Food and Agriculture Organization of the United Nations

GENDER-SPECIFIC APPROACHES, RURAL INSTITUTIONS AND TECHNOLOGICAL INNOVATIONS

IDENTIFYING DEMAND- AND SUPPLY-SIDE CONSTRAINTS AND OPPORTUNITIES IN ACCESS, ADOPTION AND IMPACT OF AGRICULTURAL TECHNOLOGICAL INNOVATIONS

Gender-specific Approaches, Rural Institutions and Technological Innovations

Published by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the International Food Policy Research Institute (IFPRI), and the Global Forum on Agricultural Research (GFAR)

Written by

Catherine Ragasa and Debdatta Sengupta from IFPRI,

and Martha Osorio, Nora OurabahHaddad, and Kirsten Mathieson from FAO

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 2014

FIGURES

BOXES

ACKNOWLEDGEMENTS

Gender-specific Approaches, Rural Institutions and Technological Innovations was prepared by the Development Strategy and Governance Division and the Environment and Production Technology Division of IFPRI, as well as the Social Protection Division (ESP) and the Office for Partnerships, Advocacy and Capacity Development (OPC) of FAO.

It has been written by Catherine Ragasa and Debdatta Sengupta (IFPRI); Martha Osorio, Nora OurabahHaddad, and Kirsten Mathieson (FAO). Comments and inputs have been provided by Marcela Villarreal, Eve Crowley, Mauro Bottaro and Boris Gandon (FAO), Ruth Meizen Dick and Mark Rosegrant (IFPRI).

The study was funded through the Global Forum on Agricultural Research (GFAR) and the Gender, Equity and Rural Employment Division (ESW) of FAO, as an activity of the Gender in Agriculture Partnership (GAP).

LIST OF ACRONYMS

AIS	Agricultural Innovation System
AWARD	African Women in Agricultural Research and Development
DRC	Democratic Republic of Congo
FAO	Food and Agriculture Organization of the United Nations
GFAR	Global Forum on Agricultural Research
GMO	Genetically-Modified Organisms
HIV and AIDS	Human Immunodeficiency Virus and Acquired Immunodeficiency Syndrome
ICT	Information and Communication Technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
Lao PDR	Lao People's Democratic Republic
NGO	Non-Government Organization
SAFE	Sasakawa Africa Fund for Extension Education
SEWA	Self-Employed Women's Association
SOFA	State of Food and Agriculture
WFP	World Food Programme

EXECUTIVE SUMMARY

This paper reviews and integrates findings from existing empirical studies and case studies received from 35 organizations in various countries to identify demand- and supply-side constraints and opportunities in access, adoption and impact of agricultural technological innovations. The most common technologies studied are improved seeds, fertilizers, farm mechanization, improved management practices, transporting technologies, and information and communication technologies. This review consistently finds that women have much lower observed rates of adoption of a wide range of technologies than men; and these are mainly due to differentiated access to complementary inputs and services. There are limited studies that looked at upstream stages including priority-setting and innovation processes, in which women continue to be underrepresented.

Over the years, the development community and local organizations have been actively working and finding solutions to improve tools and approaches to bring technological innovations closer to poor women and men farmers and making sure that they are involved from the research priority-setting and technology development. There are a number of supply- and demand-side opportunities and promising pilots, and are synthesized in this paper.

Key messages

- Female heads of households and plot-managers are less likely to adopt a wide range of agricultural and rural technologies than male heads and plot-managers. The most commonly-cited reasons and results of statistical analyses for this gender gap in technology adoption are greater time and labor constraints; relatively less access to funds and credit; more limited information, education and training; more limited capacity and opportunity for participation in innovation and decisionmaking processes; and more limited access to accompanying inputs and services. These are influenced by weak design or implementation of legislation that protect rights and promote equal playing field and by the persistence of social biases and cultural norms limiting equal access and opportunities for women and men.

- Although various labor-saving and energy-saving technologies could have huge potential to reduce considerable time burden of women and increase labor productivity in general, empirical studies show that their use and adoption among rural women has not always been high and usually much lower than men. Three reasons are commonly highlighted as reasons for this gender difference: (1) culturally-appropriateness; (2) physically accessibility; and (3) affordability. In some cases, the adoption of improved productivity-enhancing technologies has increased women's time burdens. The most commonly-cited

reasons for this is the relatively weaker participation and engagement of women farmers and stakeholders than men in priority-setting and research processes, limiting women's ability and opportunity to influence the nature and development of technologies being produced.

- In terms of ICT, men are more likely to use the Internet and to have an email address than women. There is a more promising pattern of rural women accessing and using radios for agricultural information, although men still are more likely to own and control their use. The relative difference between men's and women's access to and usage of mobile phones is diminishing, although studies have shown that in rural areas, men are more likely to own and have access to phones than women, who have greater levels of illiteracy, cultural barriers, and less available cash and access to credit.

- There is increasing attention in the literature that women and men farmers are innovators and doing their own farm experimentation. Several innovation funds are being provided in various countries and showing some promise in providing incentive for farm experimentation for women and men farmers. There are ample evidence of the role of rural institutions and innovative producer organizations in using collective action to address access and liquidity issues and in reducing gender gaps in technology adoption and productivity increases. Moreover, experience suggests that farmer-innovators benefit more if they are linked with effective and responsive support research and extension institutes. These institutions need to be strengthened and supported by creating a conducive rural business climate and linking them to lucrative markets.

- At the support organizations level, there is evidence of weak capacity and incentive of innovation organizations and their staff to be more effective and responsive to the needs of both women and men farmers. Numerous attempts of participatory and consultative approaches seem to lack evidence of significant broad-based impact on technology adoption and gender-equitable outcomes. But, there remains overwhelming underrepresentation of women as scientists, educators, graduates, managers and extension agents. Several initiatives to increase more women graduates, scientists and extension agents are increasingly being implemented, but more need to be done.

Recommendations

- Strengthening capacity of women and men farmers as innovators, evaluators of technologies, and key partners in innovation processes.

- Building measurable targets and strengthening the monitoring and evaluation to ensure that (1) planning and innovation processes addresses women and men's needs,

preferences and opportunities; (2) women and men can access and use these technologies; and (3) women and men benefit from these technologies.

- Holistic and integrated approach of looking at constraints to production and marketing and paying close attention to the complementarities of inputs and services.

- Promoting equal playing field: It will also be important to strengthen women's land, property and water rights. Affirmative action is needed to ensure that more girls are going to school and more women professionals are getting equal opportunities as men in the area of research, extension, and education systems. This emphasis on women's education is important to ensure a pool of well-qualified women candidates for leadership and management positions in organizations. However, quota systems, focal points, and gender-balanced staffing in research, extension and education organizations do not often work without genuine empowerment among women professionals including confidence-building, greater mobility, decreasing time burden, training and capacity strengthening.

- From the research perspective, more attention to gender-disaggregated data and gender analysis in mainstream research is needed. More studies are needed that provide nuanced categorization and analysis on gender and addresses the diversity and typologies of women and men farmers.

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INTRODUCTION

Two thirds of the world's poor live in rural areas and depend on agriculture and the food sector as their main source of livelihood. Increasing agricultural productivity, availability of rural employment and sustainable rural livelihoods are key to reducing poverty and decreasing the number of food insecure worldwide. Broad increases in agricultural and labor productivity will raise incomes of the rural poor and reduce food prices, which govern real incomes and poverty in urban areas and generate important spill-over effects to the rest of the economy. However, the growth in the agriculture and rural sectors in many developing countries is undermined by gender-related constraints and unequal access to productive resources and opportunities (World Bank, FAO and IFAD 2008; FAO 2011). The gender inequality in various sectors and in many developing countries imposes costs on society in terms of untapped potential in achieving agricultural output, food security and economic growth. This is the very reason why strategies and approaches promoting gender equality in productivity and access to productive resources and economic opportunities are increasingly becoming high on the development agenda. This will not only lead to the empowerment of rural women and men, but it is also important for agricultural and economic development as a whole.

This paper explores in detail the recent evidence on gender gaps in technology adoption and impacts of these technologies on women's and men's agricultural and labor productivity and access to economic opportunities. This paper answers the two specific research questions: *(1) Are there systematic differences in technology access and adoption between women and men? (2) Do women and men affected by technologies differently?* Answering these questions will help provide gender-sensitive recommendations on a bigger policy question on: *"How can we improve the adoption of improved and beneficial technologies by men and women producers and ensure their needs and specific constraints are taken into account in the planning and innovation processes?"*

This paper adds value to existing literature on gender in agriculture and rural development (e.g., the Gender in Agriculture Sourcebook; Promising Approaches in Reaching Poor Women Farmers; Engendering Agricultural Research; and SOFA 2010-2011 on Women in Agriculture) by looking more closely at agricultural and rural technologies, rather than a generalized and broad discussion on these technologies. Technology is a complex concept, deserving a more disaggregated and nuanced analysis. This paper contributes by developing a framework that systematically looks at both supply and demand sides of technology and service provision and applies this framework to draw key messages and lessons from rural projects and programs using a gender lens. In particular, it looks at the organizations and institutions that link the demand and supply sides and explores how they could be more responsive and supportive of technology adoption among women and men farmers. It looks at the role of rural institutions (both formal and informal); emerging institutional arrangements (such as

contract farming, public-private partnerships, innovation networks, and multistakeholder platforms); and the role of information and communication technologies (ICT) in increasing the flow of knowledge, productivity and incomes of poor women and men farmers.

Another added value of this paper is its focus and in-depth investigation of the continuum of technological development, adoption and impact. While technologies are intended to be productivity-enhancing, value-adding, and labor-, energy- or cost-saving, not all technologies are beneficial and responsive to the needs of poor women and men or their expected users. Available evaluation and impact assessment studies throughout this paper suggest that technologies do change the division of labor and can sometimes do more harm to poor women or men than good and this can also explain why technologies are adopted (or not) by men and women (for example, Fisher, Warner and Masters, 2000; Venter and Mashiri, 2007; Rao, 2002; Maguzu *et al.*, 2007; and World Bank, FAO and IFAD, 2008). These objectives of the paper are accomplished by conducting an extensive review of relevant literature and synthesizing the lessons learned from the 35 cases received from a joint call for case studies by IFPRI and FAO.

Following this introduction, the definition, scope, data sources and conceptual framework are presented. Then, the review and analysis are organized as follows: (1) gender differences in technology access and adoption; (2) demand- and supply-side constraints in technology adoption, as well as constraints in bridging institutions and policy environment from a gender lens; and (3) promising demand- and supply-side policies, strategies and opportunities for increasing the adoption and impact of technologies on poor women and men producers and consumers. The paper ends with a discussion of lessons learned and conclusions.

Definition and Scope

In this paper, we define technologies as "practices or techniques, tools or equipment, know-how and skills, or combinations of the aforementioned components" (http://teca.fao.org/technologies accessed September 16, 2011) that are used to enhance productivity, reduce production and processing costs, and save on scarce resources or inputs, such as labor or energy. This paper looks at technologies along the continuum from farm to fork, with a particular focus on food chain stages where women are more involved (e.g., processing and home production). The type of technologies, improved practices and innovations it examines are as follows:

- Production technologies (e.g., improved varieties and seeds, improved production or natural resource management practices, fertilizer, pesticides, knapsack sprayers, plows, irrigation, and other farm power) ;
- Harvesting technologies (e.g., hand tools, reapers) ;
- Post-harvest operations and processing technologies (e.g., solar drying equipment, threshers, improved marketing or processing practices) ;

- Labor-, time- and energy-saving technologies for household tasks (e.g., fuel-efficient stoves, key-hole gardens, technological and institutional innovations for greater access to water and energy) ;

- Rural transport (e.g., hand carts, bicycles, motorized transport) ;

- Information and communication technology – ICT (e.g., mobile phones, rural radio, internet, television, print media).

We further group these technologies into (1) intangibles (knowledge-based or management practices); (2) tangibles or physical technologies; and (3) biological technologies incorporated in the seed or planting materials. This classification can highlight the complementarities among these technologies and may have different implications for the relative role of institutions and organizations, adoption decisions, and access of these technologies. For example, improved knowledge-based management practices, information and extension systems (intangibles), and ICT (intangibles and tangibles) can help facilitate adoption of the biological and physical technologies. Physical infrastructure, transport and distribution system (tangibles) can facilitate access and adoption of other tangible and biological technologies, and mobility of frontline professionals who deliver information and intangible technologies.

We define "gender" as (1) gender of household head; or (2) gender of farmer or decision-maker in the plot. We make a careful analysis and reference to which specific definition in order to have nuanced analysis and avoid pitfalls and confusing interpretations in numerous studies as highlighted by Doss, 1999, 2001; Quisumbing and Pandolfelli, 2009; Peterman, Behrman and Quisumbing, 2010; Peterman *et al*., 2010. We explicitly specify the categories of people by gender rather than generalizing as "gender." Different gender categories used in the literature are (1) male and female heads of household, who can be further categorized as de facto or de jure female heads; (2) male- and female-headed households with or without any female or male adult member; and (3) female and male farmer, who is the decision maker in the plot, and can be in the same household. We also categorize female and male heads or farmers by age, marital status, education level, household size, and land holdings, whenever information is available from past studies.

Rural institutions include both formal and informal structures. Following Uphoff (1986: 8-10, quoted in Uphoff 1997: 6), "Institutions are complexes of norms and behaviors that persist over time by serving some collectively valued purposes, while organizations are structures of recognized and accepted roles, formal or informal." An institution may be embodied in an organization, but some institutions are sets of rules that persist without structured roles. Rural institutions and innovative producer-based organizations analyzed in this paper include farmers' groups or associations, information and social networks, multistakeholder and innovation platforms, water-user associations, self-help groups, public-private partnerships, warehouse receipt system, and other interlinked and contractual arrangements that engage small farmers with private firms and lucrative markets. Support

organizations include research and extension institutes that provide technical assistance and services to farmers.

Data sources and Methods

This paper is based on the review of literature from 2000 onwards on gender-sensitive projects and programs on technological innovations. The literature reviewed includes peer-reviewed publications and selected grey literature that provides useful insights and value addition to the discussion of issues and opportunities for improving technology adoption and impact on the poor. This paper builds on existing reviews by Doss (1999; 2001), which focuses on Africa and agricultural production technologies, and by Peterman, Behrman and Quisumbing (2010), which review microeconomic papers on non-land agricultural production technologies from 1999 to 2009. In this paper, we review additional empirical papers and we examine other technologies (that is, post-harvest and processing; homestead food production systems; ICT and rural transport) to complement the findings of earlier reviews. A number of examples and analyses from these past reviews are still cited in this paper whenever they are most relevant in the discussion.

This review paper extensively looks at impact assessments and evaluation studies related to technologies that have gender-disaggregated data and analysis. However, our review highlights that gender is largely absent from impact assessments, particularly in the context of agriculture and natural resource management.

With the aim of casting the net more widely, this literature review is complemented by a call for case studies that was widely disseminated through a range of networks, electronic channels and social platforms. These networks covered inter-governmental and other international organizations; civil society organizations (in particular producer organizations); research institutes; and non-governmental organizations (NGOs) that are working with and for farmers (following FAO's definition which includes agriculture, forestry, livestock and fishery), with an emphasis on the grassroots level. There were 35 case studies that were received from various countries, namely Burkina Faso, Burundi, Cameroon, Democratic Republic of Congo (DRC), Equatorial Guinea, Ethiopia, Malawi, Niger, Nigeria, Senegal, Tanzania, Uganda, and Zambia in Africa; Cambodia, China, India, Malaysia, Nepal, and Philippines in Asia; and Bolivia, Ecuador, Uruguay and the Andes and Latin America in general. Most of these are small cases with less than 100 beneficiaries and have not been adopted on a wider scale. There is also limited written or formal evaluation of them to validate results and outcomes of the case study write-ups. It is therefore difficult to consider them good practices, success stories, or innovative approaches due to their limited scale and lack of rigorous evaluation. Given this complexity, this paper does not attempt to assess success stories or good practices, but instead focus on the lessons learned and important insights from these case studies.

In this review paper, the overwhelming bulk of evidence is from studies in Sub-Saharan Africa, some in Asia, and a few studies on Latin America, Eastern Europe, North Africa, and Middle East. This may be a reflection of regional or cultural differences in households and farming practices. The issues of women's technology adoption are more prominent in Sub-Saharan Africa, where women are more likely to have independent farming responsibilities and where there is a tendency to more clearly demarcated men's and women's plots, as opposed to other regions, where there is more joint farming (Peterman, Behrman and Quisumbing 2010). In other regions, it is harder to measure differences in men's and women's inputs and outputs and consequently there is relatively little empirical evidence.

Nevertheless, there is a whole set of issues that are very relevant in any region. The definition of "agriculture" is very much production-focused and limited to the activities and inputs needed between land preparation and harvest, which is a mostly male domain. This ignores postharvest processing and kitchen gardens (now called "homestead food production systems") that are often women's domains. Ironically, these areas do get recognition for research and innovation when they are taken over by men and get commercialized. A related issue is the perceived dichotomy between "male crops," which are often equated with lucrative cash and export crops, and "female crops," which are often equated as crops used for home consumption (Doss 1999; Kasante *et al*., 2001; World Bank and Malawi, 2007). While in some societies, this dichotomy exists, a study using nationally representative data by Doss (2002) in Ghana finds little evidence of this. This issue is also relevant to Asia and Latin America regions and is discussed in this paper.

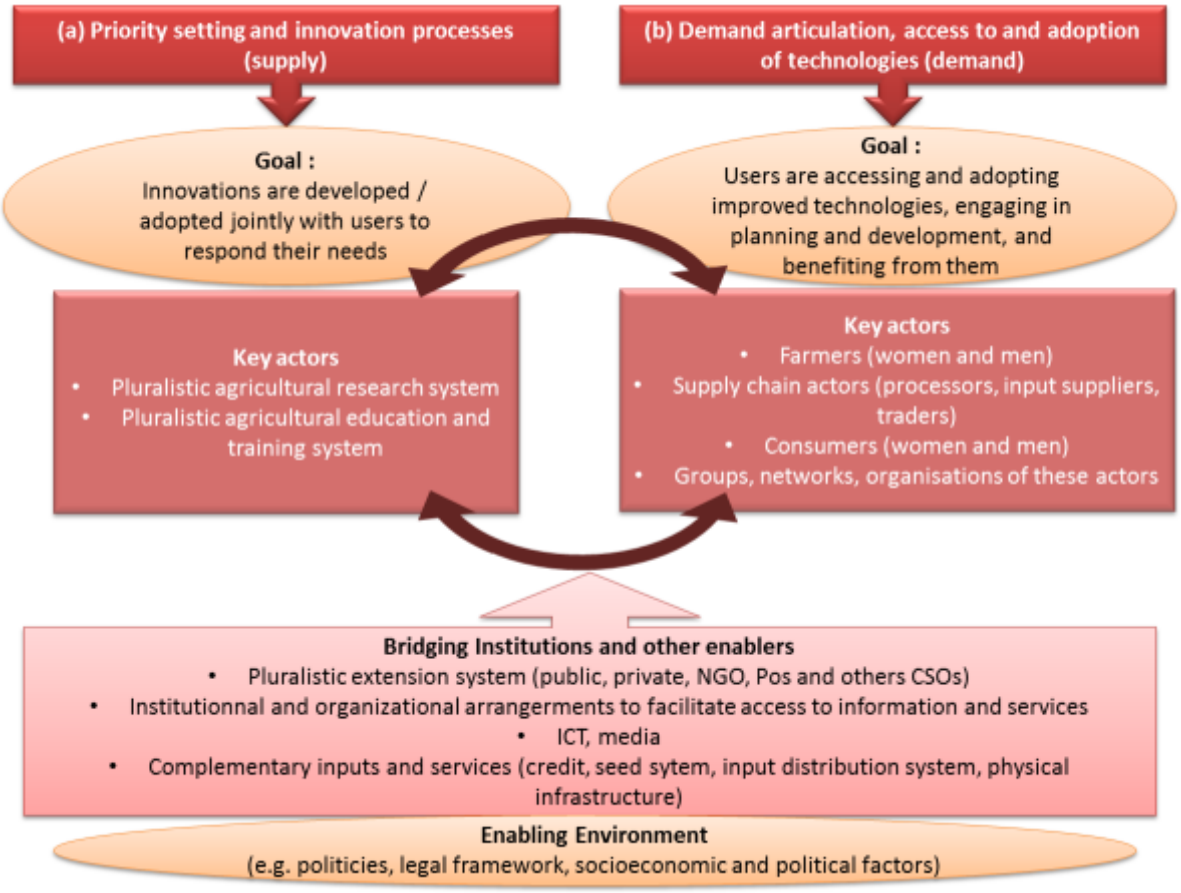
CONCEPTUAL APPROACH

Access to and adoption of technologies are analyzed in this paper by looking at both the supply and demand sides of technologies and related services (Figure 1). The demand side pertains to users of technologies and services, while supply side pertains to the developers of technology, input suppliers, and providers of services. The former includes different types of farmers and other supply chain actors who are the intended users of technologies and services. The latter includes the (1) research system (research institutes, academia, and think tanks either from public sector, private sector, non-governmental organizations, or other civil society organizations such as farmer organizations) that provide scientific and technical expertise and indigenous knowledge; and (2) education and extension systems (trainers, subject matter specialists, front-line field workers either from public sector, private sector, non-government organizations, or other civil society organizations) that provide training, education and advisory services on technologies, management practices and livelihood strategies. Between them are bridging institutions, organizations, and systems that link and integrate the two sides. This includes approaches for participatory priority-setting and feedback mechanism between the supply and demand side actors. This also includes ICTs that facilitate the flow of information, as well as physical infrastructure and efficient distribution systems to enable the flow of goods and services. The policy, legal and political environment are also enabling and conditioning factors that affect the supply and demand sides of technology development and service provision.

The distinction between supply and demand sides in this framework is useful to clearly identify constraints, as well as opportunities and approaches, in the planning, development, and evaluation of technologies for all relevant stakeholders. Demand-side constraints include problems or impediments affecting the effective engagement of different social users and groups (e.g., gender roles, social hierarchies, incentives) in articulating demand and needs; limited ability and opportunity to shape the research agenda and innovation processes; and limited individual or collective capacity of these users and their rural organizations to access technologies, information about technologies and complementary inputs. Thus, potential demand-side strategies that can address these issues include improving access to technologies and information about technologies; access to education and complementary inputs which will be important in the adoption of technologies; strengthening the ability of rural men and women to formulate and advodate for their needs in terms of technologies and services; and strengthening their capacity to be engaged in rural institutions that can hold service providers and suppliers accountable and responsive to their needs and demands. Supply-side constraints pertain to the nature of the problems affecting the performance of technology developers and service providers (e.g., incentives, organizational and bureaucratic culture, and political capture). Thus, supply-side strategies include strengthening capacity and devising innovative ways of providing incentives and

accountability of service providers to supply services efficiently and equitably while taking into account the needs of beneficiaries.

Figure 1. Conceptual framework in analyzing the demand and supply side of technological innovation while analyzing the role of rural institutions as catalysts and using a gender lens



Source: Authors.

Looking into the supply and demand sides ties in with an agricultural innovation systems perspective, which is increasingly being used to analyze and guide investments in technological development and innovations. Within this perspective, connectivity of various actors along the market and food chain and within the system and an enabling environment are critical for developing innovations and ensuring positive social and economic impacts of innovations on poor men and women farmers and marginalized groups (World Bank, 2008; 2011c). It highlights the linkages among research, education and extension systems; broader set of innovation actors; and the role of bridging institutions. It focuses on the economic and social outcomes and impacts of innovations. It looks more comprehensively at capacity, incentives and behavior change in both supply and demand sides needed to come up with creative ideas and useful innovations. These elements have been incorporated into the demand- and supply-side framework adopted in this paper. This paper is structured by looking at supply- and demand-side constraints and opportunities of all key actors along the innovation cycle and food chain, paying close attention to the policy environment, role of institutions, incentive systems, and outcomes.

GENDER DIFFERENCES IN ACCESS TO AND ADOPTION OF TECHNOLOGIES

There are numerous studies that look at gender differences in technology adoption. There is much variability among these studies in the inputs, crops, and locations analyzed, as well as in study designs, sampling, sample size, quality of data collection tools and analytical techniques, and in the definition of "gender" used. Peterman *et al*., 2010 also emphasize several methodological limitations of gender and technology adoption studies, including over-simplistic assumptions of cropping patterns and sociocultural dimensions. Given this wide variability and the limited available empirical research for many types of technologies, it is hard to generalize and develop typologies and patterns about why gender differences are evident or not. However, there are some key insights and general lessons from these empirical studies and they are discussed below. We grouped the discussion of gender differences in technology adoption into (1) improved agricultural technologies that are mainly high-yielding or production cost- or risk-reducing; (2) labor-saving technologies and transport; and (3) information and communication technologies (ICT).

Productivity-improving and cost-reducing technologies (improved seed, fertilizer and chemicals)

Evidence consistently suggests that male household heads and farmers adopt new agricultural production technologies faster than female heads and farmers across regions (Doss, 2001; Tiruneh *et al*., 2001; Bourdillon *et al*., 2002; Phiri *et al.*, 2004; Kakooza *et al.*, 2005; Jagger and Pender, 2006; Thapa, 2009; the World Bank and IFPRI study on Ghana and India, 2009; Peterman, Behrman and Quisumbing, 2010; FAO, 2011, to name a few). Many studies have used cross-sectional regression analysis, which methodologically allows controlling for other factors at a given period; and the results of these studies suggest that the gender of the head of household or of the farmer was not a statistically significant factor in explaining technology adoption. Most common factors that appear to be statistically significant are education or literacy level, fertilizer use, extension services, credit and size of plot, which are all statistically correlated to the gender of the farmer or household head. That is, women farmers surveyed in these studies have lower levels of education or literacy, less access and application of fertilizer, less access to credit, and have smaller plots. These studies emphasize that while the gender of the farmer or household head *per se* is not statistically significant, it is the differentiated lack of access to these technologies and complementary inputs and resources between women and men that mainly explain the observed lower adoption rate of technologies by women than men. Doss' (2001), Peterman, Behrman and Quisumbing (2010) and World Bank's and Government of Malawi's (2007) suggest that women and men make decisions on what crop to grow or what technologies to adopt based on the available resources, inputs, and labor that they have.

Women tend to be more risk-averse in terms of trying out new technologies. The limited available studies on new and more controversial technologies, such as genetically-modified organisms (GMOs), highlights the need for greater understanding of these new technologies and stresses the key role of extension agents or rural advisors in bringing this information to both men and women farmers and facilitating their adoption (box 1).

There are also a few randomized control trials and experimental field research that rigorously evaluate causal relationships between access to inputs or other factors and technology adoption. One available experimental study in Malawi by Gilbert *et al*. (2002) shows that before the intervention, female maize farmers have lower fertilizer use than men. However, when women were provided with seed and fertilizer inputs, their farm management efforts and fertilizer use were equally as productive as the men. These types of studies will be useful to identify binding constraints and approaches that actually work.

There are striking differences between different categories of female and male farmers or heads. For example, in Malawi, Uttaro (2002) finds that married women are more likely to access inorganic fertilizer than single household heads. In Ghana, Ethiopia and Karnataka, India, a World Bank and IFPRI (2010) study shows that differences in the likelihood of adopting improved management practices are correlated with differences in literacy and education level between women and men. Doss (2001) find that women in male-headed households are better off and command more resources and better quality land holdings than women in female headed households. In Kenya, Potash (1981) study find that actively farming older women may have more resources to draw upon to better respond to extension messages than younger counterparts. Unfortunately, only a few studies have carefully categorized women and men farmers and controlled for other factors. Future research can focus on a more nuanced analysis including different categorization and typology of women and men farmers.

Labor- and energy-saving technologies (farm mechanization, agro-processing, fuel-efficient stoves, transport)

Although various labor-saving and energy-saving technologies can have huge potential to reduce considerable time burden of women and increase labor productivity in general, empirical studies show that their use and adoption among rural women has rarely been high and usually much lower than men (Pender and Gebremedhin 2006; Horrell and Krishnan 2007; Oladele and Monkhei 2008; Babatunde *et al*., 2008; Carr and Hartl 2010). In Zimbabwe, Horrell and Krishnan (2007) find differences in the use of farm machinery between male and *de facto* female heads of household but not between male and *de jure* female heads. Three reasons are commonly highlighted for this gender difference: (1) cultural-appropriateness; (2) physical accessibility; and (3) affordability. For example, the reported value of farm tools owned between male-headed households and female-headed households (Horrell & Krishnan 2007 on Zimbabwe; Babatunde *et al.,* 2008 on Nigeria) and difference in use and ownership of animal draft or animal tractor (Pender & Gebremedhin 2006 on Ethiopia; Oladele & Monkhei 2008 on Botswana) are likely attributed to the relative affordability of these technologies, coupled with women's less income and asset holdings and less access to credit than men. Similarly, affordability and access to financing can explain less access to and use of more advanced agro-processing equipment than men; and women often rely on less mechanized and more labor-intensive processing technologies and/or are employed as workers in large processing plants (Singh and Kotwaliwale 2011).

Sometimes technologies are not physically accessible to both women and men. Women have fewer opportunities than men to use transport technologies to alleviate their heavier transporting time burden across regions (Fernando and Porter 2002; Starkey *et al*., 2002;

World Bank 2004; Carr and Hartl 2010). For example, in Nepal, while mechanized mills reduced rice processing time, women were found to travel 10 to 180 minutes to reach these mills and wait for 30 minutes for their turn (Intermediate Technology Development Group 1986). Women often lack cash to pay for fares or purchase transporting technologies. Men are more likely to own intermediate means of transportation, such a bicycle, motorbike, car or truck than women. Rural transport services are often infrequent and expensive; and at times, harassment and safety are also a major concern for women traveling long distances alone (World Bank, FAO and IFAD 2008). In some cases, women receive lower priority than men customers or those traveling a longer distance (World Bank, FAO and IFAD 2008). In some countries, restrictive cultural traditions (e.g., in Bangladesh) also have an effect on women's use of available transport facilities (Starkey *et al*., 2002). This often limits mobility of women to interact with other producers, input suppliers, and buyers; and to participate in meetings, training, and extension services that require travel. All these affect their decisions and ability to adopt improved technologies and encourage entrepreneurship. Across regions, gender-specific needs are very seldom considered when developing transport infrastructure or networks especially in rural areas (Carr and Hartl 2010). Most transport projects stress building major roads to promote connectivity of rural areas, while women often access the smaller local roads which are not always part of project considerations (World Bank 2004).

Information and communication technologies

Distinctions or classifications of ICTs are useful in analyzing access to and implications of more advanced (internet, wireless) and traditional technologies (radio, satellite radio, and television). Many developing countries, especially in rural areas, lag behind in the rates of connectivity in access to both internet and mobile phones. Liff and Shepherd (2004) argue that this digital divide is not only between rural and urban and between the rich and poor but is also closely associated with the gender divide. Due to unequal access to the factors that appear to enhance ICT access and use, such as income and education, women generally have less access to ICTs and this pattern increases as the technologies become more sophisticated and expensive.

A study by Gillwald, Milek, and Stork (2010), using empirical data across 17 African countries, finds statistically significant gender differences in access to and use of internet for all countries, except Cameroon. In most of these countries, men are more likely to claim to know more what the internet is, to use the Internet, and to have an email address than women. In terms of television, no clear pattern of TV usage can be drawn between women and men, although the process and method are quite different. In some countries (e.g., Botswana, Kenya, Namibia), significantly more men than women watch TV, but the opposite applies in other countries (e.g., Cameroon and Mozambique) (Gillwald, Milek and Stork 2010). Combined results for all countries show women are as likely as men to watch TV at friends', relatives' or neighbors' houses (Gillwald, Milek and Stork 2010).

There is a more promising pattern of rural women accessing and using radio for agricultural information and entrepreneurship, although men still are more likely to own and control their use (Gillwald, Milek and Stork 2010). In Ethiopia, 16 percent of women and 31 percent of men listen to radio at least once a week, implying that men were about twice more likely to have frequent access to radio than women (Ethiopian Society of Population Studies 2008). Across 17 African countries, average hours listened to the radio per day were higher for men than women (except in Namibia, South Africa and Kenya) (Gillwald, Milek and Stork 2010). Across various types of ICT, the majority of women in Ethiopia (54 percent) and a lower proportion of men (33 percent) did not have access to any newspaper, magazine, radio or television (Ethiopian Society of Population Studies 2008).

The relative difference between men's and women's access to and usage of mobile phones is diminishing (Sorenson 2002). Zainudeen *et al*., 2008 find a wide gender gap in access to mobile phones in Pakistan and India; less in Sri Lanka; and none in the Philippines and Thailand, where mobiles are most pervasive. In 13 out of the 17 countries, more men than women own a mobile phone and mostly spend a greater amount of money using it (Gillwald, Milek and Stork 2010). After controlling for other factors, Chabossou *et al*., 2008 find that gender is mostly insignificant. What was interesting is that in rural areas, men are more likely to own and have access to phones than women. This could be attributed to a number of factors, including greater levels of illiteracy, cultural barriers, and less available cash faced by women compared to men in rural areas.

CONSTRAINTS TO TECHNOLOGY ACCESS AND ADOPTION

There is a wide range of literature that looks at factors affecting the adoption of various kinds of technology; many of them include a variable on the gender of the farmer or household head.

Common factors in these studies are attributed to both demand and supply sides of technologies and can be broadly grouped into: (1) accessibility; (2) liquidity; (3) profitability and suitability; and (4) sociocultural factors. Accessibility includes access to information or extension services about these technologies and access to the technology or mix of inputs and labor required. This also reflects access to transportation and infrastructure and efficiency in the distribution system. New technologies often require more investments and small farmers often face liquidity constraints in purchasing these required inputs. Profitability from or suitability of technology (or lack thereof) is a major factor in non-adoption of many new improved technologies and reflects both supply and demand side issues. Limited adoption can reflect a number of factors including the lack of feasibility studies, weak planning and research prioritization processes; lack of consultation among potential users/beneficiaries; weak demand articulation of small producers' needs and preferences, and/or sociocultural constraints encompassing the various gender norms and social barriers women face in accessing and adopting new technology. Policy environments and rural institutions can also hinder information exchanges; pooling and access to resources and opportunities; and bridging the supply and demand sides.

What is largely missing in the literature are studies that systematically understand whether the issue of low adoption, especially among women, is the inappropriateness of technology, the lack of complementary inputs to enable adoption, lack of credit to access these inputs, the lack of access to information about the technology or the lack of required knowledge and skills to adopt and implement them. All studies reviewed point to a mix of these factors but none has analyzed comprehensively the root causes, bottlenecks, and binding constraints of technology adoption and outcomes and the relative contribution of each factors. This section will summarize the available evidence to date.

Demand-side constraints

1. Limited women's participation in priority setting and innovation process

Some studies cite the lack of engagement of key actors (women and men) in priority-setting of technological procedures as a reason for the limited responsiveness to the needs and constraints of rural women and men, social acceptability, and cultural appropriateness (Meinzen-Dick *et al*., 2010; FAO 2010). While women and their organizations are becoming more involved through participatory research approaches and participatory rural analyses,

relatively little attention has been given to gender issues in upstream priority-setting and decisionmaking (Meinzen-Dick *et al*., 2010; FAO 2010). While several applied research and experimentation are being done by farmers and their organizations, varietal and other basic research will continue to be the major functions of research institutes. Women and men farmers' engagement in the priority-setting, varietal selection and all stages of the innovation process will be crucial.

A number of demand-side initiatives have been implemented to promote greater and wider stakeholder engagement in priority-setting and innovation processes. For example, Research Extension–Farmer–Input–Suppliers Linkage System (REFILS) in Nigeria, the Research and Extension Linkage Committees (RELCs) in Ghana, and the Agricultural and Rural Management Councils (CARGs acronym in French) in the Democratic Republic of Congo (DRC) consult and receive farmers' input on research results through regular face-to-face meetings. If gender-responsiveness is well integrated and properly implemented, these types of initiatives can create good opportunities for increasing women's engagement into innovation and decisionmaking processes.

However, gender equal opportunities for participation are not always guaranteed. Despite quota systems for women's representation in these councils/committees, they are rarely followed. For example in the DRC, while guidelines for CARG indicate that one-third of management should be women, this quota is rarely followed due to several demand- and supply-side constraints. Interviews conducted by Ragasa, Babu and Ulimwengu (2011) suggest that reasons are multifaceted including: (1) limited number of women leaders of producer organizations and public offices, who can be members of the CARG management; (2) inability of women leaders to attend CARG-related meetings due to lack of funds for travel; (3) severe time constraints by women; and (4) lack of confidence and capacity of many women for more active engagement in these consultative processes. These demand-side constraints will need to be addressed and be part of gender-sensitive targeting and programming in order to ensure that women play an active part and make vital contributions to priority-setting, decision-making and innovation processes.

2. Limited access to information or low literacy rates to use information

Credible and timely information is essential in making decision on what technologies to adopt. A number of studies highlight the lack of access to information about technologies or the lack of required complementary knowledge and skills to use technologies as hindrances to a faster adoption of new technologies and improved management practices (Doss *et al*., 2003 based on a meta-analysis of 22 case studies in Africa; Ogulana 2003; Lubwama 2008; World Bank and IFPRI 2009; Tiwari 2010 to name a few). These issues point to the demand-side and supply-side weaknesses of extension system in providing education and training to improve their productivity, increase their incomes, and improve their welfare. Again, few

studies systematically looked at both supply- and demand-side constraints of extension service delivery.

From the demand-side perspective, there are several reasons why women are more likely to get less information or extension services or less likely to use or process the information received. Women often lack of mobility, access to transport, and funds for participation in meetings, training or demonstration plots. Women's relatively limited access to education opportunities and lower access to mass media and other forms of ICT as compared to men are also factors contributing to gender gaps in adoption of new technologies. Women farmers generally have lower education levels which affect their understanding and adoption especially if the technology requires use of more technical and intensive knowledge. In many cases, social and cultural barriers and greater time burdens are major constraints by women in acquiring information, education and training. For example, Ogulana (2003) reported that women farmers in Nigeria complained that the seminars and talks given by extension agents in community centers or other restricted areas were not accessible to them or at times which are not convenient for them. Scarce opportunities for participation and leadership in groups and organizations limit women's ability to use these platforms and avenues for consultations and information-sharing with other actors including extension agents and researchers.

Several demand-side initiatives have been pilot-tested and implemented over the years. Evidence suggests that when information constraint is addressed, demand for technologies among women farmers can be high as illustrated by the DIMITRA programs implemented in various countries (FAO, DIMITRA).

3. Limited access to complementary inputs and services

Literature suggests that one of the major constraints is a lack of access to complementary inputs and services, which restricts the number of women farmers adopting improved technologies (Ani *et al*., 2004; Drechesl *et al.*, 2005; Shiferaw *et al.*, 2008; Tiwari 2010; Meinzen-Dick *et al.*, 2010; www.genderafforum.org, accessed on September 10 2011). In a number of studies, it is observed that even when women farmers are aware of an improved technology or are very satisfied with the information and training provided, they do not always readily adopt it (Ani *et al.,* 2004 in Nigeria; World Bank and IFPRI 2009 Meinzen-Dick *et al.*, 2010 in Ethiopia). Across all studies reviewed, the most commonly cited binding constraints in technology adoption are the lack of complementary labor; access to land or insecurity of tenure; education level and access to credit (e.g., Doss and Morris 2001; Goldstein and Udry 2005 on land tenure insecurity in Ghana; Holden and Bezabih 2007).

Availability of labor is a significant factor in the adoption or not of improved management practices highlighted by a number of studies (FAO 2011; Quisumbing and Pandolfelli 2009; and World Bank, FAO and IFAD 2008). Women often face constraints or shortages of hired

male labor for agricultural tasks. Doss (2001) finds that in customary systems in most countries in Africa, men have control over women's labor, but not vice versa. In some areas, male out-migration adds to the constraint already imposed by gender-specific farming tasks and while female-headed households may receive help from male relatives, only after the men have taken care of their own plots (FAO 2011).

4. Availability and affordability of technologies and liquidity constraints

Farmers have also cited the availability and affordability of tangible technologies (improved seeds, planting materials, fertilizer, ICT applications, agro-processing technologies, or transport technologies) as major constraints (Doss 2001; World Bank, FAO, and IFAD 2008; among others). Limited availability and affordability of technologies reflect both supply- and demand-side constraints. The issue of availability is a consequence of combined effects of the nature and effectiveness of input distribution systems and physical infrastructure, as well as the geographical location and remoteness of the rural people to be reached and the presence of social networks or organizations that can help facilitate their access to these technologies. The issue of affordability reflects either the profitability of adopting the technology or activity (that is, relationship of perceived income vis-a-vis cost of acquiring the technology) or liquidity constraints (that is, technologies and activities might appear to be profitable but farmers may not have the cash available to purchase the needed inputs).

Liquidity constraints are very much associated with the availability of financial services for women and men engaged in agriculture and the effectiveness of rural financial systems more generally. Access to finance is considered a major constraint in adopting almost all types of technologies (Tiwari 2010, Olaleye 2005, Doss *et al*., 2003 on production technologies; Wickramasinghe 2009, White 1999, Okorley *et al.*, 2001 on agroprocessing; Olwande *et al.*, 2009 and Gladwin 1992 on fertilizer adoption; Maguzu and others 2007 and World Bank, FAO and IFAD 2008 on management practices such as conservation [zero] tillage agriculture). Even for access to ICTs (particularly internet and phone), financial constraints are a deciding factor in whether a woman can afford a phone or pay for internet access.

From demand-side and gender perspectives, women and men may find different profitability and technology feasibility due to different levels of risk aversion, preferences, and availability of resources and opportunities. The greater risk aversion of women in rural areas in many countries (for example China and the Philippines) is related to their observed reluctance to borrow from financial institutions and pledge their assets and land as collateral. Even when profitability is expected, some activities and technologies are not initiated due to reluctance to take loans to finance these ventures. There are knowledge gaps in better understanding this risk aversion and reluctance to take up loans in various contexts. Taking into account these differences between women and men, inclusion of both

women and men in priority-setting, feasibility studies, and research processes are important starting points in developing more gender-response technologies.

Moreover, rural women's access to financial services remains heavily dependent on microfinance. Women generally receive smaller loans than men, even for the same activities and are vastly underrepresented in programs that finance larger loans. In some societies such as DRC, women are not allowed to apply for credit without their husband's permission. These bottlenecks will need to be addressed for women to take on bigger and more profitable ventures.

5. Sociocultural constraints

Most of the constraints to technology adoption cited above are related to social and cultural biases against women that persist over time. Due to gender norms and insecure tenure system, a technology or activity that becomes commercially profitable is often expropriated by male members of the household [examples are the adoption of the stabling technique in rural Senegal (Fisher, Warner, and Masters 2000) and control over intermediate means of transport (Venter and Mashiri 2007 and Rao 2002)]. In Nigeria, UNIFEM (1993) shows that 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. In Ethiopia, Pender and Gebremedhin (2006) show that 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 Benin, Kinkingninhoun-Mêdagbé's *et al*., (2008) study of 45 rice farmers finds significant gender differences in women farmers' access to farm equipment. "While women's groups got the tractor, they did not get a driver. They had to wait until the men's fields were ploughed before the driver could start working on their fields. This caused a delay of about a week within the women's group" (Kinkingninhoun-Mêdagbé *et al*., 2008, p. 62), and resulted in lower yields. Culturally in many countries women, especially rural women, are not permitted or feel comfortable to visit public locations such as internet kiosks, or community halls to watch TV shows (GenARDIS 2010).

Another cultural issue is the risk of losing control over income among women as husbands or male adult members of the household takes over the enterprise or cash earning. Fisher, Warner, and Masters (2000) find that the adoption of the stabling technique in rural Senegal improved milk production and profits but later on was taken over as an activity by men. Venter and Mashiri (2007) and Rao (2002) show that various intermediate means of transport (such as donkey carts or bicycles) often fall into the control of men or add more tasks, responsibilities and time burden for women compared to when they were less mobile. This risk often contributes to reluctance among women to adopt and use labor-saving technologies that increase profits or incomes if they themselves do not control these economic gains.

Affirmative action and transformative programs that identify and tackle underlying causes of inequalities and challenge gender relations are needed. A good starting point is educating and mobilizing field workers and development agents to be aware of these gender differences and gender-related constraints and opportunities. Mobilizing more champions (both women and men) to advocate for these are critical and will be discussed further in the Opportunities section.

6. Gender gap in rural institutions

Rural institutions such as producer organizations, community-based organizations, cooperatives, water user associations, self-help groups, informal networks and various forms of collective action are platforms for experimentation and innovation among women and men producers. Peterman, Behrman and Quisumbing (2010); Meinzen-Dick and Pandolfelli (2008); and Doss *et al*. (2003) have enumerated a number of studies that find significant role of local producer organizations as innovators themselves and in promoting improved technology use. In particular, women are often less likely to be served by conventional extension services, and as Katungi, Emeades and Smale (2008) suggest, group-based dissemination systems may be important to increase technology adoption. Participation of women in mixed groups and leadership positions has been proven to be important in accessing resources and information, establishing contacts, and obtaining help and support from male members in case it is needed (Gotschi, Njuki, and Delve 2008; Acharya and Gentle 2008; Agarwal 2009; Apesteguia *et al*., 2010; Sun, Mwangi and Meinzen-Dick 2011). However, evidence suggests that there are considerable gender differences in participation in membership and leadership in mixed-group cooperatives, associations and organizations, with women being less likely to participate and hold management positions (for example, World Bank and IFPRI 2009 on Ghana, Ethiopia and India; Gotschi, Njuki and Delve 2008 on Mozambique; and EADD 2008 on East Africa in general).

Evidence also suggests that women's participation in mixed groups can improve group effectiveness. Arcand and Bassole (2007) find that increasing the number of females on committees is likely to raise the number of completed projects in a Community Driven Development Program in Senegal. Westermann *et al*. (2005) find that female participation increases solidarity within the group and increases the group's conflict management capabilities. Agarwal, Yadama and Bhattacharya (2005) find that female participation significantly increases the probability of controlling illicit grazing and felling activities, and increases regeneration of allotted forest. Agarwal (2009) finds that forest management institutions in which women constitute a substantial fraction of the executive committees demonstrate better forest conservation outcomes in India and Nepal. Quisumbing and Pandolfelli (2009) suggest that increasing the participation of both women and men in fishery management groups in Bangladesh increased fish protection through increased efficiency of control activities.

Despite this evidence of the importance of women's participation in collective action, they continue to be underrepresented due to various reasons. They often lack mobility, access to transport, and travel funds to enable them to participate. In many cases, social and cultural norms against women and greater time burden hinder their mobility and participation. While legislation regarding membership in rural producer organizations or associations may not overtly exclude women, it is the implicit or explicit conditions that many women cannot fulfill. As illustrated in studies on water user associations, membership is often based on access to and control of a key asset such as land, which women are much less likely than men to control (Meinzen-Dick and Pandolfelli 2008; Meinzen-Dick *et al*., 2010; World Bank, FAO and IFAD 2008). Another requirement that may disadvantage women is that a business enterprise must be a certain minimum size to be recognized as a cooperative or federation (such as the case in Madagascar [World Bank, FAO and IFAD 2008]). Many women-managed small business enterprises are excluded from the benefits of these officially-recognized associations (World Bank, FAO and IFAD 2008).

Supply-side constraints

1. Supply-side constraints in equitable and inclusive priority-setting

Gender issues in priority-setting and research planning processes come in two forms: asymmetry in decision-making power and lack of mechanisms that take into account the needs and priorities of women and men producers and consumers. And, these relate to how agriculture and research are historically 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" (Meinzen-Dick *et al*., 2010, p. 9). There is a historical bias[1] toward agricultural production (from land preparation to harvest) in traditional priority-setting, research and education in agriculture rather than looking at the "food" sector in a holistic and systems-perspective. Because of this, engagement of women in priority-setting and innovation processes has been historically weak and it is only recently that institutions and approaches are in place to understand the needs and priorities of the food sector and value chains in a more holistic way.

There has also been associated gender segregation in agricultural occupations and training for decades, only with a limited number of women entering into and getting training and education in agriculture fields. While a number of initiatives are already being implemented to address this (discussed in the Opportunities section), they need to be scaled up. There should be a stronger and more holistic focus, using a value chain approach, and systems-

[1] Mead (1976) highlights the tendency of national systems and the international development community to attribute the concern with agricultural production (land preparation to harvest) to men and to attribute the concern with food post-harvest to women. This tendency has led to the occupational segregation branding scientific agriculture as a male field and food knowledge and preparation as a female field. This dichotomy is often used to characterize capacity strengthening efforts by developed countries and donors in setting-up technical agricultural schools for males and home economics schools for females in developing countries. Mead (1976) articulates well the dangers of this type of segregated occupation and training and strongly suggested that it should be recognized and corrected.

perspective in priority setting, research, education, extension, and monitoring and evaluation. Curriculum development and adjustments are needed to encourage more women and youth in agriculture sector careers. Affirmative action will be required to promote increased numbers of women in the agricultural, sciences, and professional fields and minimize gender-segregation in agricultural training and professions (which is further discussed in the section on opportunities).

2. Gender gaps in extension systems

Gender-responsive extension systems require that: (1) women and men extension agents are aware and respond to the needs and priorities of women and men farmers; (2) women and men farmers have the same opportunities to access extension services and receive training; (3) extension delivery approaches provide equal opportunities to articulate access to extension services between women and men; and (4) training and recruiting of women extension agents to increase the likelihood that women farmers are reached, especially in areas that have cultural taboos restricting male extension agents' interaction with women farmers. Studies of agricultural extension have painted a quite different reality from the ideal gender-responsive system just described. First, similar to Mead's (1976) concern on gender-segregation in occupation and training, 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 the World Bank and IFPRI (2009) in Ethiopia finds strong evidence of a cultural perception bias that "women don't farm." In Ethiopia, extension agents preferred to work with the household decisionmakers, who in a husband-wife household were always perceived to be the male (World Bank and IFPRI 2009).

Second, women farmers usually have more limited access to conventional extension services and men are often the ones called for in training and meetings related to new technologies or management practices. There is also a perception that if extension services are given to a member of the family, the knowledge will pass on to other household members, including female members. However, men do not necessarily discuss production decisions with their wives or transfer extension knowledge to them and vice versa. Moreover, if the extension information is tailored to men's crops or priorities, the information may not be beneficial to women.

The relatively lower provision of extension services to women can also be a reflection of the policies, or lack thereof, for example, staff gender policies. Women continue to be underrepresented as extension agents and field workers. A 1993 FAO study of 24 extension programs in Africa, Asia, and Latin America suggests that the presence of female extension agents was an important factor for the participation of female farmers in extension activities. World Bank and IFPRI (2009) find that female extension workers serve a higher proportion of female farmers than male agents (the average ratio of women to men farmers is 1.3 for female agents and 0.53 for male agents). This may suggest that extension services

from female extension agents are better targeted to female farmers. In Tanzania, Due, Magayane and Temu (1997), 40 percent of women farmers preferred to work with female extension agents (compared to 26 percent who preferred male extension agents; the remaining 34 percent had no preference). These authors also find that female farmers stated that they preferred female extension agents as they were freer to discuss problems with them; and female agents were better able to accommodate their time preferences for meetings than male agents.

In Ghana, a World Bank and IFPRI (2009) study shows that of the 70 agricultural extension agents surveyed, only 10 were female. In Ethiopia, extension agents were overwhelmingly male, and cultural taboos restricted their interaction with women farmers (World Bank and IFPRI 2009). In Karnataka, India, a survey of front-line professionals responsible for extension service provision shows a limited number of women (no females among 41 agricultural extension workers, 1 female out of 41 junior engineers, and 4 females out of 40 veterinary assistants) (World Bank and IFPRI 2009). Moreover, opportunities for mid-career agricultural extension staff are also more limiting for female extension agents, due to various reasons including (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 (Akeredolu 2009). Recruitment, incentivizing, and more opportunities for mid-career training for female extension agents is therefore crucial, but this should be coupled with gender-awareness and gender training for male and female extension agents making sure that all extension agents are aware and respond to the needs and priorities of both women and men farmers (more detailed discussion in Opportunities section).

3. Gender imbalance in research organizations

Gender issues in research organizations pertain to both gender parity in staffing and application of gender-sensitive approaches to respond to the needs and problems of both women and men farmers.

The overwhelming underrepresentation of women as scientists, educators, graduates, managers and extension agents persists to date, despite a number of initiatives to increase women's representation. The fact that women play a central role in food production and post-harvest activities in most developing countries stands in stark contrast to the reality that, for example, in Sub-Saharan Africa, only one in four agricultural researchers is female, or one in three in Latin America (Beintema and Di Marcantonio 2009). Also, women hold lower degrees on average than men, and have higher attrition rates (Stads and Beintema 2009). The lack of gender balance among agricultural scientists means that women's voices are less heard in critical and often male-dominated policy debates and decision-making processes, resulting in biased decision-making. Various authors have shown that gender-

balanced groups in membership and/or leadership outperform male-only or female-only teams (Acharya and Gentle 2008; Agarwal 2009; Apesteguia *et al*., 2010; Sun, Mwangi and Meinzen-Dick 2011). Agarwal (2009) finds that group's gender composition affect women's effective participation. Her study's results support the popularly-emphasized proportions of one-quarter to one-third women's participation, along with women's economic class and other factors.

The glaring gender disparities in agricultural research and development are largely attributable to a range of multifaceted challenges women routinely face. The fundamental cause is the often lack of opportunities for girls or social norms that prevent them from going to school. Moreover, historical gender segregation of training and occupation has limited the number of girls entering sciences and technical fields and pursing more advanced degrees and career development. As a result, the supply of women graduates and professionals in the field of agriculture and sciences is limited in many societies. Meinzen-Dick *et al*. (2010) articulate various other challenges including the lack of balanced gender representation in recruitment and promotion committees; covert gender discrimination in organizations and societal attitudes toward the female professional; and work–life balance challenges owing to the prevailing perception of a woman's role as a mother and of the family as her domain, which adds to the their time poverty and limited mobility. These factors severely constrain their advancement in research organizations and achievement of more advanced degrees. Quota systems and reservation policies implemented in the past have limited positive outcomes due to the lack of complementary capacity strengthening for women and inability to address these sociocultural and gender norms that limit women's engagement in higher degrees and more advanced careers.

Greater attention to increasing gender parity in staffing should also be coupled with gender-awareness and gender training for male researchers to ensure that all researchers are aware and respond to the needs and priorities of both women and men farmers.

Policy and regulatory constraints

A broad range of actors and processes in the enabling environment are involved in making innovations work or not work. A combination of gender-blind legislation and policies and gendered norms can cause men to benefit more than women from market opportunities or public programs and directly or indirectly influence technology adoption decisions. For example, in Zimbabwe, married women need permission from their husbands to register land; while in the DRC, women need their husbands' consent to start a business. Such norms restrict women's mobility or decisionmaking and limit their opportunities and sources of livelihoods and thus the technologies to be adopted.

Even more important is the need for greater enforcement of policies and regulations that explicitly protect against gender discrimination. Many cases of discrimination against women

are indirect and unintended, rather than through formal legislation. This has been illustrated in requiring land ownership or business size for membership in organizations or associations. For example, insecure land tenure is an important binding constraint affecting men's and women's expected returns; adoption decisions of technologies; exposure to risk and access to credit. Decisions on long-term land investments and what technologies to adopt will depend on the security of income that are expected from the piece of land. Agarwal (1994); Lastarria-Cornhiel (1997); Kevane (2004); Meinzen-Dick *et al*. (2010) find that women are often disadvantaged in both statutory and customary land tenure systems and they face greater land insecurity. Even where legislation exists that protects women's rights, the lack of legal awareness and/or weak implementation of these this legislation may limit women's ability to exercise these rights (Peterman, Behrman and Quisumbing 2010).

Associated with land tenure, water use rights to use water are also a concern to for many poor households, especially women. Meinzen-Dick *et al*. (2009) finds that in Sub-Saharan Africa, women are often excluded from irrigation projects or lose their use rights to land and property when new irrigation systems are set-up. They also conclude that the poorest members of the community and women are more likely to be excluded from accessing irrigated water and less likely to be members of water user associations (Meinzen-Dick *et al*., 2009). This membership is often related to land owners and/or heads of households (Meinzen-Dick *et al*., 2009), which is often assumed to be men. Moreover, "the pricing of water resources is often calculated using affordability studies based upon men's incomes" (Meinzen-Dick *et al*., 2009).

Aside from policies and specific conditions at organizational levels, regulatory barriers and bureaucratic processes often present deep obstacles for women's entrepreneurship and innovation than for men. For example, based on the Uganda Regulatory Cost Survey Report in 2004, World Bank, FAO and IFAD (2008) find that 25 percent of all enterprises, but 43 percent of women-headed enterprises reported that government officials had interfered with their businesses and threatened to close them or asked for bribes. In the same book, results suggest that 40 percent of microenterprises headed by women felt that the total burden of regulation was "heavy" or "severe" (as compared with 35 percent for those headed by men). This may be due to social and cultural norms that restrict women's access to financial and other services for businesses and greater discrimination faced by women in dealing with officials, filing documents or requirements needed to start or run an enterprise. Profitability is a major factor affecting technology adoption; and developing markets and ensuring an equal playing field between women and men will help close the gender gap in technology adoption.

OPPORTUNITIES FOR INCREASED TECHNOLOGY ADOPTION AND OUTCOMES

There are several promising institutional and organizational arrangements that offer opportunities for inclusion of both women and men farmers and other supply chain actors in innovation processes and in ensuring that they benefit from new technologies produced. However, the actual implementation of activities and projects reveals that inclusion and equitable outcomes are not automatic and that gender and equity issues must be explicitly and consciously part of their design, implementation and evaluation to have an effect.

Demand-side opportunities

1. Participatory approaches coupled with explicit attention to gender

In order for women's needs and specific constraints to be incorporated into technology development, they should be engaged from the priority-setting and research stages to extension and evaluation, as scientists, managers, researchers, producers, processors, traders, and consumers. Participatory approaches, codesign, and innovation platforms are some of promising approaches to foster participation of stakeholders (discussed in detail in Spielman, Ragasa, and Rajalahti 2011). One of the participatory approaches being promoted is participatory plant breeding (PPB), which has been cited by many studies as successful in terms of faster adoption and higher yield and taking into account women's and men's preferences and needs (Sperling 1993 on improved varieties in Rwanda; Ashby and Lilja 2004 and Ceccarelli and Grando 2007 on various participatory plant programme breeding; Bourdillon et al., 2007 on developing high-yielding varieties of maize in Zimbabwe; and Bellón *et al*., 2007 on drought, pest and disease resistance in grain varieties in Mexico). However, the quality of participation and representation, elite capture, and limited gender impact have been noted as limitations of PPB by a number of studies (Box 2).

Participatory rural analysis is a participatory learning approach which offers a potential for women's inclusion, enabling their voices to be heard and creating a space for new rules for engagement, but it does not automatically incorporate gender issues. Moreover, it is sometimes used by facilitators who lack a concern with process, power and difference, and thus can exacerbate exclusion and cement existing relations of inequality (Cornwall 2003). Redd Barna Uganda (RBU) provides a good example of an effective participatory development project (Cornwall 2003). Key elements include (1) good facilitator; (2) provision of spaces in which gender- and generation-specific issues could be tackled within a broader participatory planning process; and (3) high-level institutional commitment enabling RBU to work with an approach that made gender and age differences explicit (Mukasa 2000) and emphasized women's subordination directly. Another example of a participatory action

research approach with an explicit gender-responsive activity is the Enabling Rural Innovation (ERI) initiative implemented in Uganda and Malawi, which is showing some promise in terms of women's empowerment. Key factors include an explicit gender strategy at the start of the project, rather than as an afterthought; a participatory approach that enables joint identification of problems and implementation of solutions involving both women and men; and emphasis on linking small women and men farmers to markets (case study from Jemimah Njuki). Moreover, participatory approaches are dependent on their institutionalization by research and development organizations working in market development (case study from Jemimah Njuki). It is an appropriate approach for linking research, extension and private sector but this will require a change in the way these sectors are organized and how they link at country level (case study from Jemimah Njuki). Moreover, even in cases of farmers' own experimentation, higher yields and incomes are observed when groups are linked with formal research institutes (Walters-Bayer 2011).

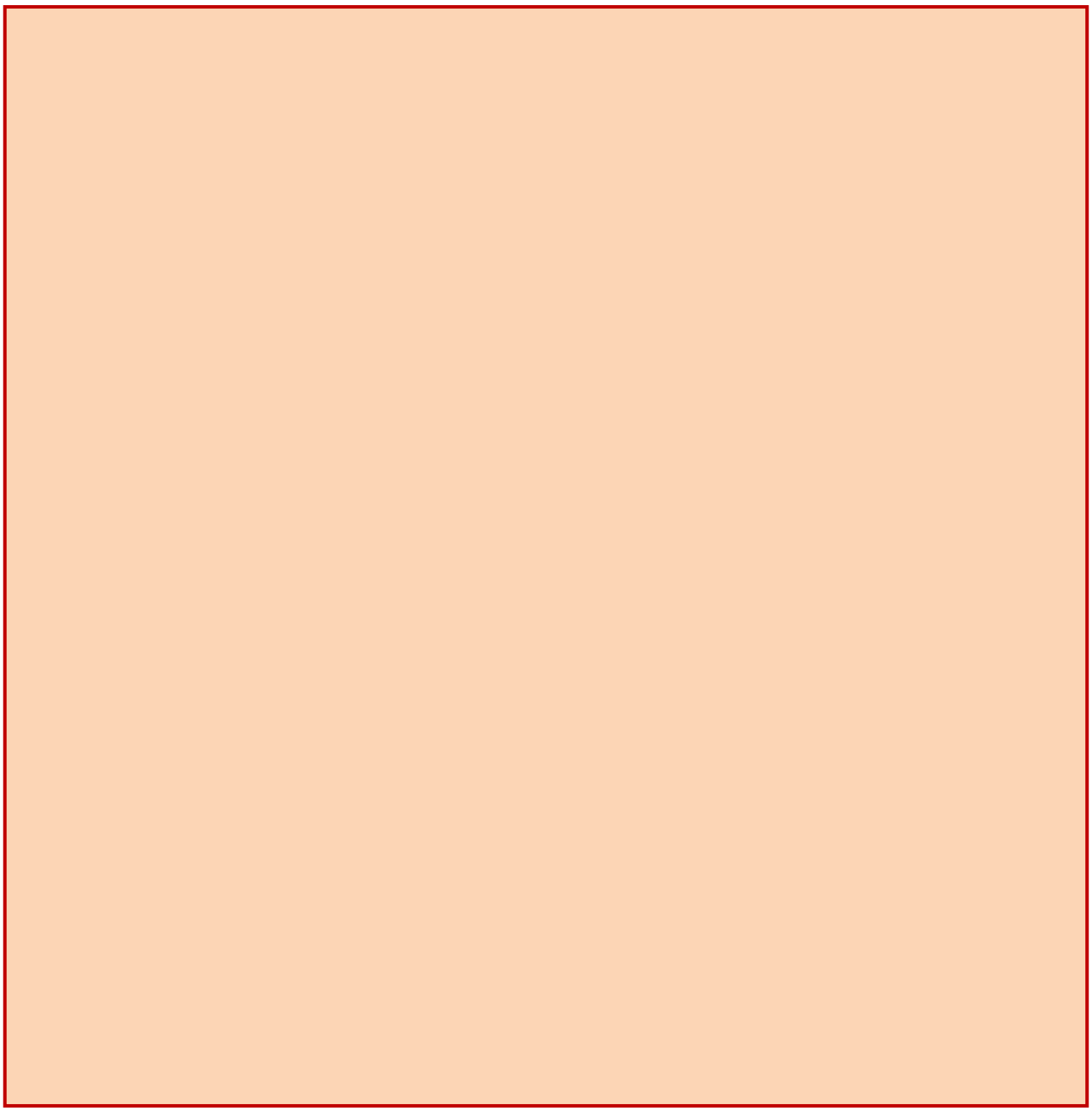
2. Access to information through appropriate ICT

By enabling broad information sharing, information and communication technologies (ICTs), have been shown to play a key role in empowering women and strengthening men and women's knowledge base. ICTs have been increasingly used to disseminate information about technologies, markets, and management practices. The ability to operate a computer

or own a mobile phone has been shown to have a direct effect on the self-confidence of women and girls (Omari and Ribak 2008). Developing content targeted to women's needs can help to increase women's use of this medium. Several organizations in developing countries are actively working to increase women's understanding and usage of ICTs for agriculture and related activities.

Households almost universally own radios even in developing countries, and they are a low cost medium to reach the rural poor, who may not have the infrastructure to access any other technologies (Bates 2000). Community radios provide new opportunities to disseminate information about technologies and educate rural populations in remote areas. The content of radio programs is also easy and cheap to create and to consume. This is especially important in countries with high illiteracy rates and where most rural people speak local, indigenous languages. **Self-Employed Women's Association** (SEWA) uses radio to disseminate information about the agricultural calendar and about crops. Despite radio's advantages, the medium has some limitations. The information needs to be complemented with more hands-on training and even demonstration plots in some cases. People can learn only so much from radio without physical demonstration. Moreover, radio is a one-way medium and needs to be complemented by other ICTs to ensure maximum two-way learning. Radio, therefore, is best used to complement rather than substitute for agricultural extension workers.

Using mixed tools such as radio-based Question and answer (Q&A), internet-based posting of questions and answers, as well as providing vouchers as rights for farmers to ask important questions for the community is being pilot-tested in 7 districts in Uganda and is showing some success (Kasangaki and Oguya 2011). Key lessons include the need for capacity strengthening (e.g., for farmers to articulate their needs and demands; for field agents to deliver vouchers and discuss the process with farmers; for rural information brokers to manage the ICT tools; for subject matter experts to provide the technical information being requested by women and men farmers (Kasangaki and Oguya 2011)). Community radio can be used along with newer forms of ICT to provide agricultural knowledge and information to rural women (Giles 2004). Both Wambui (2002) and Hafkin and Odame (2002) discuss how digital radio can be used to deliver local language programs through links with the internet and mobile phones. Radio broadcasts can also be used in distance education to air both formal and informal learning content for rural women (Maskow 2000). Similarly, radio was used in rural Ghana to conduct panel discussions featuring women who could talk about a variety of topics affecting women on local FM. While training rural women to serve as panelists, the project also increased their capacity and knowledge in these areas. The Dimitra project, which uses rural radio and listeners' club, is a promising example of mixing different tools of communication, such as the cases implemented in Niger and Democratic Republic of Congo (box 3).



Mobile phones also offer great opportunities for women and men, especially in remote areas, to be connected with information relevant for their livelihoods and social welfare. The Grameen Phone project (2005) that specifically targeted women in Bangladesh is a good example of the successful use of mobile phones in agricultural extension. Women received learning modules related to sheep and goat enterprises through their mobile phones while they tended to the animals overcame the barrier imposed by time constraints (Balasubramanian 2010). Five hundred one-minute audio messages on topics like buying goats, feed, disease and health management and marketing management were sent as voicemails. The project not only increased women's confidence from the information sharing, it also linked them to information sources. The flow of communication within the self-help groups, relatives and friends enabled the women to learn to use the phones and benefit from the information shared. It also enhanced their self-respect and status within the family. However, there are numerous types of information that cannot be delivered and

shared through mobile phones. Similar to radio, people can learn only so much from mobile phones, and these should be complemented with other forms of ICT, training, and traditional extension service delivery, especially in areas of new varieties or improvement production and conservation management practices. As demonstrated by the Grameen project, the information and knowledge shared through mobile phones were followed up with weekly group meetings to share experiences and recall information. In many instances, agricultural management practices can be delivered initiated by mobile phones and radios but hands-on training and demonstration plots will be required for effective learning by farmers.

The internet is of course the most modern form of ICT and has the capacity to be both a one-way and an interactive learning medium. The SISSI project in Uvira, Congo created a support group of women accessing agricultural information. The information center not only provided internet access to the 60 women farmers involved in the project, but also matched them with mentors from other local communities to reinforce their support networks (GenARDIS 2010). In another project in Uvira, 48 women and 18 men from 9 different women's groups received information on production and disease management for cassava crops. They were also provided with mobile phones to contact their potential buyers. A radio show was created on topics related to gender and agriculture. Similarly, the Ndola resource center in Zambia trained 115 women in open source software (GenARDIS 2010). This again demonstrates the need to combine different tools and approaches to disseminate information and technologies among rural populations. Combining different ICT tools can overcome constraints in mobility, time, and formal education, to which women have less access. ICTs can even address the high costs of certain ICT technology and liquidity constraints by women since they are able to use ICT tools owned by others.

3. Knowledge and capacity strengthening

Paying close attention to the gender gaps in education and training can help close the gender gap in technology adoption and labor productivity.

Information on returns on technology options: Farmers' knowledge about new technologies must also include information about the returns from adoption, including 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 2009). Fletschner, Anderson and Cullen (2010) find that women are more likely to choose activities with lower expected returns and with lower risks. Extension services and capacity strengthening initiatives can help farmers calculate or understand the profitability and risks associated with new technologies. For example, marketing extension approaches implemented with numerous community-based organizations in Bangladesh have proven to increase incomes, especially for poor women (World Bank, FAO and IFAD 2008). It is important to formulate extension messages and training courses that are easy to

understand. Follow-up interaction with farmers helps ensure that the knowledge gained is applied. In areas where women have lower literacy or schooling rates than men, it is critical to use simple training materials that are easily understood. Training programs should also have flexible time schedule, covering evenings, weekends, part time, and child care to be effective for both women trainees and trainers.

Continuity of trainers: Training-of-trainers approaches or training members of a household can help to continue developing and sustaining capacities. Several examples from World Bank, FAO and IFAD (2008) and case studies received can be cited here. In China and LAO PDR, strategies for offering training in weaving have a built-in multiplying effect, in which trainees are required to impart their new knowledge and skills to others. WFP has begun a program in which training focuses on all family members so that critical skills are not lost and a business can carry on if a family member should die and this is especially useful for all remaining family members especially orphans in areas with high HIV prevalence. Training family members is also an important consideration used by SEWA approach in strengthening capacity of various groups and associations in all aspects of work including organizational management, financial management, and specific livelihoods being promoted in the specific local context.

4. Addressing time burden

Technologies that reduce women's labor burden, increase their labor productivity and provide greater control over the outputs and incomes from their labor, will have considerable impact on the well-being of women farmers (Doss 2001). Programs and projects that promote labor-saving technologies targeting women need to be intensified. The need for labor-saving technologies is even more acute in households affected by HIV and AIDS since women often bear the double burden of producing food and caring for the sick. There are numerous examples of such technologies including improved and fuel-efficient cook stoves that save women's drudgery by reducing time spent cooking and also their health (Paris *et al*., 2001; Carr and Hartl 2010). In Sri Lanka, Carr and Sandhu (1987) show that cooking time on the improved fuel stoves went from 77 minutes to 62 minutes for a meal. The more advanced stoves also reduce indoor air pollution thereby reducing respiratory illnesses among the women and children (Carr and Hartl 2010). The Kenyan Ceramic Jiko stove has seen a household penetration of 17 percent in Kenya alone, covering some 78,000 rural household (Walubengo 1995 in Carr and Hartl 2010). Women also need access to complementary resources in order to benefit from new technologies. When fuel-efficient stoves were introduced in the 1980s to reduce women's energy burdens, conserve fuel, and decrease pollutants, women were slow to adopt them because they often lacked funds to buy the stoves.

Multifunctional platforms (MFP) are increasingly popular technology promoted through projects in Mali, Burkina Faso, Senegal, Ghana and Guinea (Mauritania has also asked for

assistance). They comprise a diesel engine built on a steel structure capable of carrying various tools such as a corn mill, a hulling mill, a battery charger, a pump, and others. Attached to the engine one after another and according to need, these equipment transform the motive power into the various energy services (milling, pounding, lighting, airconditioning, pressure-driven water) [Häusler, N'Guessan and Dessallien 2007]. These services have the huge potential to boost daily productivity in the villages and enable women and children to save much time and energy (Häusler, N'Guessan and Dessallien 2007). While no impact assessment or evaluation studies have been conducted on how women's autonomy and control over these assets and services are being affected, these MFP are showing some promise. In a mid-program evaluation report by Häusler, N'Guessan and Dessallien (2007), MFPs have considerably saved time for women (2-3 hours per day). They find a significant increase in girls attending school and increased productive and economic activities by women. However, they also highlight that the biggest challenges for these multifunctional platforms is their cost recovery and financial sustainability. Rigorous evaluation and impact assessment of these types of potentially-promising technologies can be useful to understand how to improve their design, development, and dissemination.

Post-harvest machinery for processing can reduce drudgery from hand pounding, increasing the volume of rice processed and allowing women to use their time more flexibly (Paris, Feldstein and Duron 2001). Depending on the local context, high-value agriculture and agro-processing have been cited as promising business ventures for poor women. White (1999) finds that in most rural areas across India, Bangladesh, Pakistan, Uganda, Tanzania and Kenya, women were significantly involved in agro-processing industries at the village level. Reports from the Middle East also show that women's involvement in agro-processing industries is high, though they are limited to low-technology sectors like tobacco processing (UN 2001). Improved and gender-sensitive food processing technologies should be promoted to women, and this should also be coupled with greater access to finance, business skills and training on quality and hygiene standards in order for them to compete in lucrative markets.

Other promising technologies that are useful in easing the burden of women's work are carrying devices and transport technologies, such as donkeys, wheelbarrows, and carts. Mwankusye (2002) cited by World Bank, FAO and IFAD (2008) find that the use of a wheelbarrow can reduce the time spent on water transport. In addition to helping with the collection of water and fuelwood, such technologies can also help women with a range of other transport tasks related to carrying tools to and from the fields, carrying crops from fields to grinding mills and markets, and transporting children and the elderly to health clinics. These technologies are also energy-efficient.

Improved roads are also useful in bringing technologies and inputs to farmers and bringing farmers to markets. Evidence compiled by World Bank, FAO and IFAD (2008) suggests that rural roads increase the productivity and incomes of men and women farmers, by reducing

time and opportunity costs and expanding their access to markets and inputs. In Peru, the rehabilitation of nonmotorized tracks in isolated communities reduced poverty from 83 percent to 74 percent, and 77 percent of the women travelled more frequently (World Bank, FAO and IFAD 2008). Planning and implementing for rural infrastructure project does not always take women and gender issues into account. It is important to use participatory approaches and pay explicit attention to gender inclusion throughout the policy formulation and project cycle to design, implement, supervise, and evaluate the gender-disaggregated effects of investments. It is also crucial to use gender-disaggregated monitoring and evaluation indicators to measure gender equity in all aspects of policy, program, and project implementation and outcomes.

Not all women, however, will benefit equally from labor-saving technologies and thus, how different groups of women gain, or lose, from the introduction of new technologies needs to be evaluated. Paris and Chi (2005) find that plastic drum seeders benefitted better-off households but have resulted in the loss of livelihoods for the many women from poorer and landless households who used to be hired to undertake these tasks. Maguzu and others (2007) and World Bank, FAO and IFAD (2008) analyze conservation or zero tillage agriculture and suggest while it has many benefits, it led to more women in landless households receiving fewer opportunities to work in planting and seeding and to more liquidity constraints for poor women to purchase inputs up front and to purchase tools suitable for direct planting. Several studies indicate that adoption of improved technologies have increased women's time burdens as additional and highly time-consuming tasks or processes are often required to adopt these new technologies (Berio 1984; Suda 1996; Quisumbing and Pandolfelli 2008). For example, in Malawi and Zambia, women who were doing processing reported that adopting hybrid maize gave them more time-consuming tasks as the hybrids were more difficult to pound (Hirschmann and Vaughan 1984; Jha, Hojjati, and Vosti 1991). Economic cost-benefit analysis and poverty and social analysis are important in order to know which type of farmers or segment of the population are adversely affected; to support the transition and adjustments needed by those affected; and to devise ways to protect those vulnerable and resource-poor who would be affected.

Failed technology uptake suggests that new technology design needs to take into account culturally permissible roles for women. Involving women in the maintenance of new technologies can be one strategy for challenging rigid gender roles. When SEWA began a campaign to mobilize women for water management in Gujarat, India, women resisted participating because they regarded the development and management of water infrastructure as male territory. However, as women became trained as hand-pump technicians to repair broken pumps, involvement in the campaign increased and women began to take ownership of water management (Panda 2006).

5. Affordability of technology and complementary resources

More affordable seed and fertilizer packages: Quisumbing and Pandolfelli (2010) emphasize that promoting divisible technologies or smaller input packages that are more affordable is proven to be effective in Malawi. A small-pack seed approach is another example of success story and has been implemented in at least 9 countries in Africa (Burundi, DRC, Ethiopia, Kenya, Malawi, Mozambique Nigeria, Niger, and Tanzania) and has spread across crops (for example, beans, cowpeas, groundnuts, and soybeans) (personal communication with Louise Sperling, September 7 2011). Quisumbing and Pandolfelli (2010) also find that fertilizer-for-work programs can be targeted to women where women do not have enough cash to pay for fertilizer. Targeting credit to female farmers for fertilizer purchases has been recommended for more than a decade (Quisumbing and Pandolfelli 2009). Gladwin (2002) and Quisumbing and Pandolfelli (2009) have suggested exploring gender dimensions of fertilizer use in Sub-Saharan Africa in relation to both inorganic and organic fertilizer and soil fertility management techniques and assessing which strategy would work best given certain local contexts.

More affordable irrigation system: Developing and disseminating small scale water management or drip technologies is also promising. In Nepal, Upadhyay (2004) found that low cost irrigation technology can help rural women meet their water needs thereby saving time and energy and also increasing incomes and that drip irrigation is accessible to small farmers, especially women farmers, through local dealers. Unlike larger state funded irrigation projects which benefitted mostly large farmers who are mostly men and irrigated only 20 percent of the land, drip irrigation can be made accessible to small and women farmers through local dealers. Drip irrigation has reduced time spent by women doing irrigation in their fields; required less capital-intensive investment; increased incomes which were spent on household expenses and schooling of kids; increased production; and improved nutritional intake of children in the household.

6. Greater access to rural finance

The most consistently mentioned factor affecting technology adoption is access to rural credit. In many cases, successful projects and programs that promote the development and dissemination of technological innovations are coupled with a component on credit provision. For example, SEWA adopts a holistic approach comprising of training and education of technologies; group-based lending; capacity strengthening and support services; market-orientation and developing mechanisms to improve the farmer's bargaining power and market access; strong linkages to researchers, input suppliers and markets; and developing farmers' organizations' networking, policy dialogue, and knowledge management skills. Various evaluation studies on specific activities adopting SEWA approach find that this approach increased both women and men farmers' productivity, improved their access to inputs and services, lowered their production and marketing costs, and increased their incomes (based submitted documents from this study's call for case studies).

Liquidity constraints of farmers should be a main consideration for technology dissemination projects. However, there is a need to strengthen the broader rural finance system rather than ad-hoc pumping of credit to rural areas. Microcredit can help in some cases, but may be limited in terms of its effect on productive ventures for women. Women's credit needs are more diverse than the initial focus on small group loans and microcredit: women need longer-term and larger amount of credit to build assets and invest in viable and productive activities. There will be a need to devise innovative ways of addressing gender-specific constraints and social biases against women that may be hindering serving the most productive and profitable potential clients. In designing loan packages for a heterogeneous clientele, lenders need to explore innovative ways of meeting clients' needs, even if it means departing from a traditionally successful business model. For example, interest rate cuts produced more borrowing by poor females (Quisumbing and Pandofelli 2009). Changing the duration of the loan significantly affected sizes of loans demanded, particularly for poorer clients (Quisumbing and Pandolfelli 2009). Allen (2005); Murray and Rosenberg (2006); and Ritchie (2007) cited by World Bank, FAO and IFAD (2008) highlight that commitment saving products and savings-led groups perform better than credit-led groups.

7. More inclusive, equitable and effective rural institutions

Promoting women's and mixed groups as innovators: Women groups and mixed groups are able to access farmer-managed innovation funds and participate in multi-stakeholder learning processes such as the case of the PROLINNOVA (PROmoting Local INNOVAtion in ecologically oriented agriculture and natural resource management) program being implemented in various countries in Asia, Africa and Latin America. Key elements of this program include: (1) focus on farmers' joint experimentation; (2) mixed approaches of learning using multimedia, training, fairs, exchange visits, and videos; and (3) competitive grants to enable farmers to start their experimentation and facilitate their learning (Waters-Bayer 2011). It has been reported that the activities of this program have improved gender relations, where women started setting-up cooperative and strengthening their capacities (Waters-Bayer 2011). Putting farmers at the driver's seat can foster innovations, but farmer's groups that had received support from research or extension service providers performed better based on the PROLINNOVA experience. The key lesson is that while the focus of innovation projects should be on farmers and on cultivating their innovativeness, this should be coupled with strengthening research and extension organizations and other service providers and enabling and incentivizing them to be responsive to the needs and demands of both poor women and men farmers.

Group-based dissemination works: Group formation is a well-established means of pooling resources and accessing technologies, information, and services. Village women can organize sizeable networks and federations of networks capable of effectively demanding improved technologies and services and asserting land and water use rights. Quisumbing and Kumar (2011) find strong evidence of long-term impact of collective and group-based dissemination

of agricultural technologies using 10-year panel data on Bangladesh. A strong national-level women's producer organization in Papua New Guinea that is hosted at the national agricultural research institute has enabled more women and men researchers to be engaged in research planning, innovation process, and technology dissemination and evaluation. In addition to formal organizations, Pandolfelli, Meinzen-Dick and Dohrn (2008) show that informal networks have been instrumental in disseminating innovation. It is useful to understand existing social networks among women and men farmers and support them in the process.

Promoting women's participation in mixed groups: Women in mixed groups found it easier to tap some of male resources, gain contacts and information, and obtain help and assistance in case of need than women-only groups (Gotschi, Njuki and Delve 2008). Various studies suggest that gender-balanced groups exploit the complementary advantages of men and women and have better access to information and services. However, many mixed groups have failed to transform power relations between men and women, continue to underrepresent women in leadership, and perpetuate female subordination. Gender norms and traditional gender roles can be challenged and addressed to provide greater gender equality in mixed groups. Capacity strengthening and empowerment of women members and sensitization of both male and female members can help in easing persistent female subordination in mixed groups. A good starting point is training and sensitization among development and extension agents to be aware and responsive to these gender differences in mixed groups (Gotschi, Njuki and Delve 2008). Agarwal (2009) also supports the need for a critical mass (at least one-quarter proportion of women) for effective women's participation in mixed groups.

Holistic approach in supporting self-help groups: Women organizing themselves into women-only groups, formal or informal, show potential to empower women, gain better access to and use of technologies and improve livelihoods. Bantilan (2006) finds that for groundnuts in India, collective action and social capital among women are the major factors of the high levels of adoption of the innovative groundnut production technology (GPT) in the site Umra. In comparison, in the other site, the adoption was very low as there was minimal collective action and high level of gender discrimination which prevented women from participation in meetings and having a strong voice.

Creating women-only groups is necessary but not sufficient condition as it often avoids addressing and tackling gender relations and traditional gender roles. In cases where mixed groups are not culturally possible or difficult to set-up, organizing women into self-help groups can offer a great potential for women to interact amongst themselves, get useful information, build social capital, gain confidence and skills, and improve their livelihoods. For women, the presence of self-help groups in the village allows them to not travel far away from their villages, yet get the benefits these groups bring. As a mechanism of self-empowerment of women, these groups have played an important part in enhancing

confidence and self-esteem for women members, which often translate into real economic benefits for women. Self-help groups in Bihar, India are effective in improving the livelihoods of women and bringing positive outcomes in agricultural development (World Bank and IFPRI 2009). In Karnataka, India, Bharati and Badiger (2006) find that women members who joined the self-help groups during the project saw an increase of 45.47 percent in their confidence building index, 33.5 percent in their decision making ability and 41.9 percent in their social empowerment index. In Gambia, the Vegetable Growers Association provides services like purchasing, marketing, processing and utilization and its insurance and financial divisions take care of health and livestock insurance and also provide deposit services and loans.

However, many of self-help groups in other developing countries remain small in terms of economic activities and continue to have low access to resources, information, and support. Supporting women's groups to form federations to pool resources and increase linkages to other groups has been proven to be effective in helping women producers. For example, in Benin, small-scale cattle herders, including women herders, organized themselves into grassroots groups, unions at district level, and a national apex organization called ANOPER (Association nationale des organisations professionnelles des éleveurs de ruminants), which provide them better bridging relations in local unions to supply inputs and provide technical advice (FAO 2012).

8. Emerging innovative institutional arrangements

Among the more recently piloted institutional arrangements for innovation are innovation networks and multistakeholder platforms. Innovation networks assemble stakeholders to share information, identify opportunities, discuss problems, and agree on joint activities related to a shared interest, often with a specific commodity/cluster focus. Innovation platforms focus on all kinds of innovation, not necessarily research alone, and they may be led by actors other than researchers. Even so, they present an important venue and opportunity for many research organizations to engage with other actors and develop partnerships. In central and west Africa, a network of regional stakeholder platforms, the "Innovation variétale chez le bananier plantain – réseau de plateformes régionales" (INNOBAP), to improve information exchange and knowledge about the needs of various value chain actors, including women farmers and processors, implemented in Benin, Cameroon, Gabon and Guinea (FAO 2012). Surveys carried out show that stakeholders, mostly women's groups have already adopted and are marketing and processing the new varieties introduced by the initiative, leading to increases in incomes (FAO 2012). The Papa Andina program implemented in Bolivia, Ecuador, and Peru successfully combined and innovation platform and "Participative Market Chain Assessment" (PMCA) approach. Although there is no gender-disaggregated impact assessments a number of reports have indicated that poor women are majority of the participants and that they benefited from the program (see Spielman, Ragasa, and Rajalahti 2011 for more details).

FAO (2012) mentioned several multistakeholder platforms active in policy dialogues at national level with active engagement of women producers, processors and traders including the Ghanaian Rice Interprofessional Body (GRIB), Senegal's "Conseil national de concertation et de coopération des ruraux" (CNCR), and National Fisheries Post-Harvest Operators Platform (NFPHOP) in Gambia.

9. Address social and cultural constraints

In sectors and areas where women are disadvantaged by gender norms, explicit targeting can be necessary to catalyze a change process for circumventing gender discrimination and securing women's access to key resources.

Another cultural issue is the risk of shifting control over profit and assets from women to the men. Special policies and provisions are often required to ensure that women retain control over important income generating assets - control which can be jeopardized when commercialization makes them more profitable and men may seek to take over control of the assets. An example is giving contracts in the name of women and having systems that enable direct payment to women (Development and Training Services, Inc. 2009). Regulations that defend women's control over loans against the demands of other family members can make rural finance a more effective instrument for poverty reduction. Prospective threats to women's access to and control over productive assets, including their own labor and the income it generates, need to be carefully assessed and accounted for in the design and planning of interventions.

Reservation or quota systems for women as project beneficiaries, in membership in producer organization, committees or associations, or in key executive or decisionmaking positions can also play contribute to reducing social and cultural constraints in accessing and using technologies, information, and economic opportunities. For example, in Bangladesh, reservation policy and quota systems for women on number of job opening and in management positions in producer associations have been reported successful and it being attributed to a 50-percent increase in women's employment and equal wages (Ashby *et al*., 2008). Chattopadhyay and Duflo (2004) analyze a constitutional amendment that mandates seats to be reserved for women in local councils on investment decisions made in West Bengal and Rajasthan, India, and find that female representative regimes make more requests for goods that satisfy women's needs, such as drinking water, while male regimes favor male goods, e.g. roads. Female reserved villages have a higher public goods provision compared to non-reserved villages, and women leaders are less prone to corruption (Duflo and Topalova 2004). In addition, female reservation was found to increase the likelihood that women actively participate in village meetings by approximately 25 percent in West Bengal (Pande and Ford 2011). A recent study on the longer-term impact of the reform finds female reservation reduces difficulties in the delivery of public goods and the likelihood to voice public problems. In addition, reservation reduces female time spend on domestic

duties and increases household labor market participation and incomes. Beyond economic outcomes, reservation impacts on the female position within the household as it increases the likelihood of using birth control methods and to have a bank account (Deininger, Nagarajan and Paul 2011). These studies suggest that there is a promising role for quota systems and reservation policies, but capacity strengthening for women will be important for them to take full advantage of their potentials and the opportunities presented to them.

Supply-side opportunities

1. Explicit gender targeting in extension services

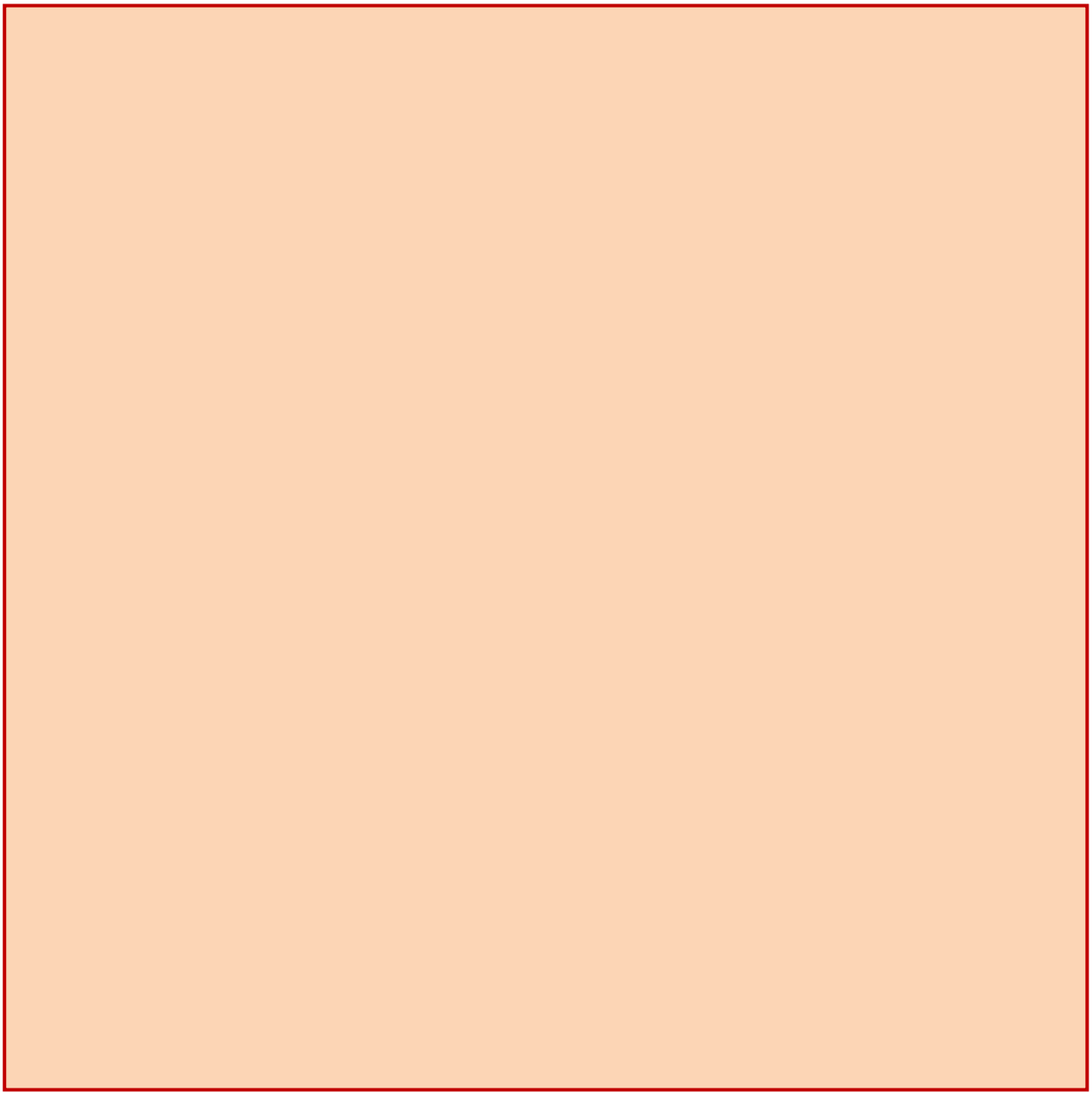
Institutional reforms toward more community-based, market-driven, or farmer-led extension systems do not automatically guarantee greater inclusion and participation of women and marginalized groups. Explicit targeting is often required. For example, in Uganda, gender-disaggregated assessments are limited. A study by Obaa, Mutimba and Semana (2005) in the Mukono district show that farmers perceive that "poor farmers were left out" and suggests that the "required relatively high levels of literacy and the lengthy debates (on prioritization) precluded women and the poor". Many women do not make use of extension services and agricultural technologies due to limited education, lack of control over land, and in some communities, cultural factors that limit women from using some technologies (for example, like sitting on tractors). The enterprise approach embraced by NAADS had tended to favor farming enterprises requiring substantial amounts of land or capital, thus putting women and youth at a disadvantage compared to men (Bukenya 2010). Moreover, although many elderly women belong to the groups, they are not empowered to influence group decisions in the groups, and very few have 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.

In India, several gender-specific provisions are included in ATMA model including mandating resources for women farmers' activities and quota system for women in trainings-of-trainers and in all committees and groups at the district level (Meinzen-Dick *et al*., 2010). These provisions were not always followed and evidence suggests that the impact of ATMA on women farmers is limited (World Bank and IFPRI 2009; Meinzen-Dick *et al*., 2010). For example, "in a case study in Bihar, a group of landless female members of a self-help group was selected for an exposure visit to West Bengal to learn new agricultural technologies. It turned out that the new technologies 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 2009).

Both farmers as innovators and the different support organizations (research and extension institutes) will need to be supported. First, experience suggests that both women and men farmer advisors and extension agents are being trained (e.g., 17 percent of farmer trainers in Kenya and 52 percent in Uganda trained in forestry conservation and management practices are women [Kip-Tot 2011]). Many NGOs are increasingly using this approach which can be cost-effective and help to hasten the dissemination and adoption of technological innovations in rural areas. The community-farmer group support program called “Leadership for Green Agriculture and Community in Rwanda is a good example of a promising women-extension-farmer approach (box 4).

Second, farmer field schools (FFS) are promising approaches and increasingly being used for education and extension, but existing studies show mixed impacts on women. In an impact assessment of FFS done in Kenya, Tanzania and Uganda, Davis *et al*. (2010) find that there was more participation by women in FFS and a significant higher productivity increases among women than men. In Vietnam, Braun *et al.* (2006) show that women’s participation in FFS has positive effects on women’s leadership, incomes, and livelihoods. However, in Uganda, Isubilaku (2007) relates that although women outweighed men in number, men dominated most discussions and activities in FFS. Capacity strengthening of women in leadership and negotiation skills will be important. In Indonesia, World Bank (2000) concludes that despite substantial increases in women’s participation in FFS (the average

percentage of women trained in IPM field schools increased from 5.6 percent at the beginning to 21.5 percent in the last year of the project), findings of the gender studies suggest that gender criteria were not always applied correctly and excessive pressure to meet gender targets resulted in participation of non-farmers (i.e. farmers' daughters who were students) in field schools in some provinces where women do not play an active role in farming. Policies, regulations, or explicit provision in project documents on women's empowerment or gender quota may be present, but impact boils down to implementation and effective targeting. Greater supervision and more regular monitoring and evaluation will be needed; and more importantly there will be a need to change mindset and practices on how we monitor and evaluate progress shifting from output-orientation (and using indicators such as number of women trained or number of women beneficiaries) to impact-orientation (and using indicators such as number of women who have increases in incomes and number of families that have increases in nutrition and food security). Evaluating



progress of projects and performance of staff and organizations (public sector, NGO, civil-society organizations and other service providers) along these lines will be crucial for greater accountability.

Third, for reasons given earlier, it may be important to increase the number of female extension workers and improve their work conditions and incentives in order to increase outreach to women farmers, especially in areas where cultural norms restrict male-female interaction. In areas with cultural norms influencing male-female interaction or where it is difficult to attract or retain female extension agents, men extension agents can be sensitized and provided with incentive to work with and meet the needs of both male and female farmers.

Fourth, use of competitive funds to co-finance research and extension projects and strong focus on indigenous peoples and women's organizations are showing some promise in fostering responsive and equitable rural innovations. An approach of using financial incentives is being pilot-tested through the Peru Agricultural Research and Extension Program (INCAGRO) to strengthen both the agricultural technologies and services delivery (supply side) as well as the articulation of the demand for them (demand side) and targeting indigenous peoples and women's organizations (box 5).

2. Capacity strengthening for women in research and education

A number of initiatives are already in place to strengthen support and mentorship for girls and women into science and agriculture. The AWARD (African Women in Agricultural Research and Development) program is showing some positive impacts to enhancing capacity and opportunities for women professionals. SAFE (Sasakawa Africa Fund for Extension Education) program also pays close attention to training women extension agents. Current approaches need to be scaled up while launching similar new initiatives at the same time.

Campaigns and affirmative action to encourage more girls taking up agriculture and sciences will be needed. Change in outdated and gender-biased curriculum in many developing counties is a priority. The production-focus, as well as branding agriculture, field crops, and technical and scientific inquiries as male fields will need to change. There has to be a greater focus on a holistic and comprehensive view of "food" and emphasize on food nutrition and security, with greater recognition of women's contribution and roles in the different stages of producing and providing food and nutrition for their families.

From a research-perspective, Kingiri (2010) finds that available studies in innovation systems have been relatively silent on gender issues. She suggests the need to conduct gender analyses using a systems-perspective, as well as developing diagnostic tools to better understand gender dimensions of agricultural innovation systems. While improved gender analyses are important, communicating and sharing the lessons and insights learned from

these analyses are even more crucial part of the institutional learning. There is also need for greater gender mainstreaming and institutionalized efforts, with complementary capacity strengthening and funding, to provide incentives to do more gender research (Kingiri 2010).

Strategies to create enabling environment and good governance

Gender-responsive technologies and changes within research, education and extension organizations to respond more to demands and needs of both women and men producers will not work without complementary changes in the wider policy environment.

Creating a conducive rural investment climate: The most significant positive impact on agriculture and employment, for both men and women, will come through creating a dynamic rural economy in both agriculture and nonfarm sectors, focusing primarily on creating a good investment climate. There is also a need for explicit attention to gender bias in the labor market, including wage inequalities; occupational segregation; women's time burden; and violence, health and safety in the workplace. Reducing labor market segmentation and wage inequalities improves the mobility of labor, increases employment, and contributes to economic growth. Empirical evidence also shows that women invest more than men in the development of children; thus higher levels of employment and earnings for women not only contribute to but also have intergenerational benefits.

Increasing land tenure security: Access to land and security of tenure are important in technology adoption and increasing productivity. Changes in the laws governing property rights are needed so that women may hold individual or joint title to land. This may also help ensure that women maintain control over land and any profits the land may incur. In Bolivia and Nicaragua, providing land titles to household heads rather than to both spouses, effectively deprived women of their customary access to land (Ashby *et al*., 2008).

In addition to joint titles, legal awareness is also important. Deininger *et al.* (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 or component in the computed index would potentially increase the propensity to undertake soil conservation that is equivalent to increasing the length of possession by more than 10 years or the head's level of education by more than 3 years Deininger, Ali, and Yamano 2006). The same study also show that exogenous increase in legal knowledge from the current level to full awareness would be associated with a 10 percent increase in the number of trees planted per acre (Deininger, Ali, and Yamano 2006). 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, but to date there have not been rigorous impact assessments of legal literacy programs.

Other gender-responsive activities implemented as part of the low-cost community land registration project in Ethiopia include (1) land administration committees at kebele level (the smallest administrative unit in Ethiopia) were required to have at least one female member and land certificates were issued after public registration for transparency; and (2) land certificates included maps and, in some regions, pictures of husband and wife (Deininger *et al.,* 2007). Complementary reforms of family law can also play an important role in ensuring that women can inherit land or continue to use family land in case of divorce. Implementation and enforcement of gender-equitable laws and policies are also urgent issues in many developing countries.

Girls' education: Affirmative action to increase the number of girls going to school is crucial in bringing forth changes in mind-set, awareness, and empowering the next generation of women. A number of initiatives have already been implemented, including the World Bank-led and multi-partner funded initiative of girls' education. A number of countries, such as DRC, are passing laws that will increase accessibility of schools to young children, especially girls, by building more schools in remote areas. These plans should be funded and implemented and scaled out in other countries. More education for women will payoff in terms of increasing the much-needed critical mass of more educated farmers, extension agents, researchers, service providers and policymakers, ready and able to respond to the needs of the poor and hungry.

Sustainable funding: Funding for research and extension is insufficient and several experts have already emphasized the need for government to invest more in them (Beintema and Stads 2011). This can also be coupled with greater farmer-based advocacy for more funds for farmer-led research and extension, together with initiatives toward gender-responsive budgeting to ensure that funds are allotted and benefits accrue to both women and men. Other structures and women-specific activities, such as setting-up gender machineries or appointing gender focal points in relevant ministries, are often not effective due to limited capacity (human, financial, operating) and limited power and authority given to these structures. These women's machineries need to be strengthened, along with their capacities for negotiation, to have an effective voice in the budget processes. These women machineries and women's organization should be linked more closely with research institutes and the Ministry of Agriculture.

SUMMARY OF DISCUSSION AND POLICY IMPLICATIONS

The following are important insights and summary of the discussions:

Female heads of households and plot-managers are less likely to adopt a wide range of agricultural and rural technologies than male heads and plot-managers. The most commonly-cited reasons and results of statistical analyses for this gender gap in technology adoption are greater time and labor constraints; relatively less access to funds and credit; more limited information, education and training; more limited capacity and opportunity in participation in innovation and decisionmaking processes; and more limited access to accompanying inputs and services. These are influenced by weak design or implementation of legislation that protect rights and promote equal playing field and by the persistence of social biases and cultural norms limiting equal access and opportunities for women and men.

Although various labor-saving and energy-saving technologies could have huge potential to reduce considerable time burden of women and increase labor productivity in general, empirical studies show that their use and adoption among rural women has not always been high and usually much lower than men. Three reasons are commonly highlighted as reasons for this gender difference: (1) culturally-appropriateness; (2) physically accessibility; and (3) affordability. In some cases, the adoption of improved productivity-enhancing technologies has increased women's time burdens. The most commonly-cited reasons for this is the relatively weaker participation and engagement of women farmers and stakeholders than men in priority-setting and research processes, limiting women's ability and opportunity to influence the nature and development of technologies being produced.

In terms of ICT, men are more likely to use the Internet and to have an email address than women. There is a more promising pattern of rural women accessing and using radios for agricultural information, although men still are more likely to own and control their use. The relative difference between men's and women's access to and usage of mobile phones is diminishing, although studies have shown that in rural areas, men are more likely to own and have access to phones than women, who have greater levels of illiteracy, cultural barriers, and less available cash and access to credit.

There is increasing attention in the literature that women and men farmers are innovators and doing their own farm experimentation. Several innovation funds are being provided in various countries and showing some promise in providing incentive for farm experimentation for women and men farmers. There are ample evidence of the role of rural institutions and innovative producer organizations in using collective action to address access and liquidity issues and in reducing gender gaps in technology adoption and productivity increases. Moreover, experience suggests that farmer-innovators benefit more if they are linked with effective and responsive support research and extension institutes.

These institutions need to be strengthened and supported by creating a conducive rural business climate and linking them to lucrative markets.

At the support organizations level, there is evidence of weak capacity and incentive of innovation organizations and their staff to be more effective and responsive to the needs of both women and men farmers. Numerous attempts of participatory and consultative approaches seem to lack evidence of significant broad-based impact on technology adoption and gender-equitable outcomes. But, there remains overwhelming underrepresentation of women as scientists, educators, graduates, managers and extension agents. Several initiatives to increase more women graduates, scientists and extension agents are increasingly being implemented, but more need to be done.

The analysis of the constraints and opportunities for increasing technology adoption and impacts on women and men farmers described above points to a number of key approaches:

- Holistic and integrated approach of looking at constraints to production and marketing and paying close attention to the complementarities of inputs and services.
- Explicit targeting, provision and support on poor women producers
- Putting women and men farmers at the center of innovation processes
- Designing incentives for organizations and service providers to respond to women and men farmers' needs
- Promoting equal playing field for women and men producers
- Greater focus on outcomes and impact

From the research perspective, more attention to gender-disaggregated data and gender analysis in mainstream research is needed. More studies are needed that provide nuanced categorization and analysis on gender and addresses the diversity and typologies of women and men farmers.

Holistic and integrative approach: Most of the promising examples and projects have adopted an integrated or holistic approach, starting with a clear joint understanding of the problem and solving the problem through collaboration of various actors. Experience suggests that binding constraints on both the supply and demand sides of technology and service provision and the use of a systems-perspective can ensure that technologies generated and disseminated respond to farmers' and target clients' demands and needs. The SEWA approach illustrates the need to have a holistic and integrated package of financial services, organizing and collective responsibility, and access to capacity building services in order to improve women's incomes and households' welfare. The aquaculture project in Bangladesh described above used technical training on good aquaculture practices and compliance with traceability and food safety standards; linkage to credit and input suppliers; linkage to international markets; targeting poor women producers; supporting collective action among women; reservation policies for women in executive committees;

and empowering women to be champions to raise awareness and tackle social development issues in their communities.

Part of the holistic approach is the need to look at complementary inputs, services or infrastructure that would be required for adopting technological innovations. For example, the use of more advanced forms of ICT, such as mobile phone and internet, are also promising, but complementary investments are needed to make it more inclusive, effective and equitable. These complementary interventions include increasing mobility, liquidity and literacy for those resource-poor, with explicit targeting for women. These have been highlighted by a majority of the case studies received. Investing in complementary physical infrastructure and power supply in many rural areas in developing countries is also important to ensure that these advanced ICT applications are useful.

An important element of an integrated approach to technology and innovation is to shift the orientation of many public organizations from crops and field production to the whole supply chain and food sector. This will open opportunities for a more systematic approach to food security and nutrition and for greater promotion of women's friendly technologies and responsiveness to their constraints and needs.

Explicit targeting of poor women while obtaining men's support: In sectors and areas where women are disadvantaged by gender norms, explicit targeting is necessary to catalyze a change process for ending gender discrimination and securing women's access to key resources. Explicit gender targeting often used by organizations includes quotas for women as project beneficiaries and reservation policies for women in producer organizations' or committees' membership or leadership positions. One strategy that is proven to be responsive to poor women farmers is offering small packages and more affordable technologies and inputs. Fertilizer and seeds being offered in smaller packages were proven to be more affordable to poor women farmers and subsequently increased their adoption of these technologies and later on their productivity and incomes. Radio is an effective ICT tool to reach poor women and men, especially in remote areas. Moreover, the use of simple extension and education messages, illustrations, and educational videos, especially to those with lower literacy level.

Affirmative action is needed to ensure that more girls going to school and more women professionals are getting equal opportunities as men in the area of research, extension, and education systems. This emphasis on women's education is important to ensure a pool of well-qualified women candidates for leadership and management positions in organizations. However, quota systems, focal points, and gender-balanced staffing in research, extension and education organizations may not work without genuine empowerment of women professionals. Quota systems and reservation policies should be complemented with genuine decisionmaking authority and empowerment by women, as well as confidence-building, greater mobility, decreased time burden, training and capacity strengthening.

This is not to say that projects and programs should exclude men. On the contrary, evidence suggests that getting men's support is critical, and often necessary for the success of gender-responsive projects. Moreover, paying attention to heterogeneity of women and men producers and careful targeting are required to reach those who really need assistance. Understanding the local context and tailoring interventions that fit this context is important.

Women and men farmers at the center of innovation processes: Many past technologies have failed because they were not able to engage farmers and other end-users into the whole innovation process starting from the upstream planning and priority-setting. Greater linkages are needed among researchers, extension agents, farmers and other innovation actors. Poor women and men farmers and their organizations need to be funded for their participation and active and engagement in key priority-setting and innovation platforms. Other innovative ways to link research, service providers and farmers should be promoted, such as hosting women's organizations at the research institute or community information and resource centers with regular interactions with researchers and women and men farmers.

While a number of opportunities and initiatives are available that promote greater farmer and end-user involvement in innovation processes, gender inclusion is not automatic. There is increasing use of civil-society organizations as providers of research and advisory services. Group-based dissemination systems are also being used in extension, education and technology transfer. Farmer's organizations are also discussed in the context of their greater role in research and extension fund management and M&E in countries and communities that have adopted more community-based innovation systems. However, attention to women's specific and differentiated constraints and their limited participation in these organizations and processes are often not the priority. Institutional and organizational arrangements such as research-extension-farmer linkage systems, innovation platforms, participatory approaches, multistakeholder networks, and competitive grants and other financial instruments often do not automatically ensure equal opportunity for participation and decisionmaking by women and men. Explicit targeting of women and gender-specific activities will be needed.Women organizations and community information and resource centers being hosted at research institutes and explicit gender targets in competitive grants, linkage committees, platforms and mixed-gender organizations are some examples of activities and initiatives that will be useful.

Incentives for organizations and service providers to respond to women and men farmers' needs: More recent initiatives to foster responsiveness and inclusiveness, such as participatory and consultative approaches, are only effective if coupled with supply-side interventions to tackle the supply-side bottlenecks. A number of cases in this paper have shown that countries that just focused heavily on participatory approaches (e.g., DRC), without strengthening the capacity and incentive of the supply-side actors, remain plagued with inefficiency of the systems and inability to respond to the needs of the population. Lack

of follow-up actions and response from research to problems, preferences and demands articulated by farmers and end users often discourages continued participation of farmers in participatory and consultative processes. Understanding and implementing other sources of incentives and accountability will help address deeply-rooted bottlenecks in innovation systems. This applies to the pluralistic research and extension systems, including government, private sector non-government organizations, church-based groups, farmers' organizations and other civil-society organizations.

One way to strengthen incentives for greater responsiveness and inclusiveness is to explicitly have them as part of research and extension organizations' performance monitoring and valuation systems. Projects have often used "number or proportion of women beneficiaries" as the indicator for gender-responsiveness in projects. There should be a shift from this narrow focus to a broader orientation on outcomes and impacts such as looking at reduced time burden, women's empowerment, increase in incomes, improved livelihoods and improved nutrition and health conditions. This can increase the motivation and accountability of researchers, extension agents, and managers to improving the effectiveness and responsiveness of research and innovation systems. Other approaches can also adopted, such as competitive grants and other financing instruments with explicit criteria and emphasis on women's organizations and marginalized groups. An example in Peru that is described above is showing promising results in terms of inclusion of women and indigenous groups in the rural innovation and more responsive delivery of technology and services.

Promoting equal playing field: Gender-responsive activities and changes within the research, education and extension organizations will not work without complementary changes in the wider policy environment. Moreover, participatory approaches and consultative processes require specific organizational commitment and policy initiatives. Farmers' associations and community-based organizations cannot operate in their members' interests in an environment hostile to grassroots and women's participation. Policies to foster equitable participation and social mobilization can provide operational funds to build resource-poor and marginalized groups' capacity to participate and cover the costs of their participation. It will also be important to strengthen women's land, property and water rights and investing in girls' schooling. In some countries, a priority is to start a change process to eliminate remaining discriminatory policies against women (for example, women are not allowed to own land and property or borrow money without permission from husband). In most countries, it is the implementation and enforcement of policies and regulations that are critical.

Greater focus on outcomes and impact: Greater attention needs to be paid to effective performance monitoring and evaluation and reward systems tailored to solving farmers' problems. It will be useful to build measurable targets and strengthen monitoring and evaluation to ensure that (1) planning and innovation processes addresses women and

men's needs, preferences and opportunities; (2) women and men can access and use these technologies; and (3) women and men benefit from these technologies.

From the research perspective, more attention to gender-disaggregated data and gender analysis in mainstream research is needed. While numerous gender analyses have been conducted and gender-disaggregated data are increasingly being collected, there are a number of remaining knowledge gaps and adjustments in research and methodology including clearly-defined gender indicators and disentangling the relationship of gender, household size, and income indicators in affecting technology adoption and productivity. There is a need to look at the heterogeneity of women in assessing differences in access to complementary inputs. These types of studies will be important in effective targeting of projects and programs.

There is a need for more evaluation and impact assessment of technologies. In particular, it is important to evaluate the impact of technology adoption on the traditional gendered division of labor and shifts in activities and domains and control. Participatory approaches and decentralization are promising avenues for a more inclusive decisionmaking for food policy processes and rural service provision, but rigorous assessments will be useful in order to understand how these approaches affect the quality of participation and the impact of representation by rural women and men. Findings and lessons from these evaluation studies and impact assessments need to be communicated to decisionmakers and form an integral part of organizational learning. Gender analyses need to be institutionalized, with effective capacity strengthening and incentives for greater attention to gender issues in research and impact assessments.

CONCLUDING REMARKS

This paper reviews and integrates findings from existing empirical studies to identify demand- and supply-side constraints and opportunities in access to, adoption and impact of a wide range of technological innovations by rural women and men. Most studies consistently find that women have much lower observed rates of adoption of a wide range of technologies than men. Most of these studies conclude that it is the gender difference in access to these technological innovations, information about these innovations, or complementary inputs and services that explain gender differences in adoption. The relatively weaker participation and engagement of women farmers and stakeholders than men in priority-setting and decisionmaking also came out several times in the studies reviewed.

At the supply-side, there is evidence of weak capacity and incentive of innovation organizations and their staff to be more effective and responsive to the needs of both women and men farmers. Numerous attempts of participatory and consultative approaches seem to lack evidence of significant broad-based impact on technology adoption and gender-equitable outcomes. Several initiatives to increase more women graduates, scientists and extension agents are increasingly being implemented, but more need to be done. The overwhelming underrepresentation of women as scientists, educators, graduates, managers and extension agents remains to date. Moreover, the broader policy environment and political commitment to tackle a number of supply-side constraints and enforce accountability among supply-side actors are consistently emphasized by a number of studies as crucial in bringing about innovations that are responsive and able to solve the needs and constraints of women and men in agriculture and rural sectors.

Effective gender-responsive interventions examine gender relations and gender inequality and they do not target only one group, while ignoring the other. Interventions that look at technology from a holistic perspective and systems-approach and that pay attention to the complementary of inputs have been the successful ones. Key elements of projects and programs that work well in providing positive outcomes in reaching women and achieving greater gender equality include: (1) providing small packages and affordable ways for bringing technologies to poor women and men; (2) a quota system or reservation policy for women, coupled with effective capacity strengthening, increasing mobility and reducing women's time burden; (3) promoting collective action and organizing among women, coupled with market-oriented capacity strengthening and mechanisms for women to secure their income and resources; and (4) utilizing a mix of delivery approaches such as radio, social networks, farmer field schools, and participatory approaches, coupled with affirmative action of staff gender policy and gender-responsive actions to ensure that useful innovations reach poor women and men farmers; and (5) paying attention to heterogeneity of women and men producers and proper targeting to reach those are in need the most.

Despite some patterns of key elements of a promising gender-responsive projects and programs, the limited evaluation studies, impact assessment, and rigorous evidence hinder understanding under what conditions or contexts certain approaches or strategies work or do not work. More evaluation studies and impact assessments are needed and more gender-disaggregated data and analyses will be important for institutional learning, maximizing desirable development impacts of scarce resources, and minimizing adverse and unintended effects on the poor and marginalized groups.

REFERENCES

Acharya, K.P., and P. Gentle. . 2006. "Improving the effectiveness of collective action: Sharing experiences from community forestry in Nepal," CAPRi Working Paper No. 54. Washington DC: International Food Policy Research Institute.

Adetoun, B. E. A. 2003. "Organization and management of extension services for women farmers in south-western Nigeria." Global Development Network, New Delhi.

Africa Rice Center (WARDA)/FAO/SAA. 2008. "NERICA: the New Rice for Africa – a Compendium."EA Somado, RG Guei and SO Keya (eds.). Cotonou, Benin: Africa Rice Center (WARDA); Rome, Italy: FAO; Tokyo, Japan: Sasakawa Africa Association. 210 pp.

Agarwal, B. 2009. "Does Women's Proportional Strength Affect their Participation? Governing Local Forests in South Asia," *World Development* 38(1): 98-112

Agrawal, A., G. Yadama, and A. Bhattacharya. 2005. "Decentralization and Environmental Conservation: Gender Effects from Participation in Joint Forest Management," *CAPRi Working Paper* No. 53, International Research Workshop on 'Gender and Collective Action', October 17-21, 2005, Chiang Mai, Thailand

Agrawal, A., A. Chhatre, and R. Hardin. 2008. "Changing governance of the world's forests," *Science* 320(5882): 1460-62.

Akeredolu, M. 2009. "Female students' participation in the University Mid-Career Agricultural Extension Training Programme in West Africa: Constraints and challenges," Proceedings of the 25th Annual Meeting of the Association for International Agricultural and Extension Education (AIAEE) held on May 24–27, 2009, at the InterContinental San Juan Resort in Puerto Rico.

Alene, A., V. Manyong, G. Omanya, H. Mignouna, M. Bokanga, and G. Odhiambo. 2008. "Economic Efficiency and Supply Response of Women as Farm Managers: Comparative Evidence from Western Kenya," *World Development* 36(7): 1247-1260.

Allen, H. 2005. "CARE's Village-Based Savings and Credit Programme: Successful Financial Intermediation in Rural Africa." HA Consulting.

Ani. A. O., O. Ogunnika, and S. S. Ifah. 2004. "Relationship between socio-economic characteristics of rural women farmers and their adoption of farm technologies in Southern Eboni State, Nigera." *International Journal of Agriculture and Biology* 6(5): 802-805.

Arcand, J.-L., and L. Bassole. 2007. "Does Community Driven Development Work? Evidence from Senegal", World Bank, Washington, D.C. http://siteresources.worldbank.org/EXTSOCIALDEVELOPMENT/Resources/244362-

1164107274725/3182370-
1164201144397/Does_Community_Driven_Development_Work.pdf.

Arun, S., and T. Arun. 2002. “ICTs, gender and development: Women in software production in Kerala.” *Journal of International Development 14: 39-50.*

Ashby J.A., L. 2004. “Participatory research: does it work? Evidence from participatory plant breeding.” In: New directions for a diverse planet: proceedings of the 4th international crop science congress. Brisbane, Australia, 26 September–1 October 2004. www.cropscience.org.au

Atreya, K. 2007. Pesticide use knowledge and practices: A gender differences in Nepal. *Environmental Research* 104 (2): 305–311.

Ayoyemi, A. A., and I. B. Oluwatayo. 2010. “Gender Mainstreaming of ICT projects: Lessons from rural Southwest Nigeria.” *Libyan Agriculture Research Center Journal International* 1 (2): 65-69.

Babatunde, R. O., O. A. Omotesho, E. O. Olorunsanya, and G. M. Owotoki. 2008. “Gender differences in resources allocation among rural households in Nigeria: Implications for food security and living standard.” *European Journal of Social Sciences* 5(4): 160–172.

Balasubramanian, K., P. Thamizoli, Abdurrahaman Umar and Asha Kanwar. 2010. “Using Mobile phones to enable lifelong learning among rural women in Southern India.” *Distance Education* 31(2): 193-209.

Bates, A. W. Tony. 2000. *Managing technological change: Strategies for college ad university leaders.* San Francisco, CA: Jossey-Bass.

Beard, V.A. 2005. "Individual determinants of participation in community development in Indonesia," *Environment and Planning C: Government and Policy* 23(1):21-39.

Beintema, N.M., and F. Di Marcantonio. 2009. “Women's Participation in Agricultural Research and Higher Education: Key Trends in Sub-Saharan Africa.” Washington, D.C.: IFPRI and Nairobi: G&D program.

Bellon, M.R., M. Adato, J. Becerril, D. Mindek. 2007. Improved maize germplasm creolization and poverty: the case of Tuxpeno-derived material in Mexico. P. 238 – 284 in Adato M., Meinzen-Dick R. (eds.) Agricultural research, livelihoods, and poverty: studies of economic and social impacts in six countries. IFPRI and Johns Hopkins University Press.

Bennett R; Buthelezi T; Ismael Y; Morse S. 2003. Bt cotton, pesticides, labour and health: A case study of smallholder farmers in the Makhathini Flats, Republic of South Africa. Outlook on Agriculture. (32):123 -128.

Bennett R., S. Morse, and Y. Ismael. 2006. "The economic impact of genetically modified cotton on South African smallholders: Yield, profit and health effects," *Journal of Development Studies* 42: 662 -677.

Best, R. 2002. "Farmer participation in market research to identify income-generating opportunities." CIAT Africa Highlights, Kampala: International Centre for Tropical Agriculture. www.ciat.cgiar.org/africa

Bharati R.A., and C. Badiger. 2008. "Impact of National Agricultural Technology Project on Empowerment of Women in Agriculture through Self Help Groups." Karnataka J. Agric. Sci., 21(4): 561-564.

Blackden, C. Mark, and Wodon, Quentin. 2006. *Gender, Time Use, and Poverty in Sub-Saharan Africa*, World Bank (Washington DC: 2006).

Bourdillon, M. F. C., P. Hebinck, and J. Hoddinott, with B. Kinsey, J. Marondo, N. Mudege, and T. Owens. 2007. "Assessing the impact of high-yield varieties of maize in resettlement areas of Zimbabwe." In *Agricultural research, livelihoods, and poverty studies of economic and social impacts in six countries*, ed. M. Adato and R. Meinzen-Dick. Baltimore, Md., U.S.A.: Johns Hopkins University

Bourdillon, M., P. Hebinck, J. Hoddinott, B. Kinsey, J. Marondo, N. Mudege, and T. Owens. 2002. "Assessing the impact of HYV maize in resettlement areas of Zimbabwe." Summary report. IFPRI, Washington, D.C.

Braun, A., Jiggins, J., Ro¨ ling, N., van den Berg, H., and Snijders, P. 2006. *A global survey and review of farmer field school experiences.* Wageningen, the Netherlands: Endelea.

Cadima, X., F. Terraraz, M. Salazar, R. Calderon, I. Antezana, V. Iriarte, E. Ajnota, R. Gonzales, and N. Ferrufino. 2009. "Preserving Biodiversity of Andean Roots and Tubers: Working with Women," Poster presented at the 15th ISTRC Symposium, Lima Peru, on November 2009.

Carr, M., and R. Sandhu. 1987. "Women, technology and rural productivity: an analysis of the impact of time- and energy-saving technologies on women." UN Development Fund for Women and UN Development Programme, New York, NY, USA.

Carr, M., and M. Hartl. 2010. *Leightening the Load: Labor Saving technologies and Practices for Rural Women.* Rome: IFAD and Practical Action Pvt Ltd.

Ceccarelli, S., and S. Grando S. 2007. "Decentralized participatory plant breeding: an example of demand driven research." *Euphytica* 155: 349–360.

Chabossou, A., C. Stork, M. Stork, and P. Zahonogo. 2008. "Mobile Telephony Access and Usage in Africa," *The Southern African Journal of Information and Communication* 9:17–41.

Chapman, R., T. Slaymaker and J. Young. 2004. “Livelihoods approaches to information and communication in support of rural poverty elimination and food security.” Overseas Development Institute: A collaborative research project with the UK Department of International Development and the Food and Agriculture Organization of the United Nations. Available at: http://www.odi.org.uk/resources/download/164.pdf

Chattopadhyay,R. and Esther Duflo 2004. “Women as Policy Makers: Evidence from a randomized policy experiment in India.” *Econometrica* 72(5): 1409-1443

Chirwa, E. W. 2005. “Adoption of fertilizer and hybrid seeds by smallholder maize farmers in southern Malawi.” *Development Southern Africa* 22 (1): 1–12.

Cornwall, A. 2003. “Whose voices? Whose choices? Reflections on gender and participatory development.” *World Development 31(8): 1325-1342*.

Croson, R., and U. Gneezy. 2009. “Gender differences in preferences,” *Journal of Economic Literature* 47(2):1-27.

Datar, G., X. Del Carpio, and V. Hoffman. 2009. "Can a market-assisted land redistribution program improve the lives of the poor? Evidence from Malawi," Policy Research Working Paper Series 5093, World Bank, Washington, DC.

Davis, K. 2006. “Farmer field schools: A boon or a bust for extension in Africa?” *Journal of International Agricultural and Extension Education 13*(1): 91-97.

Davis, K., and M. Negash. 2007. “Gender, wealth and participation in community groups in Meru Central District, Kenya”. CAPRi Working Paper Series No. 65. Washington, D.C.: Consultative Group on International Research.

Davis, K., Nkonya, E., Ayalew, D., Kato, E., Odendo, M., Miiro, R., and Nkuba, J. 2010. “Impact of farmer field schools on agricultural productivity, poverty and farmer empowerment in East Africa.” IFPRI Research Report. IFPRI, Washington, DC.

Deininger, K., and D. Ayalew Ali and T. Alemu. 2008. "Assessing the Functioning of Land Rental Markets in Ethiopia," *Economic Development and Cultural Change*, University of Chicago Press, vol. 57(1), pages 67-100, October.

Deininger, K., D. Ayalew Ali, and T. Yamano. 2006. “Legal knowledge and economic development: The case of land rights in Uganda,” World Bank Policy Research Working Paper 3868. Washington, D.C.: World Bank.

Deininger, K., D. Ayalew Ali, S. Holden, and J. Zevenbergen. 2007. “Rural land certification in Ethiopia: Process, initial impact, and implications for other African countries.” Policy Research Working Paper 4218. Washington, D.C.: World Bank.

Delve, R., Africare-Uganda, C. Chitsike, S. Kaaria, E. Kaganzi, R. Muzira, and P. Sanginga. "How can smallholder farmer-market linkages increase adoption of improved technology options and natural resource management strategies?" Available at: http://ciat-library.ciat.cgiar.org/Articulos_Ciat/Developing_farmer_market.pdf

Development and Training Services (dTS), Inc. "Promoting Gender Equitable Opportunities in Agricultural Value Chains," Handbook, USAID, Washington, D.C.

Doss, C.R. 2009. "If women hold up half the sky, how much of the world's food do they produce?" Paper prepared for 2010 FAO State of Food and Agriculture. Mimeo.

Doss, C.R. 1999. "Twenty-five years of research on women farmers in Africa: Lessons and implications for agricultural research institutions; with an annotated bibliography." CIMMYT Economics Program Paper 00-02. Mexico, D.F.: Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT).

Doss, C. R., and M. L. Morris. 2001. How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. *Agricultural Economics* 25 (1): 27–39.

Doss, C. R., W. Mwangi, H. Verkuijl, and H. de Groote. 2003. *Adoption of Maize and Wheat Technologies in Eastern Africa: A Synthesis of the Findings of 22 Case Studies.* CIMMYT Economics Working Paper 03-06. Mexico, D.F.: CIMMYT.

Doss, C.R. 2001. "Designing Agricultural Technology for African Women Farmers: Lessons from 25 Years of Experience," *World Development* 29(12): 2075-2092.

Doss, C.R.. 2002. "Men's crops? Women's crops? The gender patterns of cropping in Ghana." *World Development* 30(11): 1987–2000.

Drechsel, P., A. Olalaye, A. Adeoti, L. Thiombiano, B. Barry, and K. Vohland. 2005. "Adoption, Driver and Constraints of Resource conservation technologies in Sub-Saharan Africa." FAO, Humbolt University, IWMI. Accessed on September 1 2011. http://westafrica.iwmi.org/Data/Sites/17/Documents/PDFs/AdoptionConstraints-Overview.pdf

Due, J. M., F. Magayane, and A. Temu. 1997. "Gender again--views of female agricultural extension officers by smallholder farmers in Tanzania," *World Development, 25*(5): 713-725. doi:10.1016/S0305-750X(96)00129-5

Duvendack, M. and R. Palmer-Jones. 2011. "High Noon for Microfinance Impact Evaluations: Re-investigating the Evidence from Bangladesh," MPRA Paper 27902, University Library of Munich, Germany.

Edmeades S., J. Nkuba, and M. Smale. 2007. "Use of Hybrid Cultivars in Kagera Region, Tanzania, and Their Impact. In An economic assessment of banana genetic improvement and

innovation in the Lake Victoria Region of Uganda and Tanzania." IFPRI Research Report 155. Washington DC: IFPRI.

Enete, A. A., Nweke, F. I., Achike, A. I., Tollens, E., 2001. "Differentiated gender ownership of cassava fields and implications for root yield variations in smallholder agriculture of southeast Nigeria." *Tropicultura* **19**(3): 105–109.

Ethiopian Society of Population Studies 2008. "Gender Inequality and Women's Empowerment," funded by United Nations Population Fund, accessed on September 27 2011 at http://ethiopia.unfpa.org/drive/Gender.pdf

FAO. 2012. Good Practices in Building Innovative Rural Institutions to Increase Food Security. Rome: FAO and IFAD.

FAO. 2011. *The State of Food and Agriculture: Women in Agriculture- Closing the Gender Gap for Development.* Rome: FAO.

FAO. 2008. "Improving Seed Management Interventions: Lessons Learned from the Field: A review of Selected LinKS Studies," FAO, Rome.

FAO-TECA. Undated. FAO-TECA website.

Farnworth, C.R., and J. Jiggins. 2006. "CGIAR /PRGA PPB Monograph 4: Participatory Plant Breeding and Gender Analysis," (ISBN 958-694-054-3), Columbia: CGIAR.

Farrell, G., and S. Isaacs. 2007. *Survey of ICT and Education in Africa: A Summary Report, Based on 53 Country Surveys*. Washington, DC: *info*Dev / World Bank. Accessed on September 1 , 2011 at http://www.infodev.org/en/Publication.353.html

Fernando, P. and G. Porter. 2002. *Balancing the load: Women, gender and transport,* Zed Books, New York.

Ferris, S., Kaganzi, E., Best, R., Ostertag, C., Lundy, M., T. Wandschneider, T., 2006. "A market facilitators guide to participatory agroenterprise development." Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

Fisher, M. G., R. L. Warner, and W. A. Masters. 2000. "Gender and agricultural change: Crop-livestock integration in Senegal." *Society and Natural Resources* 13 (3): 203–222.

Fletschner, D. and M. Carter. 2008. "Constructing and Reconstructing Gender: Reference Group Effects and Women's Demand for Entrepreneurial Capital," *Journal of Socio-Economics* 37(2): 672-693.

Fletschner, D., C. L. Anderson, and A. Cullen.2010. "Are Women as Likely to Take Risks and Compete? Behavioral Findings from Central Vietnam," *Journal of Development Studies* 46(8): 1459-1479.

Freeman, A. H., and J. M. Omiti. 2003. "Fertilizer use in semi-arid areas of Kenya: Analysis of smallholder farmers' adoption behavior under liberalized markets." *Nutrient Cycling in Agroecosystems* 66 (1): 23–31.

GenARDIS. 2010. "Small Grants that make big changes for women in agriculture." Published by APC 2010.

Gender and ICT Awards. 2005. On the web at http://www.genderawards.net/gict_pr_db.shtml?AA_SL_Session=bd4c3ca897fb8&x=19162&scr_scr_Go=4).

Gilbert, R. A., W. D. Sakala, and T. D. Benson. 2002. Gender analysis of a nationwide cropping system trial survey in Malawi. *African Studies Quarterly* 6 (1). <http://web.africa.ufl.edu/asq/v6/v6i1a9.htm>. Accessed September 7, 200.

Giles, L. 2004. "ICT to reduce gender disparity in Education in Sub Saharan Africa. Capstone Project: Master of Distant Education." University of Maryland, University College.

Gillwald, A, A. Milek, and C.Stork. 2010. *Gender Assessment of ICT Access and Usage in Africa*. Volume One 2010 Policy Paper 5. ISSN: 2073-0845.

Gladwin, C. 1992. "Gendered impacts of fertilizer subsidy removal programs in Malawi and Cameroon." *Agricultural Economics* 7(2): 141–153.

Gladwin, C. 2002. "Gender and Soil Fertility in Africa: An Introduction." African Studies Quarterly 6, no. 1&2: [online] URL: http://web.africa.ufl.edu/asq/v6/v6i1a1.htm

Godquin, M. and A. Quisumbing. 2008. Separate but Equal? The gendered nature social capital in rural Philippine communities. *Journal of International Development (20)13-33*. 2008.

Goldstein, M., and C. Udry. 2008. "The Profits of Power: Land rights and Agricultural Investment in Ghana," *Journal of Political Economy* 116: 981-1022.

Gotschi, E., J. Njuki, and R. Delve. 2008. "Gender equity and social capital in smallholder farmer groups in central Mozambique," *Development in Practice* 18(4): 650-657.

Grameen Phone. (2005). Annual report. Retrieved from http://www.grameenphone.com/assets/annual_reports/pdf/GP_AR_05.pdf

GSMA Development Fund. 2010. *Women and mobile: A global opportunity: A study on the mobile phone gender gap in low and middle income countries.* <HTTP://VITALWAVECONSULTING.COM/PDF/WOMEN-MOBILE.PDF>.

Guyer, J.I. 1991. “Female farming in anthropology and African history.” In *Gender at the crossroads of knowledge: Feminist anthropology in the postmodern era,* ed. M. di Leonardo. Berkeley, Los Angeles, U.S.A.: University of California Press.

Hafkin, N.J., and S. Huyer. 2007. “Women and gender in ICT: Statistics and Indicators for development.” *Information Technologies & International Development* 4(2): 25–41.

Hafkin, N. J. 2002. “Gender Issues in ICT Policy in Developing Countries.” United Nations Division for Advancement of Women. Expert Group Meeting on “Information and Communication Technologies and their impact on and use as an instrument for advancement and empowerment of women”. Seoul, Republic of Korea. November 2002.

Hafkin, N. J., and H. H. Odame. 2002. “Gender, ICTs and Agriculture.” Situation Analysis for the 5th Consultative Expert Meeting of CTA’s ICT Observatory meeting on Gender and Agriculture in the Information Society.

Haggblade, S., P. Hezel and T. Reardon. 2002. Strategies for stimulating poverty alleviating growth in the rural non-farm economy in developing countries. Environment and production technology Division Discussion Paper 92. International Food Policy research Institute, Washington DC.

Häusler, S, N. N'Guessan, and C. Dessallien. 2007. Mid-term Evaluation of the Regional Programme RAF/03/013: Regional Energy-Poverty Programme(REPP) / Multifunctional Platform,” Final Report, United Nations Development Programme - Regional Bureau for Africa.

Horrell, S. and Krishnan, P. 2007. “Poverty and productivity in female-headed households in Zimbabwe.” *Journal of Development Studies* 43(8) 1351-1380.

Holden, S., and M. Bezabih. 2007. “Why is land productivity lower on land rented out by female landlords? Theory, and evidence from Ethiopia.” Department of Economics and Resource Management, Norwegian University of Life Sciences, Âs, Norway.

Huyer, S., Hafkin, N., Ertl, H., & Dryburgh, H. (2005). “Women in the information society.” In G. Sciadas (Ed.), *From the digital divide to digital opportunities: Measuring infostates for development* (pp. 135–195). Ottawa, Canada: Orbicom/ITU.

Ibrahim, H. I., A. A. Kigbu, and R. Mohammed. 2011. “Women’s experiences in small scale fish processing in Lake Feferuwa fishing community, Nasarawa State, Nigeria.” *Livestock Research for Rural Development* 23(3): 2011.

Intermediate Technology Development Group (ITDG). 1986. “Internal Report on Nepal,” ITDG, Rugby in Lightening the Load: Labor Saving technologies and practices for rural women by M. Carr and M. Hartl. IFAD and Practical Actions Publishing, 2010.

IEG (Independent Evaluation Group). 2011. *Impact Evaluations in Agriculture: An Assessment of the Evidence.* Washington, DC: World Bank.

IFAD. 2010. "Promoting women's leadership in farmers and rural producers organizations." Special session of the third global meeting of The Farmer's Forum in conjunction with the Thirty Third Session of IFAD's Governing Council Meeting. IFAD Headquarters, Rome. 12-13 February, 2010.

Jagger, P., and J. Pender. 2006. "Impacts of programs and organizations on the adoption of sustainable land management technologies in Uganda." In *Strategies for sustainable land management in the East African highlands,* ed. J. Pender, F. Place, and S. Ehui. Washington, D.C.: International Food Policy Research Institute.

James, Clive. 2008. "Global Status of Commercialized Biotech/GM Crops: 2008." ISAAA Brief No. 40. ISAAA: Ithaca, NY.

Njuki, J., M. Mapila, S. Kaaria, and T. Magombo. 2008. "Using community indicators for evaluating research and development programmes: experiences from Malawi," Development in Practice (18(4–5) August.

Jensen, R. 2007. The Digital Provide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector. *Quarterly Journal of Economics, 122*(3), 879-924.

Joy, L., A. Prema and S. Krishnan. 2008. "Determinants of Group Performance of women-led agro-processing self-help groups in Kerala." *Agricultural Economics Research Review*: 21. Pp 351-62.

Kaboski, Joseph P., and R. M. Townsend, 2005. "Policies and Impact: An Analysis of Village-Level Microfinance Institutions," *Journal of the European Economic Association*, 3(1):1-50.

Kakooza, J., E. Kabasimba, B. Ssemakula and A. Musisi. 2005. "Gender variation in agricultural technology: A comparative analysis of two ecological zones in Uganda." Paper submitted to Eastern and Central Africa Programme for Agricultural Policy Analysis/ Association for Strengthening Agricultural Research in East and Central Africa (ECAPAPA/ /ASARECA). Available at: http://www.asareca.org/paap/uploads/publications/Gender%20Variation%20in%20Agricultural%20Technology%20-%20A%20Comparative%20Analysis%20of%20Two%20Ecological%20Zones%20of%20Uganda.pdf

Kariuki, G. and F. Place. 2005. "Initiatives for rural development through collective action: the case of household participation in group activities in the highlands of Central Kenya," CAPRi working papers 43, International Food Policy Research Institute (IFPRI).

Karlan, D. S., and J. Zinman. 2007. "Credit Elasticities in Less-Developed Economies: Implications for Microfinance," CEPR Discussion Papers 6071, C.E.P.R. Discussion Papers.

Kasangaki, P., and V. Oguya. 2011. “Contributing to extension – the question and answer service voucher system,” paper presented at the International Conference on Innovations in Extension and Advisory Services, November 15-18, Nairobi, Kenya.

Kasante, D., M. Lockwood, J. Vivian., and A. Whitehead. 2001. “Gender and the expansion of non-traditional agricultural exports in Uganda,” In *Shifting Burdens: Gender and Agrarian Change under Neo-liberalism,* ed. S. Razavai. Bloomfield, Conn., U.S.A.: Kumarian.

Katungi, E., S. Edmeades, and M. Smale. 2008. “Gender, social capital and information exchange in rural Uganda,” *Journal of International Development* 20: 35–52.

Kevane, M. 2004. *Women and development in Africa: How gender works*. Boulder, Colo., U.S.A., and London: Lynne Rienner.

Khandker, S.R. 2005. “Microfinance and poverty: evidence using panel data from Bangladesh,” *The World Bank Economic Review* 19(2): 263–86.

Kimenye, L. N. 2001. Understanding low rate of technology adoption by women farmers: A Case study of the determinants of adoption of improved Sorghum varieties by women farmers in Mbeere District, Kenya. *Journal of Agriculture Science* 3(1) 30-40. Kenya.

Kingiri, A. 2010. “Gender and Agricultural Innovation: Revisiting the Debate through an Innovation System Perspective,” Research Into Use Programme (RIU), UK’s Department for International Development (DFID), Discussion Paper 06.

Kinkingninhoun-Mêdagbé, F. M., A. Diagne, F. Simtowe, A. R. Agboh-Noameshie, and P. Y. Adegbola. 2008. “Gender discrimination and its impact on income, productivity and technical efficiency: Evidence from Benin.” *Agriculture and Human Values* 27 (1): 57–69.

Kinwa-Mzinga, A., C. Ragasa, and J. Ulimwengu. 2012. “Gender Assessment of the Agricultural Sector in the Democratic Republic of Congo,” draft paper, IFPRI, Washington, D.C.

Kip-Tot, E. 2011. “Farmers teaching farmers: challenges and opportunities of using volunteer farmers in technology dissemination,” paper presented at the International Conference on Innovations in Extension and Advisory Services, November 15-18, Nairobi, Kenya.

Kneerim, J.1980. “Village women Organize: the mraru bus service.” Carnegie Corporation of New York, Ford Foundation and the Population Council of New York. USA.SEEDS pamphlet series.

Kwapong, O., and A.T. Frimpong. 2009. "A comparison of ICT and knowledge usage among female distance learners in endowed and deprived communities in developing countries," *E-Learning* 6(2).

Lastarria-Cornhiel, S. 1997. "Impact of privatization on gender and property rights in Africa." *World Development* 25 (8): 1317–1333.

Leino, J. 2007. Ladies first? Gender and the community management of water infrastructure in Kenya. University of California, Berkeley Calif., U.S.A. Electronic Copy.

Liff, S., and A. Shepherd. 2004. "An evolving gender digital divide?" Internet Issue Brief No. 2 (July).

Lubwama, F. 2011. "Can Labor Saving technologies Help rural women in Uganda? The Case of Manual forage chopper for small holder dairy farmers." Paper presented at the 15th International Conference for Women Engineers and Scientists. Adelaide, July 19-22, 2011.

Lyam, J. 2011. "Overview" in Module 6 on Agricultural Research within an Agricultural Innovation System," *Agricultural Innovation Systems Sourcebook*. Washington, D.C.: World Bank.

Maguzu, C. W., D. Ringo, W. Mariki, M. Owenya, F. Kola, and C. Leseyo. 2007. "Arumeru District." In *Conservation Agriculture as Practised in Tanzania: Three Case Studies,* ed. Richard Shetto and Marietha Owenya, 1–48. Nairobi: African Conservation Tillage Network.

Maskow, M. 2000. "Radio as a learning technology." In E.J. Burge (Ed.*), New directions for adult and continuing education: The strategic use of learning technologies* (pp. 59-68). San Francisco, CA: Jossey-Bass.

Mead, Margaret. 1976. A Comment on the Role of Women in Agriculture. Pp. 9-11 in I. Tinker and M. Bo Bramsen (eds.). 1976. *Women and World Development*. Washington DC: Overseas Development Council. (The whole book can be downloaded from http://pdf.usaid.gov/pdf_docs/PNAAX651.pdf)

Meinzen-Dick, R., A. Quisumbing, J. Behrman, P. Biermayr-Jenzano, V. Wilde, M. Noordeloos, C. Ragasa, and N. Beintema. 2010. "Engendering agricultural research." IFPRI, Washington, D.C.

Meinzen-Dick, R., and M. Zwarteveen. 1998. "Gendered participation in water management: Issues and illustrations from water users associations in South Asia." *Agriculture and Human Values* 15(4): 337-345.

Mhazo N., B.M. Mvumi, R.M. Nazare, and E. Nyakudya. 2005. "The status of the agro-processing industry in Zimbabwe with particular reference to small and medium enterprises." Harare: University of Zimbabwe. Available online at: http://www.nri.org/projects/PHILA/casestudies/zimbabwe.html

Morse. S., R. Bennett, Y. Ismael. 2006. "Environmental impact of genetically modified cotton in South Africa." *Agriculture Ecosystems & Environment*. (117: 277 -289.

Molinas, J.R. 1998. "The impact of inequality, gender, external assistance and social capital on local level cooperation," *World Development* 26(3): 413-431.

Moore, K. M., S. Hamilton, P. Sarr, and S. Thiongane. 2001. "Access to technical information and gendered NRM practices: Men and women in rural Senegal." *Agricultural and Human Values* 18 (1): 95–105.

Mukasa, G. 2000. "Gender and participation: the case of Redd Barna, Uganda," unpublished MA thesis, Institute of Development Studies, Brighton.

Murray, J., and R. Rosenberg. 2006. "Community-Managed Loan Funds: Which Ones Work?" Consultative Group to Assist the Poorest," Washington, D.C.

Mwankusye, J. 2002. "Do intermediate means of transport reach rural women?" In Fernando, P. and Porter, G. (eds), *Balancing the Load: Women, Gender and transport*. London: Zed Books

Njuki J., *et al.,* 2008. "Using community indicators for evaluating research and development programmes: Experiences from Malawi." *Development in Practice* 18 (4): 633–642.

Ogunlana, E. 2003. "The technology adoption behaviour of women farmers: The case of alley farming in Nigeria." *Renewable Agriculture and Food Systems 19(1): 57-65*.

Ogunlela, Y., and A. Mukhtar. 2009. "Gender Issues in Agriculture and Rural Development in Nigeria: The Role of Women," *Human and Social Sciences Journal* 4(1): 19-30.

Okorley, E, M. Zinnah, A. O. Mensah and M. Owens. "Women in Agro Processing in Ghana: A Case study of the state of women in small scale fish processing in the Central Region of Ghana." Proceedings of the 17th Annual Conference of the Association for International Agricultural and Extension Education held in Baton Rouge, Louisiana, USA, 2001 april 4-7, p. 407-420.
http://www.oceandocs.net/bitstream/1834/834/1/Okorley.pdf

Oladele, O., and M. Monkhei. 2008. Gender ownership patterns of livestock in Botswana. *Livestock Research for Rural Development* 20 (10). <www.lrrd.org/lrrd20/10/olad20156.htm>. Accessed August 11, 2009.

Olwande, J., G. Sikei, and M. Methenge. 2009. "Agricultural technology adoption: A panel analysis of smallholder farmers' fertilizer use in Kenya." Contributed paper prepared for presentation at the African Economic Research Consortium Conference on Agriculture for Development, May 28th and 29th, Mombasa, Kenya

Omari, H.H., and Ribak, R. 2008. Playing with fire: On the domestication of the mobile phone among Palestinian teenage girls in Israel. *Information, Communication, and Society*, 11(2), 149–166.

Padmaja, R., Bantilan, M. C. S., Parthasarathy, D. and Gandhi, B. V. J. 2006. "Gender and social capital mediated technology adoption." Impact Series 12. Patancheru, India: International Crops Research Institute for the Semi-Arid Tropics.

Pande, R.; E. Field, and S. Jayachandran. 2009. "Business Training and MFI Client Behavior: Findings from a Randomised Impact Evaluation in Ahmedabad, Gujarat," Institute for Financial Management and Research (IFMR) Centre for Micro Finance, Chennai, India.

Paris, T., and T.T.N. Chi. 2005. "The Impact of Row Seeder Technology on Women Labour: A Case Study of the Mekong Delta, Vietnam." *Gender, Technology and Development* 9(2): 158–84.

Pender, J., and B. Gebremedhin. 2006. "Land management, crop production and household income in the highlands of Tigray, northern Ethiopia: An econometric analysis." In *Strategies for sustainable land management in the East African highlands*, ed. J. Pender, F. Place, and S. Ehui. Washington, D.C.: International Food Policy Research Institute.

Peterman, A., J. Behrman, and A. Quisumbing. 2010. "A review of empirical evidence on gender differences in non-land agricultural inputs, technology, and services in developing countries," Washington, D.C. IFPRI.

Peters, D. 2002. "Gender and Transport in Less Developed Countries." Paper commissioned by UNED Forum for expert workshop on "Gender Perspectives for the Earth Summit 2002," Berlin, January 20.

Pionetti, Carine. 2006. "Seed Diversity in the Drylands: Women and Farming in South India." Gatekeeper 126, International Institute for Environment and Development, London

Phiri, D., S. Franzel, P. Mafongoya, I. Jere, R. Katanga and S. Phiri. 2004. Who is using the new technology? The association of wealth status and gender in the planting of improved tree fallows in Eastern province, Zambia. *Agricultural Systems 79(2004) 131-144*.

Plant, S. 2003. "On the mobile: The effects of mobile telephones on social and individual life." http://www.motorola.com/mot/doc/0/234_MotDoc.pdf

Pitt, Mark M. and Shahidur R. Khandker, 1998, "The Impact of Group-Based Credit Programs on Poor Households in Bangladesh: Does the Gender of Participants Matter*?" Journal of Political Economy*, 106 (October): 958-96.

Plou, D.S. 2003. "What about gender issues in the information society?" *In* B. Girard and S. O. Siochru eds Communicating in the Information Society. United Nations Research Institute for Social Development (UNRISD), Geneva 2003.

Quisumbing, A. R. 1996. "Male-female differences in agricultural productivity: Methodological issues and empirical evidence," *World Development* 24(10): 1579–1595.

Quisumbing, A. R., and B. McClafferty. 2006. Using gender research in development. Food Security in Practice Technical Guide Series 2. Washington, D.C.: International Food Policy Research Institute

Quisumbing, A. R., Otsuka, K., Suyanto, S., Aidoo, J. B., & Payongayong, E. 2001. Land, trees and women: Evolution of land tenure institutions in Western Ghana and Sumatra. Research report 121, International Food Policy Research Institute, Washington

Quisumbing, Agnes R. and Yohannes, Yisehac. 2004. How Fair is Workfare? Gender, Public Works, and Employment in Rural Ethiopia (May 2004). World Bank Policy Research Working Paper No. 3492. Available at SSRN: http://ssrn.com/abstract=650201

Quisumbing, A., and L. Pandolfelli. 2009. Promising approaches to address the needs of poor female farmers: Resources, constraints, and interventions. *World Development* 38(4) 581-592. DOI: http://dx.doi.org/10.1016/j.worlddev.2009.10.006

Quizon, J., G. Feder, and R. Murgai. 2001. "Fiscal Sustainability of Agricultural Extension: The Case of the Farmer Field School Approach." *Journal of International Agricultural and Extension Education* 8: 13-24.

Ragasa, C. 2011. "Improving Gender Responsiveness of Agricultural Extension", in IFPRI. 2011. "Gender in Agricultural Development and Food Security." (Forthcoming).

Ramirez, A. F., E. de Nys, and M. E. Dasso. 2001. "Fostering Inclusive Rural Innovation: The Case of INCAGRO in Peru," *En Breve* Number 169 (August), World Bank, Washington, D.C.

Rao, N. 2002. "Cycling into the Future: the Pudukkottai Experience." In *Balancing the Load: Women, Gender and Transport,* ed. Priyanthi Fernando and Gina Porter, 151–68. London: ZED Books.

Ritchie, A. 2007. "Community-Based Financial Organizations: A Solution to Access in Remote rural Areas." Agriculture and Rural Development Discussion Paper 34, World Bank, Washington, D.C.

Roodman D., and Morduch, J 2009. "Impact of Microcredit on the poor inBangladesh: Revisiting the evidence." Center for Global Development Working Paper No. 174. June 2009.

Sanginga, P. C., A. A. Adesina, V. M. Manyong,O. Otite, and K. E. Dashiell. 2007. *Social impact of soybean in Nigeria's southern Guinea savanna*. Ibadan, Nigeria: International Institute of Tropical Agriculture. <http://pdf.dec.org/pdf_docs/Pnacq302.pdf>. Accessed September 27, 2009.

Sani, B. *et al.,* 2011. "Increasing the outreach of information to farmers in Nigeria: The Nigeria agricultural question and answer service (NAQAS) approach," paper presented at the International Conference on Innovations in Extension and Advisory Services, November 15-18, Nairobi, Kenya.

Sanyang, S.E, T-C. Kao, and W-C. Huang. 2009. "Impact of agricultural technology transfer to Women vegetable production and marketing groups in Gambia," *World Journal of Agricultural Sciences* 5 (2): 169-179.

Scherr, S. J., C. Rhodes, L. Buck, C. Ochieng, R. Marsh, and J. Nelson. 2008. "Farmer-Based Extension for SLM in Africa," TerrAfrica and Ecoagriculture Partners meeting, April.

Schneider, K. 2007. "Public Finance Management, Including Gender-Responsive Budgeting." Draft, UN Division for the Advancement of Women, New York. Swedish International Development Agency (SIDA). 2005. "Policy Promoting Gender Equality in Development Cooperation." SIDA, Stockholm.

School of Oriental and African Studies (SOAS), Wadonda Consult, Overseas Development Institute and Michigan State University. 2008. Evaluation of the 2006/7 Agricultural Input Supply Programme, Malawi: Final Report, School of Oriental and African Studies, London, March.

Shiferaw, B., T. Kebede, and L. Yoou. 2008. "Technology adoption under seed access constraints and the economic impacts of improved pigeon pea variety in Tanzania," *Agricultural Economics 39 (2008): 309-323*.

Singh, G. Singh, G., and N. Kotwaliwale. 1999. A Report on Agricultural Production and Processing Technologies for Women in India. *Gender Technology and Development* 3(2): **259-278**. http://gtd.sagepub.com/content/3/2/259

Sinha, C. 2009. "Effects of education and ICT use on gender relations in Bhutan," *Information Technologies & International Development* 5(3): 21–34. Available at: http://itidjournal.org/itid/article/viewFile/379/175

Smale, M., P. Zambrano, G. Gruère, J. Falck-Zepeda, I. Matuschke, D. Horna, L. Nagarajan, I. Yerramareddy, and H. Jones. 2009. "Measuring the Economic Impacts of Transgenic Crops in Developing Agriculture during the First Decade," IFPRI Food Policy Review 10, (http://www.ifpri.org/publication/measuring-economic-impacts-transgenic-crops-developingagriculture-during-first-decade

Smale, M., B. Dembele, I. S. Traore, O. Guindo, and B. Konta. 2007. "Trading Millet and Sorghum Genetic Resources: Women Vendors in the Village Fairs of San and Douentaza Mali," Discussion paper, IFPRI, Washington, D.C.

Smith, R. 2008. “Cattle’s effect on land and labour productivity: Evidence from Zambia,” *Journal of International Development* 20(7): 905–919.

Somado, E., R. Guei, and S. O. Keya. 2008. NERICA: New Rice for Africa. A Compendium. Cotonou: AfricaRice.

Sorenson, K. 2002. “Love, duty and the S-curve: An overview of some current literature on gender and ICT.” Edinburgh: University of Edinburgh.

Sperling, L. 1993. Farmer Participation and the Development of Bean Varieties in Rwanda. *In* J. Moock and R. Rhoades, eds. *Diversity, Farmer Knowledge, and Sustainability*. Ithaca and London: Cornell University Press.

Spielman, D., C. Ragasa, and R. Rajalahti. 2011. “Thematic Note 1: Designing Agricultural Research Linkages within an Agricultural Innovation Systems Framework” in Module 6 on Agricultural Research within an Agricultural Innovation System,” *Agricultural Innovation Systems Sourcebook*. Washington, D.C.: World Bank.

Stads, G.J., and N.M. Beintema. 2009. Public Agricultural Research in Latin America And The Caribbean: Investment and Capacity Trends. ASTI Synthesis Report. Washington, D.C.: International Food Policy Research Institute and Inter-American Development Bank.

Starkey, P., S. Ellis, J. Hine and A. Ternell. 2002. “Improving Rural Mobility: Options for developing motorized and non motorized transport in rural areas,” World Bank Technical Paper No. 525, World Bank, Washington, DC.

Subramanian A, and M. Qaim. 2009. “Village-wide effects of agricultural biotechnology: The case of Bt cotton in India.” *World Development* (37): 256 -267.

Subramanian, A. and M. Qaim. 2010. “The impact of Bt cotton on poor households in rural India.” *Journal of Development Studies* 46(2): 295 – 311.

Subramanian, A, K. Kirwan, D. Pink, and M. Qaim. 2010. “GM crops and gender issues,” *Nature Biotechnology* 28, 404–406. doi:10.1038/nbt0510-404

Sulaiman, R. V., and A. Hall. 2008. The fallacy of universal solutions in extension: Is ATMA the new T&V? *Link News Bulletin* (United Nations University), September, 1–4. <www.innovationstudies.org/index.php?option=com_myblog&show=The-Fallacy-of-Universal-Solutions-in-Extension-139.html&Itemid>.

Swanson, B. E., Farmer, B. J., & Bahal, R. 1990. The current status of agricultural extension worldwide. In B. E. Swanson (Ed.), Report of the global consultation on agricultural extension. Rome: FAO

Thapa, S. 2009. “Gender differentials in agricultural productivity: Evidence from Nepalese household data.” University of Trento, Department of Economics, Trento, Italy. Electronic paper.

Thirtle, C., L. Beyers, Y. Ismael, and J. Piesse. 2003. “Can GM-technologies help the poor? The impact of Bt cotton in Makhathini Flats, KwaZulu-Natal,” *World Development* 31 (4): 717-732.

Tiruneh, A., T. Tesfaye, W. Mwangi, and H. Verkuijl. 2001. Gender differentials in agricultural production and decision-making among smallholders in Ada, Lume and Gimbichu Woredas of the central highlands of Ethiopia. *Centro Internacional de Mejoramiento de Maiz y Trigo*, Ethiopian Agricultural Research Organization, and the European Union, Mexico City.

Tiwari, N. 2010. Economic and technological constraints facing rural women. International Journal of Rural Studies. Vol 17. No. 1. April 2010.

Udry, C. 1996. ‘‘Gender, Agricultural Production and the Theory of the Household,’’ *Journal of Political Economy*, 104(5): 1010-1046, October 1996a.

Udry, C., J. Hoddinott, H. Alderman, and L. Haddad. 1995. “Gender Differentials in Farm Productivity: Implications for Household Efficiency and Agricultural Policy,” *Food Policy* 20: 407–423.

United Nations. 2001. Gender in Agriculture and Agroprocessing in Lebanon. Economic and Social Commission for Western Asia, United Nations. New York. 2001.

United Nations Educational, Scientific and Cultural Organization (UNESCO). 2003. “Good Practices:

Gender Equality in Basic Education and Lifelong Learning through CLCS: Experiences from 15 Countries.” Report, UNESCO Asia and the Pacific Regional Bureau for Education, Bangkok.

UNIFEM (United Nations Development Fund for Women). 1993. Cereal processing: Food cycle

technology source book. New York

Upadhyay, B. 2004. “Gender aspects of smallholder irrigation technology: Insights from Nepal,” *Journal of Applied Irrigation Science* 39(2): 315-327.

Uphoff, N., 1986. Local Institutional Development: an analytical sourcebook with cases. Kumarian Press, West Harford, Conneticut.

Uphoff, N., 1997. Institutional Capacity and Decentralization for Rural Development. Paper prepared for the Technical Consultation on Decentralization. FAO, Rome.

Uphoff, N., and L. Buck. 2006. "Strengthening Rural Local Institutional Capacities for Sustainable Livelihoods and Equitable Development." Paper prepared for the Social Development Department, World Bank, Washington, DC.

Uttaro, R. 2002. Diminishing choices: gender, small bags of fertilizer and household food security decisions in Malawi. African Studies Quarterly 6. No(1). URL: http://www.africa.ufl.edu/asq/v6/v6i1a4.htm

Van den Berg, H. 2004. "IPM Farmer Field Schools: A synthesis of 25 impact evaluations', Prepared for the Global IPM Facility, Wageningen University, the Netherlands. ftp://ftp.fao.org/docrep/fao/006/ad487E/ad487E00.pdf.

Venter, C. J., and M. Mashiri. 2007. "Gender and Transport: Towards a Practical Analysis Framework for Improved Planning." Paper prepared for 26th Annual South Africa Transport Conference, Pretoria, July.

Wambui, M. 2002. Meet the champions: DG interview with Dr. Nancy Hafkin on ICT and gender in Africa. Development Gateway, ICT for Development. Retrieved November 10, 2004, from:http://topics.developmentgateway.org/ict/sdm/previewDocument.do~activeDocumentId=346156

Waters-Bayer, A. 2011. "Farmer-managed innovation funds drive multi-stakeholder learning processes," paper presented at the International Conference on Innovations in Extension and Advisory Services, November 15-18, Nairobi, Kenya.

Westerman, O., J. Ashby, and J. Pretty. 2005. Gender and Social Capital: The importance of gender differences for the maturity and effectiveness of natural resources management groups. *World Development* 33(11): 1783-99.

White, S. 1999. Women's Employment in the Agro and Food Processing Sector: South Asia and East Africa. Draft report submitted to the Aga Khan Foundation, Canada.

Wickramasinghe, A. 2009. "Tackling poverty and gender inequality through agricultural commercialization in rural Sri Lanka: A Case study," Paper presented at the FAO-IFAD-ILO Workshop on Gaps, trends and current research in gender dimensions of agricultural and rural employment: differentiated pathways out of poverty. Rome, 31 March - 2 April 2009.

WomenAction 2000. "We Met Our Commitments, and You? Latin American NGO Declaration." www.mujeresaccion.org/docs.php3?id=20 Accessed on September 1, 2011.

World Bank and IFPRI. 2010. *Gender and governance in rural services: Insights from India, Ghana, and Ethiopia*. Washington, DC: IFPRI and World Bank

World Bank, FAO and IFAD. 2008. *Gender in Agriculture Sourcebook*. Washington, DC: World Bank.

World Bank. 2000. "Implementation Completion Report for Indonesia: Integrated Pest Management Training Project." Report No: 20212, June 6. Available at http://www.wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2000/07/28/000094946_00071906170162/Rendered/PDF/multi_page.pdf

World Bank. 2004b. "Gemidiriya Community Development and Livelihood Improvement Project." Project Appraisal Document, World Bank, Washington, DC.

World Bank. 2004a. 'Making rural roads work for both women and men: The example of Peru's Rural Roads Program', [online], Promising Approaches to Engendering Development, http://siteresources.worldbank.org/INTGENDER/Resources/PeruRRPFINAL.pdf

World Bank. 2005. "Gender and 'Shared Growth' in Sub- Saharan Africa." Briefing Notes on Critical Gender Issues in Sub-Saharan Africa 2005-1, World Bank, Washington, DC. Also available at http://siteresources.worldbank.org/EXTABOUTUS/Resources/GenderGrowth.pdf.

World Bank. 2008. Enhancing Agricultural Innovation: How to go beyond the strengthening of research systems. Washington, D.C.: World Bank.

World Bank. 2011a. "*IAP 4: Social Mobilization to Generate Effective Demand: Community Managed Sustainable Agriculture in Andhra Pradesh," in "*Module 3. Coordination and Collective Action for Agriculture Innovation Systems," Agricultural Innovation Systems Sourcebook. Washington, D.C.: World Bank.

World Bank. 2011b. *Impact Evaluations in Agriculture: An Assessment of the Evidence*. Washington, DC: World Bank.

World Bank. 2011c. *Agricultural Innovation Systems Sourcebook*. Washington, D.C.: World Bank.

World Bank and Malawi. 2007. *Malawi poverty and vulnerability assessment (PVA): Investing in our future. Synthesis report: Main findings and recommendations.* Poverty Reduction and Economic Management 1, Report 36546-MW. Washington, D.C.: World Bank.

You, L., and M. Johnson. 2008. "Exploring Strategic Priorities for Regional Agricultural R&D Investments in East and Central Africa," IFPRI Discussion Paper 00776, IFPRI, Washington, D.C.

Zainudeen, A., T. Iqbal, R. Samarajiva, and D. Ratnadiwakara. 2008. "Who's got the phone? Gender and the use of the telephone at the bottom of the pyramid," Paper presented at 2008 International Communications Association conference, Montreal, Canada, 26 May 2008.

Zambrano, P., L. A. Fonseca, I. Cardona, and E. Magalhaes. 2009. "The socio-economic impact of transgenic cotton in Colombia." In *Biotechnology and agricultural development: Transgenic cotton, rural institutions and resource-poor farmers*, ed. R. Tripp. Routledge Explorations in Environmental Economics 19. London: Routledge. Chapter 8. Pp. 168-199.

Zambrano, P., J. H. Maldonado, S. L. Mendoza, L. Ruiz, L. A. Fonseca, and I. Cardona. 2010. "Gender and GM Cotton in Colombia," draft paper, June, IFPRI, Washington, D.C.

Zuckerman, E. 2002. "Poverty Reduction Strategy Papers and Gender." Background paper for the Conference "Sustainable Poverty Reduction and PRSPs— Challenges for Developing Countries," in Abbassi, Z. F. Pro poor and gender sensitive information technology: Policy and practice. Available at: http://www.hubrural.org/pdf/gender_and_it.pdf

Food and Agriculture Organization of the United Nations (FAO)
Vialle delle Terme di Caracalla, 00153 Roma (Italy)
Phone: +39.06.57051
www.fao.org

International Food Policy Research Institute (IFPRI)
2033 K Street, NW, Washington, DC 20006-1002 (USA)
Phone: +1.202.862.5600
www.ifpri.org

GFAR - The Global Forum on Agricultural Research
c/o FAO, Viale delle Terme di Caracalla, 00153, Roma (Italy)
Phone: +39.06.5705.3413
http://www.egfar.org/