of a self help group were selected for an exposure visit to West Bengal to learn new agricultural technologies that it turned out required access to land, and instead of sending five women for the exposure visit, as specified, only three were sent and the remaining two positions were filled by men from a dominant caste group (World Bank and IFPRI 2010).

Training programs targeting women's groups provide indications of positive impact such as increases in general awareness among women farmers, increase in income, and visible impact on women's socioeconomic status and food security (Planning Commission 2007). An estimated 1.4 million women farmers have been benefited through women-specific programs in India in more than 23 years at a cost of INR 2.3 billion (US$50 million), or approximately INR 1,700 (US$37) per woman farmer (Planning Commission 2007). The schemes have covered about 143 districts in most of the states and have promoted 28,000 self help groups. Concerns expressed relate to limited coverage, especially in terms of direct beneficiaries, despite large coverage of states and districts and seemingly low impact in terms of economic and overall empowerment (Planning Commission 2007). Substantial gaps exist in most of the aspects, like access to technology, markets, and credit; and this mismatch between people trained and their access to resources often results in poor outcomes.

NAADS in Uganda

Uganda's National Agricultural Advisory Services (NAADS) program focuses on farmers' groups as the lead players in extension service delivery, and where government provides services through private service providers in line with farmers' needs. The strategy of NAADS features gender issues; it stipulates sensitizing districts in gender issues and concerns, and identifying indicators to address gender issues at the district and sub county levels. The NAADS program is generally appreciated by the different categories of farmers for enabling people from remote villages to get a lot of knowledge and information on agriculture production; the demonstration farms were also highly appreciated for their practical training components, for being close to the farmers, and for the fact that the farmers control the proceeds from the demonstrations. However, its gender impact seems to be limited. First, there is a general lack of resources by individual farmers to put into practice the ideas acquired, and while NAADS provides a lot of training to farmers, adoption level of skills gained by farmers and particularly women is low due to lack of capital to access the required inputs and technology as well as the inability to read the provided information. Many women are limited in use of the agricultural technologies they may be trained in due to limited education, lack of control over land, and cultural factors that limit women from using some technologies like sitting on tractors in some communities. Second, although the elderly women are many in the groups, they are not yet empowered to influence decisions in the groups, and very few of them are in the leadership positions. Despite the overwhelming participation of women in farmer groups, men still retain control over NAADS processes and actual decisionmaking, even in supposedly women-only groups. Some of the factors found to undermine women's control and influence over NAADS processes include (1) low literacy rates for women (as a result, even in many women-only groups, men advisors or secretaries are co-opted to provide linkage to the literate outside world); (2) time burden due to women' triple roles (productive, reproductive, and community service); and (3) weak ownership and control over resources, especially land (where the level of influence or control over group activities relates to the resources at one's disposal) (CEEWA nd; NAADS Secretariat 2004).

The NAADS gender analysis conducted by CEEWA-Uganda highlights a few important points. First, it highlights the importance of gender-disaggregated data to see sources of inequalities and biases to better inform policy and project design. Second, it highlights need for more capacity building of service providers in gender analysis to enable them to identify the different needs of the farmers in the program. Many seem to view gender wrongly as numbers of women in the program. This assumption needs to be corrected to that of gender being a tool to view the society in totality and to make sure that the interests of all categories of farmers are addressed. Third, it highlights using a wide range of channels for communication, like drama, pictorials, and use of local languages in message delivery. Women need to be consulted on timing of radio messages to meet their time constraints and also on location of messages, for example, at water points or health centers where the majority of women converge. When selecting a technology, efforts should be made to assess the impact of the technology on time use, its cost, availability of credit to purchase it, and its appropriateness to level of education of women.

Privatization and Decentralization in Venezuela

The third case is the Venezuelan reform initiative, which combined decentralization, privatization, and cost sharing by different government levels, agencies, and beneficiaries. Extension service provision was to be the responsibility of the Foundation for Training and Innovation for Rural Development (CIARA), which contracts private service providers. State and municipal participation is also established through contracts, and cost sharing was introduced through municipal Civil Extension Associations (Spanish acronym, ACEs). The increased program focus on gender and the environment has heightened recognition of the productive role of women and youth and promoted an enhanced awareness of environmental conservation issues. Programs show a positive trend toward a greater participation of women and youth in income-generating activities. The access of rural women and youth to extension services is enhanced by mainstreaming women's programs, identifying potentially differentiated needs for these groups, conducting additional gender-sensitizing programs for policymakers and implementers, and maintaining program flexibility in dealing with situational specificities. The program's achievements include an increase of 42percent in annual farm income; an increase of 54 percent in average crop productivity in relation to the base year; an increase of 127 percent in average livestock productivity in relation to the base year; a 21 percent share for women in program participation in productive activities; and a total of 68 organizations created or strengthened by the program (World Bank, FAO, and IFAD 2008).

The Venezuela privatization experience raises two important lessons. The first is the crucial need not to ignore but to focus strongly on the social and human capital development needs of resource-poor smallholder farmers. To respond adequately to the complex needs of those groups, extension service providers need public-sector program managers and field advisers with greatly enhanced competencies to plan and provide services using facilitation and problem-solving approaches with farmers in the context of wider community needs. This implies a significant shift from the traditional paradigm of technical expertise alone to the broader competencies needed for effective responses to the new "social" challenges faced by extension personnel, including (a) the practice of participatory extension approaches and (b) local farmer organization development. Second, other extension system reforms have been initiated but were silent in terms of gender strategy and gender-disaggregated impact. Lessons indicate that these reforms do not guarantee greater outreach to women farmers. This requires accompanying earmarked funding and provisions or conditions for gender in terms of more capacity building, literacy, and consideration of women's time constraints. Proponents of extension system reforms need to take a broad view of extension services, and as Rivera and Alex emphasized, "the client base goes beyond that of the 'male-head-of-household' and the agenda goes beyond the traditional agricultural production focus" (2004,79).

Sectoral Policies in Ethiopia

To ensure that gender is taken into account in the agricultural planning process, many districts have established a system of gender desks or focal points within sectoral policies and are supposed to guarantee that the office reviews budgets, plans, and operations through a gender lens. However, there are considerable variations in the effectiveness of this policy. All of the gender focal points in the World Bank and IFPRI (2010) study were junior staff members, but male professional staff were in some district offices of women's affairs. Gender focal points in some districts have conducted training in gender analysis for all the extension agents in those districts; however, some feel that the sectoral focal point system is somewhat redundant because the district offices of women's affairs are already responsible for mainstreaming gender issues in planning activities. In some districts, neither a women's affairs officer nor a focal point system is present.

Extension agents interviewed under the World Bank and IFPRI (2010) study had a great deal of awareness of the gender bias and had employed strategies to deal with it. Considering the cultural barriers to male extension agents reaching women alone, extension agents have employed different approaches to reaching women farmers, such as contacting their husbands first and explaining the purpose of the visit;

meeting women in groups; addressing women in public meetings; and seeking support of women's affairs offices. The district governments also carried out gender analysis as part of a comprehensive needs assessment, and all district government staff in some received in-service training on gender issues. Awards and recognitions for high-quality work among women extension agents are also being provided in some districts. The Ministry of Agriculture has also developed a broader variety of extension packages, recognizing that one size does not fit all farmers. This includes the "women's development package," which emphasizes support for women's agricultural activities (poultry, small ruminants, and home gardens). However, the women's package remains relatively standard and undiversified based on women engaging in different tasks and in particular does not distinguish between the needs of female household heads and female spouses. For example, a case study by the World Bank and IFPRI (2010) indicates that it is difficult for female household heads to raise chickens because they spend a great deal of time providing weeding services to male farmers to earn income. To the extent that the women's packages emphasize poultry, it is really a "married women's development package" (177).

Farmer Field Schools

At the microlevel, several innovative extension and education approaches are being piloted or implemented. For example, FFS is a popular education and extension approach, and evidence to date suggests that this approach works in reaching small farmers, particularly women. Because women all over the world are in the field—planting, weeding, harvesting—FFSs suit women at least as much as men in many countries. Although the perspective does not specifically focus on gender equity, the FFSs meet in the fields where women work, and with the women's central role, they naturally become members and leaders of the FFS groups (CIP-UPWARD 2003). Davis et. al. (2009) evaluated the experience in Kenya, Tanzania, and Uganda and found that female membership of FFS was 50 percent and that gender of the household head did not matter in the participation of FFS. Adoption was significantly higher among the FFS farmers for nearly all of the major technologies, with the major ones being improved crop varieties, soil fertility management, pest control, and livestock management. Participation in FFS increased income by 61 percent when pooling the three countries. FFS improved income and productivity overall, but differences were seen at the country level. Participation in FFS led to increased production, productivity, and income in nearly all cases: Kenya, Tanzania, and at the project level (all three countries combined). The most significant changes were seen in Kenya for crops (80 percent increase) and in Tanzania for agricultural income (more than 100 percent increase). When disaggregating by gender, however, female-headed households benefited significantly more than male-headed households in Uganda. However, controversy surrounds the cost-effectiveness of FFS (Quizon, Feder, and Murgai 2001). Other than the study by Davis et. al. (2009), multi-institutional impacts and long-term benefits to rural communities have not been assessed to date.

Lessons Learned

It is evident from the preceding cases in this section that problems and priorities vary from country to country and thus analysis and program design should cater to variability and context specificity. For example, in India, the issue is low government extension capacity; in Ghana, the issue is the lack of focus on outcomes and low access to extension services in rural areas, particularly among women, despite that the ratio of extension agent to farmer is comparatively high; and in Ethiopia, the overreliance on fixed technology packages that give less discretion to extension agents and are irresponsive to farmers' demands, especially women's needs, is the main issue.

Policy: From the policy perspective, raising more awareness and advocacy to correct the perception bias that "women do not farm." It will be important to promote political awareness, leadership, and advocacy abilities for women, and at the same time, to encourage and support more men to advocate for gender issues.

Project interventions: From the program or project perspective, there is a need for increased earmarked funding for women farmers. Reforms in the extension systems (privatization, decentralization,

and so on.) do not automatically guarantee greater attention to women's needs, due to persistent social and cultural norms and perception bias that often prevent equal access and opportunities for women and men. The above-mentioned studies highlight several needs: the need for affirmative action and policy shift to enable research and extension to focus more on women; the need for role models within the agricultural extension service systems to make the contribution of women visible at every opportunity, in multiple ways, and in as many venues as possible; the need to provide leadership training to increase women's capacity to leverage and negotiate; the need to increase educational opportunities for women who wish to study in the field of agriculture; and the need for midcareer women to improve their skills and competencies. Extension organizations must encourage and recruit more female extension agents, who were found to be more effective than male extension agents in reaching female farmers. In Senegal, researchers found that female extension agents have a significant positive impact on the dissemination of natural resource management knowledge among both men and women (Moore et. al. 2001). Creating incentives for reaching female farmers, by, for example, rewarding such outreach in performance reviews, would be important. At the same time, there is a need to evolve strategies that will help male agents to work better with women farmers.

In most cases, information from extension services and training is not applied and does not create sustainable business enterprises because of lack of complementary inputs and resources. Because women have disproportionately fewer advantages than men, programs that specifically target female household members will be important. Some initiatives that would help include creating policies to increase assets for the resource-poor, strengthening group-based approaches, and piloting voucher programs or grants to ensure women smallholders' access to resources. There is a need to scale up pockets of success from gender-responsive strategies and approaches, which include creating and strengthening women's groups, innovative forms of extension and education such as FFSs and radio, and women-friendly forms of information technologies. Strategies and approaches need to be designed that address women's needs, but more importantly, that pay special attention to the implementation and monitoring.

Research: From the research perspective, more gender-disaggregated data collection and rigorous impact assessments are needed. These play a crucial role in identifying sources of bias and inequality and bottlenecks in furthering food security and agricultural development to inform policy and project design. Topics that need further research include (1) analysis and studies to understand constraints, bottlenecks, and opportunities for scaling up and rolling out successful gender-responsive actions; (2) rigorous methodologies for assessing quality or satisfaction from extension services as current methods and studies show conflicting results; (3) studies exploring the demand side, including motivations, incentive, and constraints of women to become extension agents; and (4) gender-disaggregated impact assessment of reforms in extension systems.

7. FACTORS AFFECTING ADOPTION

Evidence from throughout the developing world indicates that men and women do not adopt new technologies at the same rate or benefit equally from their introduction. Authors note that women in Africa continue to adopt high-yielding crop varieties and improved management systems at low rates (Doss 2001). Recent empirical studies in Ethiopia (Tiruneh et. al. 2001), Ghana (Doss and Morris 2001), Nigeria (Sanginga et. al. 2007), Malawi (Gilbert, Sakala, and Benson 2002) and Benin (Kinkingninhoun-Mêdagbé et. al. 2008) all document gender-based disparities in adoption of improved technologies including improved seed, inorganic fertilizer, chemical insecticide, and so forth; see Peterman, Behrman and Quisumbing (2009) for a recent review.

This section brings together the literature documenting the reasons behind differential adoption rates by female farmers. Understanding gender-specific constraints to adoption may help agricultural research systems develop new varieties and technologies that are better suited to women's needs, aid extension systems in identifying the most binding constraints to adoption, and help development practitioners and policymakers address the elimination of these gender-specific constraints. It also suggests some criteria for evaluating the gender-specific impact of new technologies, which may help guide the prioritization of technologies to be developed and the choice of technology to disseminate in particular settings.

There is an extensive literature on factors that affect the likelihood of adoption of agricultural technologies and natural resource management practices (Feder, Just, and Zilberman 1982; Knox and Meinzen-Dick 1999). These include access to infrastructure and information, environmental and price risk, wealth and credit, labor, price policy, property rights, collective action, culture, and other conditioning factors. Although most of the general literature on constraints to adoption has not considered the gender dimensions, when we look a bit closer, women farmers often face additional challenges in each of these areas. The following discussion draws heavily from Knox and Meinzen-Dick (1999) but adopts a more gender-focused perspective as in Quisumbing and Pandolfelli (2010).

Infrastructure, Information, and Risk

Access is a critical dimension of technology choices (Knox and Meinzen-Dick 1999). Unless the appropriate physical, economic, and information infrastructure is in place, farmers may be unable to acquire technological inputs or market their output. Because women's mobility may be limited in many contexts, even basic access to infrastructure such as roads and public markets may be limited. In some geographic regions, notably South Asia, the Middle East, and North Africa, social norms that value female seclusion limit women's ability to benefit from public infrastructure. Women's access to information, which also determines whether or not they will adopt new technologies, may also be less than men's, partly because of extension systems that do not effectively target or reach female farmers (see Section 6, above). Farmers' knowledge about new technologies must also include information about the returns from adoption, which involves value judgments regarding profitability and risk. A growing body of empirical evidence in developed countries suggests that, by and large, women are more risk averse and less prone to competition (Croson and Gneezy 2008). A study of 500 couples in Vietnam (Fletschner, Anderson and Cullen 2010) finds that women are more likely to self-select into economic activities with lower expected returns to avoid setups that require them to be more competitive or have less predictable outcomes. Such differences in risk preferences may underlie differences in men's and women's willingness to adopt new technologies. Effective extension services can accelerate the spread of knowledge about the profitability and risks associated with new technologies. Social networks also play a salient role as farmers observe and learn from others in their network about the suitability and profitability of new agricultural production methods. These networks are particularly important for women, who often have less access to formal dissemination channels.

Wealth and Credit

Lack of wealth need not be a constraint to technology adoption for poor and low-asset households, provided financial markets are available to provide necessary financing arrangements. However, a sizable body of literature points to the lack of access to credit and savings services for farmers in many rural areas, limiting their ability to purchase needed technological inputs (Lipton 1976; Jehangir 1998; Bhalla 1979; Wills 1972; Feder, Just, and Zilberman 1982; Feder 1980; Subbarao 1979; Hazell and Anderson 1984). Although subsidized agricultural credit programs, often tied to purchases of new technology, have been used as a solution, they have been criticized because of lack of sustainability and low repayment rates. They also often failed to reach small farmers and women. The contraction of subsidized and publicly funded credit schemes in recent years has led to new approaches to rural finance, including development and strengthening of local institutions for microcredit and mobilization of rural savings. The growth of microfinance institutions, particularly those that deliver financial services through women's groups or those that use group liability as a substitute for collateral, have proven to be effective in reaching poor female farmers (see a review of recent innovations in the delivery of financial services to poor female farmers in Quisumbing and Pandolfelli 2010). Kabeer (2005) cautions us that, while access to financial services does make vital contributions to the economic productivity and social well-being of poor women and their households, it does not automatically empower women. It only provides possibilities, rather than a predetermined set of outcomes. Which of these possibilities are realized in practice will be influenced by the philosophy that governs the delivery of financial services, the extent to which they are tailored to the needs and interests of those they are intended to reach, the nature of the relationships that govern their delivery, and the caliber and commitment of the people who are responsible for delivery. Therefore, the design of financial services for the poor—especially poor female farmers—should be based on an empirical understanding of the relationship between context, approach, and impact.

Labor

Farmers' access to labor (family or hired) critically impacts their ability to adopt new technologies and augment overall production. High-yielding crop varieties not only may add to total labor requirements, but they often exacerbate seasonal peaks in labor requirements (Knox and Meinzen-Dick 1999). Peaks typically occur at planting, weeding, and harvest times. If the new varieties have a shorter growing season and permit additional multiple cropping, there may be consequent overlapping of the harvesting and planting of successive crops with very sharp increases in seasonal labor requirements. Unless local labor markets are elastic, increases in demand for labor raise seasonal wage rates, which can quickly dampen the profitability of new technologies, particularly for farms that cannot get by with family labor alone. In this case, female-headed households may be at a disadvantage because they have fewer male members and fewer resources to buy outside labor. For example, in Malawi, inducements of credit and extension were not enough to overcome the problems of labor scarcity and perceptions of greater risk that impeded Malawian female-headed households from adopting an improved technology package for fire-cured tobacco and improved (mainly hybrid) maize (Abbas 1997). Even when family labor is not constraining for small farms, women's available labor supply may be quite limited due to many competing demands for their labor, thereby leaving them little time to manage new technologies.

Investments in improving natural resources (for example, construction of terraces, irrigation, water catchment areas, drainage, and regular composting) can be particularly labor demanding and may be too expensive to undertake in communities with limited access to labor. However, if many of these investments are carried out in the off-season when they do not compete directly with labor for agriculture, opportunity costs for labor may be lower. And in communities where men typically work in agriculture, public works—often financed through food- or cash-for-work programs—may offer outside employment opportunities for women, enabling them to earn cash that they can control (Ahmed et. al. 2009). Women's labor may be especially valuable in reforestation programs, where they can work on a piece-rate basis and

therefore spread out their labor to accommodate their domestic responsibilities (Quisumbing and Yohannes 2005).

Price Policy

The profitability of new technologies is affected by input and output prices, both of which are often influenced by government policies in developing countries. As such, policies that discriminate against agriculture have worked against the uptake of capital or cash-intensive technologies, although more recent devaluation and market liberalization policies have in many cases improved relative prices for traded agricultural goods and, therefore, induced adoption of technologies associated with them. Whether these changes in output prices provide enough incentives for female farmers to adopt new technologies associated with tradable agricultural goods depends crucially on patterns of intrahousehold decisionmaking—a factor often neglected in conventional studies of price policy. Simulations using data from Burkina Faso suggest, for example, that the increase in cotton supply is less in response to increased prices in households where husbands and wives do not share the same preferences (Smith and Chavas 2003). The authors argue that differences in preferences within the household, in the presence of imbalances in bargaining power between husband and wife, may be quite significant quantitatively and can thus be added to the list—along with market failures, poor infrastructure, and risk aversion—of potential structural constraints to agricultural supply response in West Africa.

Changes in relative prices as a result of structural adjustment have also been associated with increased price volatility for agricultural produce and the removal of many input subsidies, such as credit, fertilizers, and irrigation water; so the net effect on farm-level profitability can be quite mixed. The removal of input subsidies may have larger detrimental impacts on poor female farmers, who often do not have the same ease of access to credit as men. Women might not buy seed or fertilizer because the large packages are too expensive and too difficult for cash and labor-constrained women farmers, and reducing the size of packages (as in Malawi) can increase adoption by women farmers. Some of the recommendations from the recent implementation of a fertilizer voucher program in Malawi that would specifically benefit female farmers in other sub-Saharan African countries include not limiting the subsidy to maize but extending it to include all smallholder farmers, and providing farmers with more choices of inputs and fertilizer bag sizes to buy at subsidized prices (Quisumbing and Pandolfelli 2010).

Property Rights

Secure land tenure plays a key role in providing the incentives and authority for farmers to adopt technologies with long time horizons or payback periods, so that farmers have some assurance that they will benefit from the investments. Secure property rights can also provide collateral to obtain loans for investments (where credit markets operate). Lack of secure property rights is a factor not only at the household level but also within the households. While land rights vary enormously across countries and cultural contexts, women are often disadvantaged in both formal and customary land titling systems. For example, several studies suggest that women are less likely to adopt agroforestry because they lack rights to grow trees and secure land rights (Fabiyi, Idowu, and Oguntade 1991; Tonye, Meke-Me-Ze, and Titi-Nwel 1993; Diaw 1997; Fortmann et. al. 1997).

Women's insecure property rights to land may underlie differences in productivity between men and women. In Ghana, Goldstein and Udry (2005) attributed the productivity differential among male and female farmers to women's higher level of tenure insecurity, which renders them less likely to leave their land fallow since they risk losing the land if they are not actively farming it. Imperfections in land rental markets also create productivity differentials that are not gender neutral: Not only is productivity lower on female-headed households' land, but female household heads also tend to rent out their land to tenants with much lower productivity (Holden and Bezabih 2007). An important policy implication of their analysis is that strengthening women's land rights may improve both equity and efficiency of land use.

It is clear that any efforts to improve the productivity—and by extension often profitability—of female-managed plots need to be backed up by social and legal changes ensuring that women maintain control over said land and any profits the land may incur. Legal awareness is also important. Deininger, Ayalew Ali, and Yamano (2008) found that households' awareness of their land rights as defined by the 1998 Uganda Land Act, which strengthened tenure security and legal protection of customary owners and women, increased the propensity to undertake soil conservation measures. An increase of a household's legal knowledge by one element would potentially increase the propensity to undertake soil conservation that is equivalent to increasing the length of possession by more than 15 years or the head's level of education by more than 7 years. Moreover, because only a minority of land users are aware of these provisions, legal literacy campaigns can have a potentially large impact on agricultural productivity.

Collective Action

Working with groups is a major mechanism through which development programs can enable women to increase their control of assets, improve their productivity, and enhance their status and well-being. Membership in informal groups by women is especially high in Asia and sub-Saharan Africa. A recent study in East Africa (EADD 2008) found that 97.1 percent of men and 95.3 percent of women belonged to at least one informal group. In fact, the social capital that groups generate has been recognized as an important asset in itself. In both Kenya and India, women have been able to acquire property such as land through a group purchase scheme or through allocation by local authorities, which they would not otherwise access or control as individuals at the household level (Njuki 2001; Agarwal 1994, 2010). But building social capital is not costless. Women in poor households face particularly serious time constraints because of their various livelihood activities and childcare responsibilities. Membership fees may create a further barrier to participation by poor women who have limited control over cash (Meinzen-Dick and Zwarteveen 1998).

While women's membership in informal groups is relatively high in sub-Saharan Africa, their membership in formal cooperatives, which are an important mechanism for marketing, input, and credit supply, is quite low. In East Africa, a study of membership and registration patterns in dairy cooperatives indicated that only 27.6 percent of households who had registered in cooperatives had registered a female member; in Rwanda it was only 3.1 percent, and no females were registered as members of a dairy cooperative in Uganda. In most of the cases in Kenya and Rwanda where females were registered, they were in female-headed households (EADD 2008).

Institutional mechanisms that enable women to join groups and remain active members include allowing nonhousehold heads and non-landowners to be group members; timing meetings to accommodate women's workloads; ensuring that poorer women have opportunities to voice their concerns in group meetings; and soliciting women's feedback in project monitoring and evaluation (Pandolfelli, Meinzen-Dick, and Dohrn 2008). Women are also more likely to participate when projects directly incorporate their concerns. In the Philippines, attempts to have women monitor lake water to determine if soil conservation techniques were reducing silting were unsuccessful until project staff realized that women were more interested in health issues than in soil loss. When the project began to raise awareness about how water quality affected the health of families and the program expanded to include monitoring for E. coli, women's participation significantly increased (Diamond et. al. 1997).

Where strong gender segregation exists, working with existing women's groups may help facilitate entry into communities and allow women to retain control of project benefits, such as through programs of Grameen Bank and Bangladesh Rural Advancement Committee in Bangladesh or the Self Employed Women's Association (SEWA) in India. However, men will account for a minority of members in women's groups in some areas.

Gotschi, Njuki, and Delve (2008) in a study in Mozambique, however, found that although women in mixed-only groups may not have full benefits as members (such as equal opportunity in leadership positions), being in mixed groups provided access to more resources such as information and capacity building through the networks that the men in such groups are able to draw from external

sources. Women in mixed groups were more likely to have more contacts and more access to external organizations than those in women-only groups. The authors suggest that the use of women-only groups therefore solves only part of the gender problem with respect to collective action. Njuki (2001) found that women in women-only groups had lower education than those in mixed groups, were relatively older, and had no other source of income and livelihood besides farming.

Hambly Odame (2002) notes that in western Kenya, failure by an agroforestry extension project to understand the importance of men's role in the distribution of resources and benefits within women's groups led to a 67 percent rate of collapse during a 12-year period, often resulting in a loss of labor, capital, and moral support for group members. Where women's and men's motivations for joining groups differ, projects that encourage mixed-sex groups also may be less sustainable, particularly once external funding runs out. In other cases, mixed-sex groups may be more effective at meeting project objectives, especially when women and men are both key users of a resource. In Bangladesh, Sultana and Thompson (2008) found that compliance with rules limiting fishing in protected areas is higher when both men and women are actively involved in fishery management groups because women, who control catches, exert pressure to ensure compliance with fishing rules, while men patrol the fish sanctuaries at night when it is unsafe for women to do so. In Madhya Pradesh, India, when women belong to forest protection committees, participate in committee meetings, and patrol the forest, control of illicit grazing and felling increases by 24 percent and 28 percent, respectively, and the regeneration of allotted forest also increases by 28 percent (Agrawal et. al. 2006). In the highlands of central Kenya, where women are regarded as more trustworthy than men with money, Kariuki and Place (2005) report that men express more satisfaction with the group's financial management in mixed-sex groups than they do in all-male groups, because men are perceived as being more vulnerable to corruption.

Culture and Other Conditioning Factors

Some technologies appear to be more easily adopted by women than others; however this varies widely based on context and culture. For example, in Bangladesh, Hallman, Lewis, and Begum (2007) found that women are more easily able to adopt improved vegetable varieties for homestead production than group polyculture fishpond technologies because the former activity does not require women to leave their homestead and potentially expose them to sexual harassment. Had a similar intervention been conducted in parts of Africa where women's mobility is less restricted or threats of sexual harassment are not as great or take different forms, the results of the intervention may have been quite different.

Sociocultural norms and conceptions have an important role to play in determining women's access to and ability to use important technologies. Pender and Gebremedhin (2006) note that in Ethiopia strong cultural norms prevent women from plowing fields, thus disadvantaging women without adolescent or adult sons who must hire additional labor to plow the fields. In Nigeria, a pedal-operated, bicycle-mounted rice thresher was rejected by female processers because using the thresher exposed women's thighs, and wearing trousers was not a culturally appropriate alternative in the region (UNIFEM 1993). In addition, perceptions that women are not "real" farmers may also impede women's access to credit, extension, and land (Doss 2001). As Doss (2001) notes in her review of designing technology for African female farmers, there is enormous diversity and complexity between different African villages, let alone countries; thus, interventions that work in one context, culture, or country very well may not in the next.

8. EVALUATION

Evaluation of the outcomes of agricultural R&D is necessary to ensure that systems are meeting the needs of the poor. It is all the more critical at a time of change to ensure that evaluations feed back into the systems so that institutions adapt to changing conditions. Because attention to the needs of women has not always been central to agricultural R&D, it is even more important now to ensure that gender is integrated into the evaluation and impact assessment systems and that this, in turn, feeds back into future priority setting, conduct, and extension of agricultural R&D.

Integrating Gender in Evaluation of Agricultural Technologies

Given that men and women have different roles and responsibilities, it is not surprising that research indicates they also have different preferences when evaluating new technologies or practices for potential adoption. Preferences are conditioned by the end use of the crop, whether it will be sold right away (yield and profitability) or used for home consumption (storage, taste, and processing). Bellón et. al. (2007) looked at men's and women's differential preferences for grain characteristics in Oaxaca and Chiapas, Mexico, and found that traits related to vulnerability (tolerance to drought, resistance to rot, and resistance to pests) are significantly more important to poor female farmers than to their male counterparts. In general, consumption characteristics were more relevant for women than for men, a reflection of the women's role as subsistence farmers and household food providers. Smale's (1995) work on farmer preferences in Malawi found that while hybrid maize improved yields for sale, traditional maize stores better and ultimately provides better yields for household consumption. Given that households produce for both sale and personal consumption, there are obvious trade-offs.

Within the African context, the standard explanation is that men are responsible for producing the cash crops, and women, the food crops (Koopman 1993); thus, differential preferences stem from such divisions. However, Doss (2002) has critiqued such characterizations by providing evidence that both men and women are involved in cash and food crop production. Moreover, food crops can be sold for cash if marketable surpluses exist. Nonetheless, it is clear that differential gender preferences do exist, and this needs to be taken into account when introducing new technologies.

Ultimately, gender norms, and roles are all dynamic. As women's activities become more lucrative as a result of adoption of new technologies, traditionally female tasks may be taken over by men—or women may move into spheres formerly controlled by men. Unfortunately, examples of the former are more common, as illustrated by an example from Gambia, where Schroeder (1993) found that women lost control of communal vegetable garden plots after an environmental stabilization intervention. Following the intervention, men asserted control over plots, a traditionally female domain, because of the lucrative new fruit trees, fenced enclosures, and improved soil. As a result, women lost an important source of income and bargaining power.

Several studies indicate African women's burdens actually increase with the adoption of new technology (Suda 1996; Berio 1984). Authors suggest with the onset of new technology women must take on additional and highly time-consuming tasks or process increased levels of output. For example, in Malawi and Zambia, women, who are in charge of processing, reported hybrid maize was more difficult to pound and this became a more time-consuming, arduous task (Jha, Hojjati, and Vosti 1991; Hirschmann and Vaughan 1984).

Nonetheless, Doss (2001) points out that in certain instances increases in women's labor and time availability come with a corresponding increase in responsibility and control over output. For example, in western Ghana, Quisumbing and colleagues (2001) found that a new land transfer practice has resulted where husbands transfer land to their wives in exchange for labor on cocoa fields. This change has come about as result of increased incentives to adopt cocoa, which uses women's labor intensively, owing to increased profitability. Ultimately, it is difficult to predict the impacts of interventions without a thorough knowledge of the culture and context. That is why it is essential to have evaluation systems that will identify the positive and negative impacts of agricultural R&D on gender relations, and can feed back that

information to help adapt priorities for future agricultural programs. Moreover, capturing the full impact of agricultural technologies on lives and welfare requires going beyond narrow indicators of productivity, particularly in capturing the impact on women.

Toward Indicators for Gender-Equitable Agricultural Research

The many studies that have found gender-differentiated determinants of technology adoption as well as differential impacts of new technologies by gender provide compelling justification for the adoption of gender-sensitive indicators for prioritizing technologies for development and dissemination. While the specific criteria will vary by culture, context, and agroclimatic zone, among others, the most important overarching principles for evaluation are as follows:

- The extent to which women are involved in the crop or sector in terms of production, marketing, or processing has not decreased (or has increased) as a result of the program
- Reduction of gender disparities in access to productive resources and control of incomes as a result of the program
- Improvements in diets or nutritional status of individuals, particularly in areas where there are marked gender disparities in nutritional status / nutrient adequacy

Table 1 provides more detailed gender-sensitive indicators with which to evaluate new agricultural research emerge, that are relevant to specific stages in the research innovation process, these are intended to go beyond a simple yes/no checklist, to lead to consideration of how gender issues are taken into account at each stage of the research, development, and extension processes. We also introduce two indicators of cost-effectiveness: (1) Scheduled number of contacts between principal researchers and female experimental subjects/farmers per $100,000 research funds expended; and (2) Scheduled and actual visits between male and/or female extension agents and female farmers per $100,000 research funds expended. Indicators of cost-effectiveness allow policymakers to evaluate alternative approaches to accomplishing a specific target. The first indicator attempts to measure the extent to which scientists take into account views of female farmers and stakeholders. The second allows for the possibility that, in countries where there is a shortage of female extension staff, it may be more cost-effective in the short-term to train the existing cadre of male extension agents to work with female farmers, but more cost-effective in the long term to recruit and train female extension agents. Given that gender is context-specific, and that implementers in the field may have to adjust the design of interventions to specific conditions, a cost-effectiveness criterion provides another way of ranking alternative approaches.

It is important to consider both what is evaluated and how it is done. Evaluation, adoption, and impact assessment studies have often focused on household-level indicators and collected the data from male heads of households, often using standard and predetermined indicators. In a project in Malawi, Njuki et. al. (2008) report using community indicators to evaluate research for a development program. Men and women had different indicators for similar objectives and different perceptions of the extent to which the project had achieved these objectives. This underscores the need in evaluation and impact assessment studies to interview both men and women and to have gender-specific indicators.

Table 1. Suggested indicators of gender-responsiveness in agricultural research

Identification of the Target Population
Use of basic demographic data, by age, sex, education, and sex of household head, to characterize target population (for example, # female and male farmers, sex of household head, literacy or numeracy rates)
Proportion of female and male beneficiaries reflect their proportion in the population
Consultation of male and female stakeholders to determine priorities for technology development; representation of men and women in stakeholder groups in proportion to their population shares
Consideration of cultural, social, religious, or other constraints to women participating in and benefiting from the agricultural intervention, inputs, or outputs of the research program
Women's and Men's Roles in Production and Marketing Systems
Consideration of impacts of agricultural technology on men's and women's time use, roles in on- and off-farm work, family care, and other main tasks in the household and the community
Consideration of impacts of agricultural technology on labor of boys and girls (and schooling attendance of boys and girls)
Consideration of impact of agricultural technology on agricultural decisionmaking (whether by men, women, or jointly) in production, marketing, processing, and control and disposal of income
Consideration of men's and women's different motives and preferences for specific crop and livestock species
Consideration of men's and women's access to and control of productive resources (land, physical assets, irrigation, animals) and identification of opportunities to reduce gender gaps in assets
Gender in the Innovation process
Involvement of women in setting priorities for technology development, drawing on farmer sources of innovation and dissemination, and indigenous technical knowledge
Active participation of women in farmer field schools, extension groups, and dissemination activities
Participation of rural men and women in evaluation of technologies using mechanisms that allow women to participate and speak freely
Use of evaluation criteria that reflect not only yield considerations but also postharvest characteristics such as perishability, ease of transformation, nutritional value, and taste
Gendered Access to Productive Resources and Services
Consideration of gendered access to and control of productive resources and services that may influence men's and women's differential adoption of new technologies (whether women have access to land, irrigation, credit, other inputs, extension services; whether women can grow these crops on their parcels; whether this affects production of their existing crops or vegetables)
Consideration of strategies to address women's constraints to obtaining access to land or credit
Consideration of possible gendered constraints to adoption of technology (including access to information, access to extension services, cultural norms, different preferences)
Provision of training and expertise for crops women farm, animals women raise, and tasks women perform; consideration of means to relieve additional constraints to women's mobility that may impede attendance at training events (transport time and costs, child care, restrictions on mobility, cultural barriers preventing interaction with extension workers)
Training of female extensionists, balance in gender ratio of extension agents, and women trained as lead farmers
Access to New Technologies
Consideration of who owns, controls, uses, and supplies the existing agricultural technologies in the community (for example, seeds, fertilizers, vaccines, equipment, processing and post harvesting technologies, irrigation technologies)
Consideration of how new technologies will be marketed to men and women and whether different strategies need to be developed to reach them
Impact of New Technologies
Design of gender-appropriate components of the proposed technical packages, messages, and technologies
Consideration of the impact of technology introduction on gender division of labor (men, women, girls, boys)
Consideration of the impact of technology on the environment and natural resource use by men and women

Farmer Organizations
Consideration of differences in participation of women and men in social, community, and farmer organizations that exist in the project areas and influence resource distribution
Design of strategies to ensure that women have the skills and self-confidence needed to articulate their concerns and that their input is incorporated into project design, implementation, and evaluation
Consideration of whether there is an opportunity to support or grow preexisting women's organizations or to create new ones in areas where gender segregation precludes the establishment of effective mixed-sex groups
Institutional Capacity
Whether CG centers, NARS, and partners have capacity in gender analysis to address gender issues throughout all stages of the project cycle Key indicators that they have the understanding or capacity are as follows: • Whether goals, purposes, or objectives of the program explicitly reflect women's needs and priorities • Whether assumptions at each level of the planning framework reflect the constraints on women's participation in the program, including how cultural norms and practices related to gender and intrahousehold or community-level issues may inhibit the success of the project • Whether potential risks are understood and addressed on how the project may further exacerbate gender inequality (for example, men's appropriation of activities and increased income or increases in gendered conflict) • Whether project performance indicators identify the need for data to be collected disaggregated by gender • Whether performance appraisal system for project staff includes performance objectives related to women and girls' involvement and success • Whether monitoring and evaluation system includes specific and measurable indicators related to women and girls' involvement and economic, social, educational advancement
Whether there is gender balance in project staffing at all levels, or whether systematic efforts are being made to redress the shortage of women in trained positions
Whether policies and programs exist to ensure women's participation and voice in partner organizations
Monitoring and Evaluation
Whether the program has a gender-sensitive monitoring and evaluation system in place, including a gender-disaggregated data collection and analysis strategy
Whether the program includes measurable indicators for the attainment of its gender objectives to facilitate monitoring and postevaluation Some suggested substantive (content) indicators are as follows: • Changes in time/labor requirements for women/men and girls/boys • Control over resources or income by women and men • Level of gender conflict/violence • Household food security, individual food security, nutritional status of girls and boys • Girls' attendance at primary and secondary schools relative to attendance of their cohorts Administrative (process) indicators could include participation of men and women in implementation and among beneficiaries
Whether proposed methods for monitoring and evaluation ensure that views of male and female stakeholders are heard and that research results are fed back to stakeholder groups (including communities where research is undertaken)
Budget
Budget items reflect adequate resources for gender-specific activities and strategies to ensure that services are delivered to women and men and that gender is integrated throughout the research/project cycle
COST-EFFECTIVENESS OF RESEARCH AND EXTENSION EFFORTS
Scheduled number of contacts between principal researchers and female experimental subjects/farmers per $100,000 research funds expended
Scheduled and actual visits between male and/or female extension agents and female farmers per $100,000 research funds expended

9. CONCLUSIONS AND WAY FORWARD

A Revitalized Agricultural Research System

The core of this paper has discussed how the agricultural research system, which focuses on the generation of improved production technology and its dissemination, can be revitalized to better meet the needs of all farmers—male and female. Reorienting the agricultural research system to be more gender responsive requires being more aware of the different needs and preferences of male and female farmers; the different roles that men and women play in the production and marketing process; differential access to and control of productive resources; differential constraints that female farmers may face in adopting new technologies, including time constraints owing to domestic responsibilities and nonmarket production; the representation of male and female scientists and extension agents in the agricultural research and extension systems, among others. In most cases, the distribution of private and public resources has ignored or disadvantaged female farmers. In this paper, we have argued for ways that the agricultural research system and its partners can make a difference. These include

- Identifying the strategic priorities for gender-equitable agricultural research. In many cases these strategic priorities may lead to new emphasis, for example, more on foods contributing to diverse and nutritious diets, or require addressing underlying gender inequalities in access to resources in order to unleash the full productivity of millions of women agricultural producers.
- Fully integrating gender into the agricultural R&D system, including priority setting, conduct of research and development, extension, adoption, and evaluation of outcomes.
- Transforming the enabling conditions, including institutional structures and policies for gender-equitable agricultural research.

Research on gender mainstreaming across a range of development organizations has found that to be successful, four enabling factors are necessary: political will, technical capacity, accountability, and organizational culture (James-Sebro 2005). Political will refers to the ways in which an organization's leadership conveys the importance of, and expresses its support for, the integration of gender, including the inclusion of gender in policy documents and the allocations of funds. Technical capacity refers to the professional qualifications and skills staff have to integrate gender into their work. Yet even if these skills are present, accountability mechanisms need to be in place to ensure that staff operationalizes the institute's commitment to gender integration. Such mechanisms include monitoring and evaluation of gender results and staff incentives. Finally, organizational culture refers to creating an environment supportive of gender integration, one in which staff are encouraged to share lessons learned on gender and to ask questions about its relevance to their work.[12]

Involving Women in Agricultural Research and Development

Key to revitalizing the agricultural research and development system is increasing the number of women involved in the system. We need to increase the number of female scientists at national and international agricultural research centers, as well as in extension systems. There are simply not enough women employed in agricultural research and development. The numbers cited above are a woefully small proportion of the number of women in the agricultural sector, as well as in the population at large. Even as female secondary and tertiary enrollment increases, particularly in the sciences, the growing pool of trained female scientists will be underutilized if employers in both the public and private sectors do not hire them. Successfully addressing gender issues will require increasing the number of women employed in national, regional, and international agricultural research institutes, as well as providing them the

[12] Drawn from the Gender Audit Questionnaire Handbook. 2003. Washington, D.C.: InterAction

incentives and structures needed to succeed. In many cases this will involve addressing employment conditions and institutional structures to ensure that women can succeed and become more involved in higher-level decisionmaking.

But we also need to recognize and increase the involvement of women farmers and consumers themselves. The knowledge and experience of women farmers is a valuable resource that the agricultural R&D system needs to tap. Involving women in participatory research can provide a bridge between local knowledge and formal systems. But their involvement should not only be left in "downstream" or adaptive research: It is also crucial to include women's voices (for example, through women farmers' associations) in priority-setting processes to ensure that their needs are met.

Beyond Production Technology

Throughout this paper, we have also argued that creating a gender-responsive agricultural research system means going beyond the traditional boundaries of crop-oriented research and revising the way we think about gender roles throughout the agricultural sector. A gender-responsive agricultural system not only addresses the gender differences in needs and priorities in all aspects of conventional agricultural research and development, but it is also able to stimulate thinking beyond production agriculture to consider the following issues.

Gender roles in natural resource management: A narrow focus on production technology often neglects the natural resource base—trees, soils, water, agrobiodiversity, and other natural resources—that men and women manage. But here we need to look beyond the narrowly defined agricultural uses of these resources to also consider domestic uses of water, the energy needs of women for cooking fuel, and how these impact forest use, carbon emissions, and the like. Although outsiders may segment these into different departments, for rural people, and women in particular, the lines between productive and domestic uses of resources are not distinct.

An expanded concept of the food sector: The food sector is broader than crop production, also including fish, livestock, garden production, and water. Most agricultural research is devoted toward increasing yields of staple crops, often neglecting vegetables grown in home gardens, despite the important contributions these make to household consumption and nutritional status.

Postharvest processing: Postharvest processing needs to be considered, not only for reaching high-value markets, but also for reducing food losses, preserving nutrient content of food, ensuring food safety, reducing drudgery, and releasing women's time for other activities.

Value chains: Even though most of the leading donor institutions have adopted value chain approaches as a strategy for enhancing economic growth and reducing poverty, until recently, very few have considered how gender issues affect value chain development (Rubin, Manfre, and Barrett 2009). It is now increasingly recognized that the introduction of new technologies can affect the on-farm division of labor and that the adoption of high-valued crops can alter men's and women's control of resources within the household; however, the gender dimensions of the link between household and market is relatively less understood. As agriculture becomes commercialized and market linkages become formalized, household dynamics may be affected (Rubin, Manfre, and Barrett 2009). Even if the agricultural research system is not involved in all stages of the value chain, understanding gender issues in value chains can help identify leverage points at which interventions can avoid transferring income or control from women to men, and even generate positive gender outcomes, while meeting the goals of improved efficiency and poverty reduction.

Linkages to health and nutrition: A gender-responsive agricultural research system recognizes the strong linkages between agriculture, research, and nutrition. Agriculture can play a critical role in improving the nutritional quality and diets of the poor by recognizing that men, women, and children have different biological needs for macro- and micronutrients. Agricultural research can improve access to—and utilization of—inexpensive, nutritious, and diverse foods to improve nutrition outcomes, while also improving food security and health outcomes. Agricultural research can also pay closer attention to agriculture–health linkages, particularly to help fight infectious diseases. Most of the world's emerging

diseases are zoonotic, transmitted between animals and people. Animal diseases that decrease meat and milk production also strongly impact human health. Recognizing the important roles of men and women in livestock production would help mobilize them to prevent the spread of zoonotic diseases, or arrive at more gender-equitable risk-mitigation mechanisms. Similarly, better water management can reduce waterborne diseases or those, such as malaria and schistosomiasis, with water-related vectors. Reducing the burden of ill health also alleviates women's time burdens.

Supporting policies and institutions: For the agricultural research system to think broadly to encompass issues of gender equity requires a supportive institutional and policy environment. Strengthening women's property rights or rights under family and civil law can give women greater incentive and ability to invest in the land, have bank accounts, or obtain credit. Collective action institutions can play a major role, either through women's organizations or through ensuring that women are fully included in farmers' associations, water user groups, forest committees, or local decisionmaking bodies that manage natural or financial resources and services.

Necessary Partnerships

All of this is an ambitious agenda. Serious work for poverty reduction must be ambitious and multifaceted. Addressing gender in agricultural research and development must be a shared endeavor. No single type of organization can be solely responsible, but neither should any be exempt from responsibility for considering how their work will affect women as well as men. What is needed is real partnerships between international research institutions such as the CGIAR, national agricultural research systems, universities, NGOs, government agencies (including not only agriculture but also other sectors such as women's affairs), and the private sector, bringing to bear the expertise of each in a variety of combinations to meet the wide range of situations.

The first step is to increase awareness that gender issues are not peripheral to agriculture but are fundamental to increasing productivity, incomes, nutrition, sustainability, and ultimately the contribution of agriculture to poverty reduction. Both research and firsthand experience play an important role in generating this awareness. Statistical and impact assessment agencies need to be involved to ensure that the data and methods are developed to capture gender differences in needs, contributions, and outcomes.

The second step is to ensure that those who set priorities, those who implement and disseminate research, and those who evaluate the impacts of agricultural R&D can identify the relevant gender dimensions of their work. As a result, paying attention to gender will no longer be seen as the responsibility of a small group or something that people do in their spare time as an addition to their "real" work, but will be seen as an integral part of excellence in agricultural R&D. This, in turn, requires strengthening the capacity of all involved, linking contextual knowledge about gender relations to broader patterns and even global lessons.

Political will and supportive structures are needed that create accountability; make financial, human, and time resources available for this; and recognize and reward excellence in these endeavors. There are costs to addressing gender and expanding the clientele of the agricultural research and development community to include women farmers and consumers on a par with men. However, the returns are also significant, not only in terms of productivity but also food security, nutrition, environmental sustainability, and long-term poverty reduction. Mechanisms are needed to share lessons from countries and programs that have made significant strides toward gender equity: What motivated these changes; what key changes were made; and what outcomes have they seen for women, their families, and society as a whole? The agricultural sector is not alone in this; much can be learned from experiences with gender integration in other sectors and development agencies (Moser and Moser 2005; Rao and Kelleher 2005) that share with agricultural research and development the objectives of fighting poverty and hunger while conserving the environment.

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