A review of empirical evidence on gender differences in non-land agricultural inputs, technology, and services in developing countries

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A review of empirical evidence on gender differences in non-land agricultural inputs, technology, and services in developing countries[1]

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Abstract: This paper reviews existing microeconomic empirical literature on gender differences in use, access, and adoption of non-land agricultural inputs in developing countries. This review focuses on four key areas: (1) technological resources, (2) natural resources, (3) human resources, and (4) social and political capital. In general, there has been more empirical research on inorganic fertilizer, seed varieties, extension services, and group membership than on tools and mechanization, life-cycle effects, and political participation. Across input areas, generally men have higher input measures than women; however, this finding is often sensitive to the use of models that control for other background factors, as well as the type of gender indicator implemented in the analysis. We find few studies that meet our inclusion criteria outside Sub-Saharan Africa. Finally, future directions, opportunities, and recommendations for microeconomic gender analysis of non-land agricultural inputs are discussed.

Keywords: Gender, agriculture, access to farm inputs, assets, women

JEL: J16, J22, O13, Q12.

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Introduction

Since the 1990s policymakers and development practitioners have highlighted the critical importance of gender in the implementation, evaluation, and effectiveness of programs across a range of social and economic sectors.[1] *Gender and Agriculture*, a recent sourcebook produced by the World Bank, FAO and IFAD (2009, p. 2), warns that the "failure to recognize the roles, differences and inequities [between men and women] poses a serious threat to the effectiveness of the agricultural development agenda". Similarly, the International Fund for Agricultural Development (IFAD) states that although female farmers are primary contributors to the world's food production and security, they are "frequently underestimated and overlooked in development strategies" (UN News Center, 2010). In short, there is agreement that gender inequalities and lack of attention to gender in agricultural development contribute to lower productivity, lost income, and higher levels of poverty as well as undernutrition. This recent and renewed interest in gender and agriculture has produced several new initiatives, calls for action, and commitments from the international development community since 2005 (See, for example, IFAD, 2003; IFPRI, 2007; World Bank, 2007). In addition, guides, toolkits, and other resources on theory and practice of gender integration and promising programmatic approaches have been developed to streamline gender-specific agricultural development initiatives (Doss, 1999; Mehra and Rojas, 2009; Quisumbing and Pandolfelli, 2010; UN-HABITAT, 2006; World Bank, FAO and IFAD, 2009). Despite these advancements, there is a lack of consensus on the actual magnitude and effects of gender differences in access to agricultural inputs. Where information is available, it is generally focused on access to land or based on dated and region-specific research. Given the importance of producing evidence-based policies, this paper proposes to update the current knowledge on household-level microeconomic effects and levels of gender differences

[1] Here *gender* represents a social construction of what it means to be of the male or female sex, including cultural, ethnic, economic, religious, and ideological influences. Likewise, *gender equity* refers to fairness in the distribution of opportunities, responsibilities, and benefits given to men and women.

in access to non-land agricultural inputs through review of published and unpublished literature between 1999 and 2009.

This review contributes to the literature in several ways. First, we focus *strictly* on empirical household or plot-level data from program evaluations and agricultural and socioeconomic research in order to summarize and bound parameters for estimates in a reasonable range. We include only articles that are based on quantitative indicators, reasonable measurement of outcomes, and attention to econometric evaluation techniques.[2] We therefore do not review studies based on aggregate cross-country data or cluster means generated from census data, because such data do not adequately capture the inter-cluster variation and heterogeneity of the agricultural sector. We review studies that focus explicitly on gender as well as those that include gender as an explanatory indicator in evaluations of other outcomes. This assessment will be conducted with the knowledge that percentages and effect sizes are not strictly comparable because of the diverse technological products, crop varieties, program designs, and empirical techniques from which results are derived.[3] Therefore, although we discuss and include outcome measures in the review, the common theme across all studies included is the provision of gender-disaggregated input data. Second, as previously mentioned, we focus on papers published between 1999 and 2009 to update the literature, given the rapidly evolving environmental, technological, and demographic trends in that period. A body of rigorous and significant literature from the 1980s and 1990s has provided empirical evidence on gender differences in access to inputs. However, this literature has been reviewed sufficiently in past studies, and there is little value in continuing to revisit this material (Quisumbing, 1994, 1996; Schultz, 2001; Kevane, 2004). Finally, although we attempt to make regional comparisons to help identify how women farmers face similar or diverging constraints according to their geographic region of origin (Asia, Sub-Saharan Africa, the Middle East, Eastern Europe, or South/Latin

[2] We do not use a strict sample size cut-off per se but include only studies that generate descriptive statistics across gender-disaggregated subgroups.
[3] Although we attempt to compare and contrast findings, please note that we do not conduct a meta-analysis. Meta-analysis would necessitate a substantial number of studies examining the same types of inputs (and associated outputs), which is not an appropriate analysis because of diversity of inputs.

America), our ability to do so is limited by data availability, since most studies on gender differences in access to inputs (with the exception of labor) come from Sub-Saharan Africa.[4]

The review is focused on access to agricultural inputs in four main areas: (1) technological resources (including inorganic fertilizer, insecticide, improved seed varieties, and equipment), (2) natural resources (including water and soil fertility), (3) human resources (including labor, extension services, and life-cycle concerns), and (4) social and political capital (including group membership, social networks, and political representation).[5] The review is compiled by online searches of published material as well as inclusion of working papers and forthcoming evaluations from researchers working in gender and agriculture.[6] Each section is summarized in a table with key components and effect sizes as a method of organizing and comparing inputs and outcomes. As we mentioned earlier, we do not explicitly include access to land because it has traditionally been the focus of other reviews, although we will inevitably touch on linkages between land access and access to other inputs. In addition, although we acknowledge the importance of bargaining power, women's status, cultural and religious beliefs surrounding agriculture, and community norms, we do not explicitly include how these are determined but rather focus on how these factors affect the distribution of inputs between men and women. We conclude by making recommendations to address the research gaps in measuring gender differences in non-land agricultural inputs, to highlight the policy implications of the reviewed empirical work, and suggest directions for future research.

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[4]As noted, the regions we compare include Asia, Sub-Saharan Africa, the Middle East (including North Africa), Eastern Europe, and South/Latin America. When we refer to "region-specific" trends, we lump areas of the world into these four regional categories. Throughout the paper we sometimes refer to sub-regions within these four categories (for example, South Asia) or within specific countries (for example, the southern region of Zimbabwe); these instances will be specifically noted.

[5] We acknowledge the importance of two other input categories: access to credit and financial services (collateral-based and other forms of credit, microfinance, and savings products), and value/supply chain (roads, transport, crop processing, and market accessibility); as these will be addressed in-depth in complementary sections of FAO (2010-11), we omit them here.

[6] We started by reviewing original research on gender inequalities in agriculture, followed by papers that cite these studies. We then conducted online searches using keywords for various inputs in each category (Google Scholar, peer-reviewed journals, and websites of the Consultative Group on International Agricultural Research) and publication searches of websites of agricultural research organizations. We also conducted "snowball" citation techniques and sent e-mails to researchers in the field working on gender and agriculture within various institutions.

Before we present our review of the four focus areas, it is useful to more clearly articulate the range of definitions implicitly or explicitly assigned to the term *women's use* of various resources. When generalizing about gender differences for a given input (such as fertilizer or seed varieties), we often use the terms *use*, *access*, or *adoption* interchangeably; however, within a specific study or framework, these terms may connote entirely different outcomes. These distinctions are critically important, as differences across studies may in fact be the result of variations in definitions of terms rather than magnitude of gender differences. The literature on property rights and collective action defines bundles of rights, which refer to gradients of control over a given resource, usually applied to land or other natural resources. For example, bundles of rights for land can be divided into the right to use the asset (including the right to access, the right to extract resources), the right to appropriate the return from the asset (including earnings and income), the right to change its form, substance, and location (including decision-making rights such as management, and the exclusion of other users), and alienation (including transfer of rights to others) (Di Gregorio et al., 2008).[7] These bundles of rights are applied at different levels (individuals, families, groups, the state), and actors often overlap in their levels of rights. Although this framework is a useful starting point for thinking about women's control of agricultural inputs, we limit our review to production, and thus concepts of transfer or exclusion will not typically apply. Therefore we define *use* of an input as the actual application of that resource in productivity-producing outputs, specifically, at the individual or household level, whether the input was obtained through extraction, purchase, or barter. The use of inputs is generally straightforward and can be operationalized for both technological inputs, such as fertilizer or seed varieties, and natural and human resources. We define *access* to an input as the availability or potential for use at the individual, household, or community level. Access implies the right or ability to use a resource or input but is not an actual use measurement. We define *adoption* as the initial use of an input or method by an individual, household, or community that often, but not always, occurs in the context of an established program or scheme. Finally, in discussions about differential access to social

[7] For a detailed presentation of property rights and collective action framework, including measurements, institutional actors, and linkages to poverty reduction, see Di Gregorio et al. (2008); for a review of implementation of this framework in evaluation work, see Mwangi and Markelova (2008).

or political capital, we often make use of the additional term *participation,* which we define as the ability to freely and fully partake in and engage with a social or political group or network. Although not all the inputs and studies we review relate directly to these definitions, they will serve as a general guide throughout the paper. Where deviations from these terms are necessary, they will be noted in the text.

In part, the levels and appropriateness of use, access, and adoption of inputs are determined by the setting, farming systems, and context of the study in question. A number of rudimentary generalizations can be made about the differences in farming systems across regions. In Asia, where monogamous extended or nuclear families dominate, and where families jointly farm agricultural land, men serve as the primary agricultural decision makers and laborers.[8] In many African societies, where polygamous families are common, access to resources and decision making is divided between household members (Dey, 1985). While African women play a large role in agricultural production, there is often a gendered division of labor that links women to the production of food crops and men to cash crops (Boserup, 1970). In Latin and South America, where the monogamous family structure is dominant, there is a gender division of labor in both industrialized crop production and peasant farming (Ashby, 1985). In general, women's agricultural participation in family farming systems is much more important in the Andean countries and Central America than in the southern region of South America (Deere and Leon, 1987). These regional differences will be further explored in the discussion section.

Evidence of Gender Inequities

Technological Resources: Inorganic Fertilizer, Insecticide, Improved Seed Varieties, and Mechanical Power

Advancements in technological resources have positively impacted farmers in developing countries by providing a means to improve soil fertility and increase land productivity and overall crop yields. Female farmers, who are more likely to be asset poor and subsistence oriented than their wealthier male

[8] Polygamy exists in Asia but not to the same extent as in Sub-Saharan Africa.

counterparts, stand to benefit significantly from such technology (World Bank, 2009). In this paper we examine four main categories of inputs of particular importance to small-scale female farmers: (1) inorganic fertilizer, (2) insecticides, (3) improved seed varieties, and 4) mechanical power. Inorganic fertilizer (chemical) refers to a nitrogen-based chemical mixture used to improve soil fertility. Inorganic fertilizer is differentiated from organic fertilizer (such as animal manure, compost, or other living mulch) by its manufacture, chemical modification, and external purchase. Insecticides and pesticides (also called farm chemicals, agrochemicals) are primarily synthetic spray-applied agents used to expand agriculturally productive land and increase crop yields through pest, bacteria, and weed destruction or control.[9] Improved and genetically modified seed varieties are artificially produced by cross-pollination to increase yield, uniformity, and resistance to disease. By *mechanization* we mean the introduction of mechanized farming tools or other equipment (tractors, plows, seeders, and weeders) into the farming practice. For the purposes of gender analysis, technology inputs are unique in that they typically (but not always) imply a monetary purchase as a prerequisite to use, in contrast to other categories, which may require time or natural resource endowment.

Table 1 summarizes the 24 studies reviewed that contain statistics on gender differences in access to technological resources. Articles are listed in alphabetical order of the first author’s surname (column 1) and therefore do not represent importance or significance of studies. Column 2 lists the country or countries or region of the indexed study and the crop, if applicable. Column 3 reports the sample size and unit of analysis in the study. Columns 4 though 7 indicate differential access or mean values of a specified input type (column 4, for example, shows fertilizer or seed varieties) reported for women (column 5) and for men (column 6) in a specified unit of disaggregation (column 7). Where additional analysis was conducted, columns 8, 9, and 10 list stratifying variables, outcome variables, and effect sizes (coefficients and standard errors in parenthesis) for each study. Comments on relevant findings, including methods or

[9] Pesticides may also be organic or organic compounds synthesized in a laboratory.

caveats, interpretations of use operationalized by the study, and indicator of peer-reviewed publication status follow in the remaining columns.

Much of the research on gender differences in access to technological inputs focuses on inorganic fertilizer, which perhaps reflects the important role fertilizer continues to play within debates about agricultural productivity and poverty reduction. In the literature on inorganic fertilizer an important theme is that, given equal access to fertilizer (controlling for other inputs and background factors), female farmers adopt fertilizer at the same rates as male farmers. Such findings suggest that accessibility of inputs, not propensity to use inputs, is a key issue for many female farmers. A highly cited paper is Doss and Morris's (2001) study of 420 maize farmers in Ghana, which found that once researchers controlled for access to complementary inputs (land, education, labor), they found no significant difference in rates of adoption between male and female farmers. Similarly, Thapa (2009) found little evidence for gender differences in value of farm output in 2,360 Nepalese households after controlling for access to inorganic fertilizer and other key inputs. Gilbert, Sakala, and Benson (2002) analyzed a cropping system trial survey in Malawi and found a significant gender difference in fertilizer use among the 1,385 farmers selected to participate in the trial. Following a treatment period in which all participants were supplied with inorganic fertilizer inputs, the authors found no significant gender difference in maize yield. Jagger and Pender (2006) examined the effects of the presence of local organizations that promote improved technology use in rural Uganda and found female heads of household are significantly more likely to adopt inorganic fertilizer than their male counterparts.

Findings from several additional studies contradict initial expectations that female household heads are disadvantaged in their fertilizer usage and adoption rates. Freeman and Omiti (2003) and Bourdillon et al. (2002) found that the gender of household head has no significant effect on adoption and intensity of use of inorganic fertilizer in 399 households in Kenya and among stratified samples of 136 to 200 households in Zimbabwe. In a sample of 156 households in Malawi, Chirwa (2005) found men and women plot owners do not differ significantly with respect to fertilizer adoption. However, in a parallel analysis using the same sample but using headship as an indicator of gender, he found female-headed households are less likely to adopt fertilizer (note, however, the sample size is only 156 households). Horrell and Krishnan (2007) found no significant difference in maize yields achieved or fertilizer usage by female household heads in Zimbabwe. However, further analysis found de facto female heads of household do receive lower prices for their output and lack access to selling consortiums; thus disadvantages persist.

Many of the same studies that examine fertilizer use also analyze gender differences in seed varieties. The Doss and Morris (2001) study in Ghana found that once researchers controlled for access to complementary inputs (land, education, labor), they found no significant difference in rates of modern seed variety adoption between male and female farmers. Similarly, Horrell and Krishnan (2007) found no significant difference in maize yields achieved or seed usage per acre by female heads of household. Tiruneh et al. (2001) in their study of households in Ethiopia found that a significantly higher proportion of male than female heads of household use improved wheat.[10] Logit analysis stratified by gender shows that in male-headed households, farm size and extension service contact significantly and positively affected adoption, whereas farm size and asset ownership are associated with adoption in female-headed households. Sanginga et al. (2007) found female farmers less likely to use improved soybean seeds in Nigeria, at least in part because male farmers continue to have more money to spend on hiring extra labor and have better market access opportunities. However, Sanginga and colleagues also found that more and more women are growing soybeans, a traditionally male crop, thus blurring presumed cropping norms. The studies by both Chirwa (2005) and Bourdillon et al. (2002) found the gender of household head has no significant effect on adoption of improved seed in Malawi and Zimbabwe, respectively, though the authors of neither study provide an explanation for why this might be the case, and, as previously mentioned, sample sizes are relatively small (*N* = 156 to 200).

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[10] Improved wheat seed is artificially produced by cross-pollination to improve yield, uniformity, and resistance to disease.

We found fewer relevant studies that examined inequities in pesticide use by gender. Jagger and Pender (2006) used a two-stage model to examine program effects on pesticide adoption among 451 Ugandan households and found female headship is insignificant in predicting adoption. Atreya's (2007) exploration of pesticide knowledge, attitudes, and practices (but not actual use) among 434 households in Nepal found that almost all respondents were aware of negative impacts of pesticide use on human health and environment; however, females were at higher risk of incorrect usage because they had less knowledge of how to use pesticide safely. Kinkingninhoun-Mêdagbé and colleagues' (2008) study of 45 rice farmers in Benin found significant gender differences in farmers' use of pesticide, which they largely attribute to gender-based discrimination. This lack of information may be indicative of the relatively low importance placed on pesticide use by agriculture-based research and programs.

Only two qualifying empirical studies were reviewed that found gender differences in use of production tools and equipment; again, we return to this lack of research in the discussion section. In the Zimbabwe study of agricultural differences in productivity, Horrell and Krishnan (2007) included an index of farm machinery as a control indicator and found significant bivariate differences between male and de facto female heads of household but not between male and de jure female heads of household. Babatunde and colleagues (2008) also found significant bivariate differences between male and female heads of household in value of farm tools owned in a sample of 60 Nigerian households. However, several related studies looked at gender-based differences in access to/ownership of draft animals. Draft animals are essential for the operation of manual plows and are an important source of manure; some studies cite ownership of draft animals as a key factor in increasing agricultural productivity among the rural poor (Smith 2008). Oladele and Monkhei (2008) found significant differences in the populations of animals owned by men and women in Botswana; men are significantly more likely to own cattle, donkeys, and horses, whereas women are significantly more likely to own goats. Pender and Gebremedhin (2006) found that female heads of households are negatively associated with the use of draft animals (oxen) in Ethiopia. This study also found female heads of household achieve 42 percent lower crop yields than male heads of household with similar use of labor, ox power, and other inputs, thereby indicating a further gender-based disadvantage in productive use of inputs. Fisher, Warner, and Masters (2000) examined the role of women's bargaining power among Senegalese cattle owners in the decision to adopt a bundle of "stabling technology" and found that the more bargaining power a wife has, the more likely the household is to reject adoption of this labor-intensive technique.[11] This may be because stabling leads to an increase in labor for women and a concurrent loss in income (when milk becomes more lucrative, men take on the traditional women's role of selling milk). Further analysis reveals adoption of the practice does lead to a loss of income for women but an overall improvement in household welfare that may benefit women in the long run.

In summary, we reviewed 24 studies of technological input use, access, and adoption that fit our criteria. The majority examine more than one technological input, including 18 measures of fertilizer, 13 measures of seed varieties, 7 measures of tools, and 3 measures of pesticide use, access, and adoption. Sixteen of 24 studies were published in peer-reviewed journals. Overall, where descriptive statistics for inputs were provided (for 24 input indicators), 19 (79 percent) found men have higher mean access and 5 (21 percent) found women have higher mean access to the given resource. Where further bivariate or multivariate analysis was conducted (for 39 input indicators), 23 (59 percent) found gender indicators are not significant with respect to outcome measures when other factors are controlled for, while 15 (38 percent) found differences persist and men have higher outcome measures; one study (3 percent) found women have higher outcome measures. The lack of significant differences is driven by the studies on inorganic fertilizer, where key background factors accounting for differences are education, wealth/asset stores, and land indicators. Many of these studies, however, identify alternative channels, through which gender disparities persist, such as receiving lower prices for yields or through poor access to markets.

[11] Stabling is a technological package consisting of a stable, a food supplement, an animal health-care program, and an improved method of producing manure. A major benefit of stabling is increased milk production.

However, since these channels are outside the main focus of these studies, they are only described and not analyzed in great detail.

Natural Resources: Water and Soil Fertility

The importance of natural resources is a growing concern in agricultural production as population pressures expand and stress the finite provision of environmental resources. Water is a supremely valuable resource not only for agriculture but also for domestic and household work, small business, commercial use, and general health and hygiene. It is therefore not surprising that there are social constructs concerning decisions about policy, access and allocation, and pricing of water and that gender has been high on the policymaking and programmatic water agenda (Singh et al., 2006; UNDP, 2006; von Koppen, 2002; World Bank, FAO and IFAD, 2009, Module 6). Because access to water can refer to a wide range of provision types, not all which are appropriate for our review, we limited inclusion to studies that specifically include water for agricultural or mixed garden and household use.[12] We therefore included studies on soil fertility that use gender-disaggregated data on any natural soil improvement technique, including, but not limited to, use of manure and compost, application of fallow periods, or other intercropping techniques, such as hedgerow or alley farming, that have the ability to improve soil fertility.

Table 2 summarizes the 13 studies that examine gender differences in access to natural resources and follows the format described for Table 1 on technological resources. Despite the importance of irrigation and access to water for agricultural outcomes, comparatively few empirical micro-level studies examine gender differences.[13] Using a sample of 1,131 households from the 2000 China National Rural Survey, de Brauw et al. (2008) found no difference in the percentage of irrigated land under female management (66.4 percent) and under male management (65.2 percent). The absence of differences in

[12] Studies that examine drinking water or domestic use only are therefore not included. However, women might use drinking water for kitchen gardens or small plots for home consumption even if it is not noted or analyzed in the study. Because the literature on any type of water use is so large, we decided to exclude these studies.

[13] Since irrigation often relies on water schemes or centralized infrastructure, there have been more case studies and other institutional analyses since 2000.

water use is consistent with a study of 45 rice growers in Benin that found average distance of female farmers to the main irrigation channel is slightly greater than that of male farmers (2.7 meters versus 2.55 meters); however, the sample size is very small (Kinkingninhoun-Mêdagbé et al. 2008). Findings from a Limpopo household survey (N = 552) in South Africa linking poverty and water supply found female-headed households are significantly disadvantaged in their access to piped water (22 percent; 32 percent of male-headed households have such access), and bivariate methods show that access is significantly associated with an increase in kitchen garden crops (Hope, Dixon, and von Maltitz, 2003). The mixed findings for gender differences in water use and access may be in part obscured by the fact that women are often responsible for fetching water for household domestic use, which may also be used for small-scale farming for household consumption.

A range of improved soil fertility methods has been the focus of many interventions, partially because of the gain in productivity realized without the provision of infrastructure or costly technology. Although the sample sizes of the studies included are relatively small, results generally indicate men are more likely to have access to or implement soil fertility techniques than women. For example, in Cameroon male plot owners are significantly more likely to adopt alley farming techniques controlling for other inputs), which the authors attribute to potential disincentives to invest because of lack of land and tree property rights for women (Adesina et al., 2000). Low acceptance rates also were found among Kenyan women heads of household for alley farming, which the authors speculate may owe to the view of hedges as men's crops and women's reluctance to trim hedges, a task that involves heavy physical labor (Swinkels et al., 2002). Although mean differences indicate female heads of household are actually more likely to adopt tree fallows in Zambia in a sample of 218 households, the difference is insignificant once other factors are controlled for (Phiri et al., 2004). While one may suspect women would have comparatively more access to natural products, like manure and compost, than they would purchased fertilizer products, the few studies we reviewed give mixed results. Horrell and Krishnan (2007) found no significant differences in use of manure between female and male heads of household in Zimbabwe. In

Uganda a study of 80 plots found female owners report higher use of manure in comparison to male owners (70 percent versus 62.5 percent); however, in Nigeria among 62 cassava-producing households female farmers applied manure on 19 percent of plots, whereas manure was applied to 71 percent of male owned plots (Goldman and Heldenbrand, 2001; Enete et al., 2001). Jagger and Pender (2006) evaluated the effect of a program for natural resource management 451 households in Uganda and found no differences between male- and female-headed households in their adoption of animal manure, mulching, and crop residue. Using probit regression, Pender and Gebremedhin (2006) found female heads of households in Ethiopia are no different than their male counterparts in burning to prepare fields, however, women are less likely to use manure and composting to increase productivity. Finally, in a sample of 116 households in Burkina Faso, gender analysis of composting techniques found mixed results by region, suggesting that cultural or cropping differences may effect adoption (Somda et al., 2002).

In summary, we reviewed 13 studies of natural resource input use, access, and adoption that fit our criteria. The majority of studies examine measures of soil fertility (14 measures), while the minority examine water measures (three measures). Eleven of 13 studies were published in peer-reviewed journals. Overall, where descriptive statistics for inputs were provided (for 11 input indicators), eight (72 percent) found men have higher mean values, and three (27 percent) found women have higher mean values for the given resource. Where further bivariate or multivariate analysis was conducted (for 14 input indicators), nine (64 percent) found gender indicators are not significant with respect to outcome measures when other factors are controlled for, while five (36 percent) found differences persist and men have higher outcome measures. None of the reviewed studies found women have higher outcome measures in further bivariate or multivariate analysis. The factors accounting for the differences in significance vary, ranging from regional and market variations to quality and quantity of land. We hypothesize this is in part the result of the diverse nature of inputs (ranging from soil improvement techniques to formal irrigation schemes) and because sample sizes in this section are relatively smaller than in other sections.

Human Resources: Agricultural Labor, Extension Services and Life-Cycle Challenges

The effect of human resources on agriculture is a broad and extensive topic, ranging from health and nutrition to education and labor contributions. The process through which intrahousehold allocations of human resources are determined may in fact reflect the distribution of agriculture-specific inputs. However, because other studies have reviewed many of the relationships with these broader categories of human resources, we chose to limit our examination of human resources to three main proximate and definitive inputs: (1) agricultural labor, (2) extension or agricultural knowledge services, and (3) life-cycle challenges.[14] Agricultural labor refers not only to women's own ability to produce outputs (own labor) but also to the quantity and quality of supplemental labor they are able to access (hired or outside labor), which is often nonpaid labor allocated within the household. Note this evidence is strictly differentiated from macroestimates of women's contribution to the total agricultural workforce or the percentage of output produced by women farmers. Extension services (also known as agricultural advisory services) refer to the range of information, training, and agriculture-related knowledge provided by government, nongovernmental organizations (NGOs), and other sources that increase farmers' ability to improve productivity. Extension services are delivered on the ground by extension agents or livestock officers who are charged with information dissemination. Extension services may take the form of individual field visits, technical advice at organized meetings, visits to demonstration plots and model farms, or Farmer Field Schools (FFS) (for reviews of gender and agricultural extension frameworks, systems, policy, and programs, see Davis et al., 2007; World Bank and IFPRI, 2010; World Bank, FAO and IFAD, 2009, Module 7). Finally, women face a unique reproductive and life-cycle challenge during their prime years of labor-force participation, including, but not limited to, marriage expectations,

[14] Because the literature on human resources is so extensive, particularly in regard to gender differences in labor and health, we have to limit the scope of the paper to those that speak directly to the use of agricultural inputs. Several interesting gender differences in anemia/iron status have been shown to affect time use and general productivity but are not directly relevant to agricultural work specifically (see, for example, Thomas et al. 2006). For a review of general education and health by gender, see, for example, King, Klasen, and Porter 2007).

pregnancy, and childbirth, the postnatal period, childcare, and ongoing gender-specific health concerns such as menstruation and contraception.

Table 3 summarizes the 17 studies that examine gender differences in access to human resources, following the format described for Table 1 on technological resources. By far the most research has been conducted on various forms of extension services. A comprehensive and extensive review of primary survey data in Ghana, Ethiopia, and India completed by a “gender and governance” team of more than 16 researchers for the World Bank and IFPRI (2010) found large gender inequalities in access to extension services. Although the type of extension varies by county, mean differences are especially prominent in Ghana, where an average of less than 2 percent of female heads of household and female spouses in male-headed households have contact with extension agents, whereas nearly 12 percent of men do. In Karnataka, India, 20 percent of female household heads but 27 percent of male household heads report extension service visits at home or on the farm in the past year. The authors not only included measures of access by gender but also analyzed measures of farmer satisfaction with services, gender aspects of service provision, and institutional frameworks by country and validated by using qualitative research. Interestingly, in conducting multivariate analysis to explain contact with agents, gender variables become insignificant across countries; this is true in India and Ghana due to inclusion of asset/wealth variables and in Ethiopia due to local fixed effects. This dynamic perhaps speaks to the tendency of female heads of household to be asset poor and/or to variation in the supply-side characteristics/policies of extension services, which may be more women friendly by region within Ethiopia. It is also possible that results reflect the diminished power of the female headship variable to produce statistically significant results because of low percentages of women reporting contact with extension services. It is of note that in the World Bank and IFPRI findings (2010) on women’s access to livestock-related extension services are slightly better than for agricultural extension. In Ghana 0 to24 percent of female heads of household and 0 to 15 percent of female spouses have access to livestock-related extension services compared with 5 to 34 percent of male household heads who have such access.[15] In Karnataka, India, 71 percent of female heads of household have access to these livestock-related services, as do 78 percent of male heads of household. In the Indian context researchers attribute the similar rates of access to the importance of dairy cooperatives, which tend to be more gender neutral. Interestingly, evidence from Ghana, Ethiopia, and India indicates that the public sector provides the majority of extension services. The World Bank and IFPRI (2010) study found NGO, private-sector enterprises, and community-based organizations (CBOs) all play a relatively limited role in delivery of extension services. Because of the magnitude of information in the World Bank and IFPRI (2010) report, an entire section could be dedicated to discussion of extension services alone; we will discuss these findings further throughout this section and in the fourth section, in relation to governance and CBOs.

Another recent comparative study by Davis and colleagues (2009) examined FFS in Kenya, Tanzania, and Uganda using a longitudinal quasi-experimental impact evaluation design. Findings suggest female community members in Kenya and Tanzania have equal access to services, while women in Uganda are less likely to participate in FFSs. A promising finding of the Davis et al. (2009) study is that women who participate in FFS are more likely to adopt nearly all other major technologies, including improved seed varieties, soil fertility management, and pest control techniques. All other reviewed studies on extension services report mean values of access that are lower for women than men: 19 percent versus 81 percent in Malawi (Gilbert, Sakala, and Benson, 2002), 1.13 contacts versus 2.03 contacts in Uganda (Katungi, Edmeades, and Smale, 2008), 7 percent versus 13 percent in Malawi (World Bank and Malawi 2007). The only study with somewhat mixed results is from Senegal and looks at husband-wife pairs. It found women’s knowledge of various agricultural techniques is less than men’s, with the exception of nursery techniques, in which they are approximately equal (Moore et al., 2001). In general, sample sizes in the extension literature are much larger (for example, 1,385 farms in the Gilbert et al., 2002 study, 11,280 in the World Bank study using the Malawian Integrated Household Survey) as compared to

[15] The varieties in percentages refer to the differences in percentages between different zones surveyed.

sample sizes in studies examining other inputs, perhaps reflecting use of household and other survey data not collected specifically for an extension or other scheme evaluation.

One interesting, yet relatively unexplored, avenue of research is whether there are gender-based differences in the quality of information received by men and women. One factor that may influence quality and quantity of information is the gender of the extension agents or livestock officers. The World Bank and IPFRI (2010) study found extension agents and livestock officers in Ghana, Ethiopia, and India to be predominantly male; in Ghana only 10 of 70 extension agents interviewed were female; in Ethiopia agents were almost exclusively male; in Karnataka, India, none of the 41 agricultural extension workers was female, 1 of 41 junior engineers was female, and 4 of 40 veterinary assistants were female. Gender imbalances may cause problems in disseminating information. For example, in Ethiopia researchers note that male extension agents are prevented from interacting with female farmers by strict cultural taboos. Another issue noted is that male extension officers may be more likely to subscribe to the common misconception that women are not farmers and overlook women in the household when delivering information. On the other hand, researchers in Senegal found that female extension agents can have a positive impact on dissemination of knowledge among both among men and women (Moore et al., 2001). Another factor that may influence both quality and quantity of information available to women is access to information and communication technologies (ICT—telecommunications, computer and Internet use, and the like). While ICTs are increasingly becoming important tools in information dissemination, women often have limited access to ICTs. For example, a recent study found women in Africa, the Middle East, and South Asia to be, respectively, 23, 24, and 37 percent less likely than their male counterparts to own a mobile phone, a key communication technology (GSMA Development Fund, 2010).

The disparities in male and female access to extension services, noted throughout the literature, are particularly troubling, given that evidence from the World Bank and IFPRI (2010) study indicates that access to extension services is a key determinant of adoption of new information and use of new technologies and farming practices. For example, in the case of Ghana multivariate analyses indicate that an extension agent visit was the only variable positively and significantly associated with adoption of new agricultural technology. Even if men and women are given equal access to extension services and information of equal quality, gender-based differences in use or adoption of new practices often persist because of lack of complementary knowledge or necessary inputs. A key example of this comes from the Doss and Morris (2001) study, which found gender-based differences in adoption of modern maize varieties and chemical fertilizer result from gender-based differences in access to necessary complementary inputs.

Comparatively fewer studies discuss gendered labor differentials. The most rigorous examples come from de Brauw et al. (2008), who compare large-scale panel surveys from China and from a working paper that uses the Nepal Living Standards Survey of a population-level sample of 2,360 households (Thapa, 2009). In the China study de Brauw and colleagues specifically examined the "feminization" of Chinese agriculture by measuring labor allocation decisions within the household on labor use, welfare, and productivity over time and found little evidence to support the hypothesis for the feminization of agriculture. Findings are robust to use of alternative survey data and construction of gender indicators at different units of analysis. Results from Nepal show female heads of household report higher commitments of female labor (6,857 hours) than male labor (1,450 hours), whereas male household heads also report more female labor, although they claim a more equitable ratio (5,105 hours of female labor to 3,922 hours of male labor). Interestingly, female-headed households report slightly more hours of hired labor, although these values are relatively low and quite similar (227 hours for female and 217 hours for male heads of household). Although in subsequent production function estimates being in a female headed household does not seem to matter for productivity, all labor indicators are highly significant (at the 1 percent level) and contribute positively to value of farm output, indicating differences in productivity are explained by differences in access to inputs (including labor, land, and technology).[16] Also in Nepal, Paolisso and colleagues (2002) evaluated the effect of the Vegetable and Fruit Cash Crop Program (VCP) in a sample of 264 households, stratifying results by gender of respondent.[17] Findings indicate men and women spend roughly the same average time in cereal and livestock production (228 and 244 minutes per 12-hour day for men and women, respectively); however, women spend more time caring for children younger than five, while men spend more time in fruit and vegetable production (women spend 33 minutes on childcare, whereas men spend 11 minutes; women spend 21 minutes and men 43 minutes on fruit and vegetable production). Interestingly, Paolisso et al. (2002) find differential program impacts both by gender and by family type. The VCP had a greater impact on shifting men's time use to vegetable and fruit production; however, men, and especially women in households with one preschooler, reduced the time they spent caring for the child (this result was not found for households with more than one preschooler). In regression analysis Pender and Gebremedhin (2006) also found female heads of household are significantly associated with lower labor participation, as measured by person days per acre using a 500-household sample from Ethiopia. Again, the Horrell and Krishnan (2007) study included the number of working-age adults in the household as an indicator of labor availability and, by using bivariate methods, found differences exist between male household heads and de facto female household heads—male-headed households are larger, on average, by one person (4.14 versus 3.12 people). Fletshner's (2008) study of 210 households in Paraguay found that households with more male labor exhibit higher technical efficiency, whereas additional female labor has no impact on technical efficiency.[18] The two remaining studies on labor inputs in Nigeria (Enete et al., 2001) and Benin (Kinkingninhoun-Mêdagbé et al., 2008) both report higher labor inputs for female-owned plots and

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[16] Thapa (2009) includes contact with extension services in his analysis, and results indicate a positive and significant relationship with value of farm output. He does not include gender-disaggregated mean values of extension services, which therefore are not included in this summary.

[17] The VCP was implemented in 22 communities in five districts of Rapti in midwestern Nepal, with the goal of increasing commercial production of vegetables and fruits in farm households. The VFC provided technical assistance and crop technologies; specific vegetables and fruits vary by agroclimactic conditions and agricultural practices of the community. Data collection occurred between 1991 and 1993 (Paolisso et al., 2002).

[18] By definition a household is considered technically efficient if no other household (or combination of households) produces more output with a similar level of inputs (Paris, 1991).

female farmers than men. However, because studies are limited in their sample sizes and crop diversity, results should be regarded with caution (62 cassava-farming households in Nigeria and 45 rice-farming households in Benin). With the exception of Paolisso et al. (2002), who examines tradeoffs between time spent on childcare and agricultural production, virtually no qualifying empirical studies were reviewed that addressed life-cycle differences. This lack of research will be noted in further detail in the discussion section.

In summary, we reviewed 18 studies of human resource input use, access, and adoption that fit our criteria. These include 15 measures of extension services and other educational services, 14 measures of labor, and 1 measure of life-cycle inputs. Fourteen of 18 studies were published in peer-reviewed journals. Overall, where descriptive statistics for inputs were provided (for 28 input indicators), 15 (53 percent) found men have higher mean access and 13 (46 percent) found women have higher mean access to the given resource. Where further bivariate or multivariate analysis was conducted (for 14 input indicators), eight (57 percent) found gender indicators are not significant with respect to outcome measures when other factors are controlled for, while five (35 percent) found differences persist and men have higher outcome measures, and one (7 percent) found women have higher outcome measures. Assets and geographical variations seem to be key factors in accounting for differences across studies where gender differences were found previously. In comparison with other sections, analysis of extension services is especially well developed and increasingly has considered alternative gender dimensions, including gender of extension agents, quality of information, and time constraints in participation in trainings.

Social and Political Capital: Group Membership, Information Exchange through Networks, and Political Representation

Social capital plays an important role in agricultural production by providing farmers with social networks in which they can exchange information about farming practices and with social safety nets that they can use in times of hardship. Likewise, political capital provides farmers with forums in which they can organize to protect or regulate local resources and with venues in which they can challenge legislation that is unfavorable to small-scale producers. Access to social and political capital is particularly important for female farmers as it provides the formal and informal networks in which they can gain valuable information and influence. Throughout the discussion we will differentiate several different ways that female farmers can gain access to social and political capital: (1) membership in groups, (2) non-group information exchange through social networks or local media such as radio or television, and (3) political representation. By membership in groups, we mean local-level groups (such as agricultural co-ops, water user boards, and forest committees) that provide women with knowledge, contacts, and collective action opportunities. By non-group information exchange, we mean the informal exchange of information that facilitates the formation of social and political capital and takes place outside the bounds of an organized group, including social media channels. By political representation, we mean formal political representation that facilitates the exchange of social/political capital.

Table 4 summarizes the 11 studies that examine gender differences in access to social and political capital, following the format described for Table 1 for technological resources. In comparison with other categories of inputs, there are fewer published studies of gender differences. The vast majority of empirical work that looks at gender-differentiated access to social and political capital does so by looking at group membership. Of particular note is the World Bank and IFPRI (2010) research on gender and governance. In the study's survey of 966 households in India, researchers found that the gender of the household head does not play a significant role in determining number of memberships in local CBOs. However, the type of group joined varied along gender lines; women mainly joined self-help groups or women's groups, and men primarily joined forest groups, cooperative societies, and caste associations. The complementary studies in Ghana and Ethiopia also found group membership varies along gender lines, with male households tending toward agriculture-oriented organizations. In Ghana probit regression showed that male household heads are significantly more likely to belong to a farmer-based organization than are female household heads, and in Ethiopia a significantly higher proportion of male than female respondents is involved in agricultural cooperatives (24 percent versus 4 percent).

A number of other studies look at gender-based differences in group membership. Davis and Negash's (2007) study of 88 Kenyan farmers found that gender has a significant impact on the type of group that respondents participate in; males dominate agriculture-oriented groups, while females dominate women, clan, and village groups. Godquin and Quisumbing's (2008) study of 304 households in the Philippines found that men and women do not differ significantly in their probability of participating in groups or the number of groups they join. However, there are clear gender differences in the types of groups to which men and women belong, and significantly more men are members of production-oriented groups. Kariuki and Place (2005) explored motivation for group membership in Uganda, finding that women, who are usually subsistence farmers, join groups for social insurance or household asset building, whereas men, who are more market oriented, join groups to enhance their marketing and commercialization ventures. Jagger and Pender (2006) found female-headed households in Uganda are more likely to be involved with local CBOs and NGOs that do not focus on agriculture and the environment. Beard (2005) found that married women are significantly more likely than non-married women to know about and participate in civil society organizations in rural Indonesia.[19] Beard concluded that participatory community development organizations restrict women's roles to that of caretaking. Only one study explored differential access to resources and assistance from community groups, CBOs, and NGOs. Perdana, Matakos and Radin (2006) used a probit regression to explore whether gender of household head has affected access to assistance from a variety of groups since the 1998 Indonesian economic crisis. This study found female headed household indicators are a significant determinant of assistance received with respect to CBOs, although not for the government or NGOs assistance.

[19] Civil society organizations are defined as those that deliver public goods and services to territory-based communities. Men usually participate in civil society organizations related to community-level governance, physical infrastructure, environmental improvements, and neighborhood security, whereas women participate in organizations that focus on family welfare, economics, and health. As a result the survey asked men and women about participation in different organizations.

We found a few empirical studies that examine the differential impact of group participation by gender. Agrawal and colleagues' (2006) study of forest committees in India found that women's participation has substantial positive effects on regulating illicit grazing and tree felling, even after controlling for the effects of a range of independent variables. Leino's (2007) study examined a targeted intervention in rural Kenya that was designed to increase female participation in water user committees. It found the intervention dramatically raises female participation levels. However, the increased levels of female participation did not have a significant impact on water source maintenance outcomes. Nonetheless, Leino notes that the increased participation may have "spillover effects" in the community because of the gains in female leadership capacity. Another interesting avenue of exploration is the impact of group membership on women. Fletschner and Carter (2008) found that for women in rural Paraguay, demand for entrepreneurial capital is positively driven by the behavior of members of their reference group. Thus the larger the membership of a co-op (a sign of an entrepreneurial mentality), the more likely the woman is to demand entrepreneurial capital herself.

Although there is a wide range of sociological literature on informal social networks and information exchange, there is little empirical research that explores differential access to agriculture-related information exchange by gender. One related study by Katungi, Edmeades, and Smale (2008) examined the exchange of agricultural information in Uganda using multinomial logit modeling. Katungi and colleagues (2008) found social capital is an important factor in information exchange, with men generally having better access to social capital than women. We found virtually no empirical studies exploring issues of gender and political representation in the agricultural domain.

In summary, we reviewed 12 studies of social and political capital that fit our criteria. The majority (18 input measures) are measures of group participation, while only one study measured non-formal information exchange, and one study measured social networks. Six of 12 studies were published in peer-reviewed journals. Overall, where descriptive statistics for inputs were provided (for six input indicators), four (67 percent) found men have higher mean access, and two (33 percent) found women have higher mean access to the given resource. Because subsequent bivariate and multivariate analysis differs in outcome from those in the previous sections (which more commonly predict participation in certain types of groups), and since the signage on many of these outcomes is not clear, we do not summarize direction of effects for this section. However, it can be concluded that strong gender effects persist in decisions to participate in groups, across nearly all studies examined, and, based on this, we conjecture that group-based evaluations will be a focus of future gender and agricultural research.

Discussion and Policy Implications

What value does this review add to the overall knowledge of gendered access to non-land farm inputs? We focus the discussion on three key aspects of the review and finish with a summary, suggestions for future research, and policy implications of our findings. First, we offer some conjectures and speculations as to why we find (and do not find) differences in women's access between and across studies. Second, we try to note some general regional similarities and differences across research on gender and non-land inputs throughout Asia, Latin/South America, Sub-Saharan Africa, and the Middle East. Third, we discuss briefly some issues and promising work in two areas (life-cycle effects and mechanization) in which we find few studies fitting our inclusion criteria. Fourth, we discuss the new challenges and opportunities in high value, organic, and fair-trade agriculture for female farmers and how this may have repercussions for and interact with women's access to inputs in the developing world.

It is hard to generalize why gender differences are or are not found across inputs, study designs, and regions. However, a common theme throughout the literature reviewed is that crop choices and division of labor differ by gender within disparate regional and cultural contexts. For example, throughout Sub-Saharan Africa lucrative cash crops are often perceived to be "male crops," and crops for home consumption are perceived to be "female crops" (Kasante et al., 2001; World Bank and Malawi, 2007). Related to this issue, Doss (1999) notes that there may be differences in choices of inputs by gender based on whether the crop is produced for home or for the market. For example, yield may be the most important consideration in market-targeted crops, while other factors such as taste, storability, and ease of processing (such as drying, fermenting, pounding) may be important in determining crops for home consumption. However, Doss's (2002) study of nationally representative household survey data from Ghana found few crops can be defined as men's crops, and none is obviously a women's crop. Therefore this and other evidence suggests that, in some settings, boundaries between male and female crops may be less rigid than they initially appear (Quisumbing et al. 2001).

Concerning division of labor, within Sub-Saharan Africa males are often responsible for the physically intensive task of clearing the land, and women are responsible for weeding and postharvest processing (Guyer, 1991; Kasante et al., 2001). In Asian systems men typically provide the labor in land preparation, and women provide labor in planting, cultivation, and crop care such as weeding (Quisumbing and McClafferty, 2006). In future research it is worth further exploring the impact of technology adoption on the traditional gendered division of labor. For example, Fisher Warner, and Masters (2000) find that the adoption of the stabling technique in rural Senegal makes milk more profitable by improving production; as a result the marketing of milk shifts from the female to the male domain. In reality, studies that examine one input in isolation capture only a partial picture of realities in which synergies exist between farm inputs and relative outputs. Therefore it would be expected that as inequalities in access to technology and services are reduced, the potential for increased productivity and output will increase across sectors.

On a methodological note, throughout the reviewed studies authors make use of (mainly) two very different units of analysis when assessing inequalities in use, adoption rates, or outputs. For example, in examining fertilizer and seed varieties within the technological section, Enete et al. (2001); Freeman and Omiti (2003); the World Bank and IFPRI (2010) study on Ethiopia; and Gilbert, Sakala, and Benson (2002) studied the gender of the individual farmer/plot owner, whereas Bourdillon et al. (2002); Jagger and Pender (2006); Tiruneh et al. (2001); the World Bank and IFPRI (2010) studies on Ghana and India; and Thapa (2009) examined the gender of the household head. Only Chirwa (2005) and Doss and Morris

(2001) examined both. In their sensitivity analysis, Doss and Morris (2001) point out that using the gender of the farmer allows for examination of female farmers in both male- and female-headed households. This is significant because, as Bourdillon and colleagues (2002) point out, even in female-headed households of rural Zimbabwe, men (such as adult sons) are expected to make agricultural decisions. Because gender of household head is not always a perfect indicator of female access or decision making, there is a need for more studies that conduct sensitivity analysis between measures of female management and female headship. As they discuss extensively, Horrell and Krishnan (2007) make a further distinction between female de jure and female de facto households and find differences persist mainly among de facto households. However, it should be noted that because the full sample size is 300 households, this stratification results in small sample sizes, especially among the de facto female-headed households (*N* = 17). The heterogeneity of women or men within these categorizations is important, as they may differ significantly with respect to background characteristics, as shown by different technology adoption rates when interactions between headship and literacy are included to predict adoption rates (World Bank and IFPRI, 2010). Uttaro (2002) makes another pertinent differentiation in men, married women, and single women when looking at differential access to inorganic fertilizer in Malawi, finding married women access inorganic fertilizer at a higher rate than single household heads. In short, the specific gender indicator used seems to matter, and further research is needed to conduct these types of sensitivity analyses (Deere, Alvarado, and Twyman, 2009).

The overwhelming bulk of evidence we reviewed is from studies in Sub-Saharan Africa (more than 75 percent, depending on inclusion of cross-country studies). In the Latin and South American, Eastern European, and Middle Eastern regions we found few qualifying studies.[20] This may be a reflection of regional or cultural differences in households and farming practices that, in turn, influence research questions and methods. For example, outside Sub-Saharan Africa, where there are clearly

[20] This lack of diversified empirical research on gender differences does not necessarily apply to land (access, ownership, and rights), where there is comparatively more evidence in South America and Asia (see, for example, Deere et al., 2004 in Brazil, Paraguay, and Peru; Allendorf, 2007 in Nepal).

demarcated men's and women's plots, it is harder to measure differences in men's and women's non-land inputs, perhaps with the exception of labor inputs. In addition, this may be driven by regional differences in research funding streams, policy interest, and donor programmatic focus. While there has been a larger body of research with a regional focus on Asia in the past few decades, these studies typically use a different kind of gender disaggregation. For example, in general, labor and other inputs are disaggregated by gender (male-hired labor, female-hired labor, male family labor, female family labor), but outputs are not. This is likely the result of the joint nature of Asian family farming and the relatively low incidence of female headship. Ultimately, the percentage of female-headed households in most studies has been so small that it does not necessarily warrant separate estimation by sex of household heads. Some recent exceptions to this trend are the study by de Brauw et al. (2008), which found little support for the hypothesis of Chinese feminization of agriculture, and the studies by Thapa (2009) and Paolisso and colleagues (2002) in Nepal. We also found a comparatively higher number of studies use data from Asian and South Asian countries for examining social and political capital (six of 11 studies include at least one Asian country), a statistic that may be driven by donor and research interest around women's groups as a program delivery modality.

The regional disparities in evidence may also be a function of the percentage of women engaged in agriculture in the Sub-Saharan region; however, we should not assume that this is a driving force. For example, according to International Labor Organization (2009) estimates, agriculture accounted for 65.1 percent of the sectoral share of employment for women in Sub-Saharan Africa in 2007; however, this percentage is identical to that of South Asia, followed by Southeast Asia and the Pacific (43.9 percent), East Asia (41.2 percent), North Africa (38.9 percent), and the Middle East (32.0 percent). In fact, in comparison with men, women in the Middle East have the higher regional proportion of agricultural workers (agriculture accounts for only 13 percent of the sectoral share of employment for men). *Women in Agriculture in the Middle East* reviews published and unpublished work and compared the state of women working in agriculture in Palestine, Israel, Egypt, and Jordan, including the gender effects of the resettlement process (Motzafi-Haller, 2005). The compilation of research emphasizes the importance of discriminating and oppressive political factors, especially in the context of civil conflict, that determine women's ability to obtain and successfully use agricultural inputs. Given the importance of context and cultural influences on the underlying ability of women to secure and use inputs, there is a great need for regionally diversified micro-empirical work on women and agriculture.

We also found little empirical evidence on the effect of life-cycle considerations in agriculture. In some ways the impact of the life cycle on agricultural productivity is hard to quantify because, unlike the other categories of traditional inputs we review, there is no consensus regarding inputs to be measured. Life-cycle effects can be biologically or socially determined and thus are highly sensitive to cultural context. However, the lack of standardization and research make the discussion and acknowledgment of life-cycle challenges particularly important to include. For example, if a woman is expected to abandon a plot or agricultural investment because she moves to her husband's village upon marriage, this represents a significant life-cycle challenge, especially if her knowledge of farming and output techniques is no longer relevant in her new setting. In addition, if a woman must stay near her home or must reduce her working hours to breast-feed or take care of children, this will impact her decisions around agricultural work.[21] Often these interactions are not clear cut and/or anticipated. For example, a study conducted in a Chilean hospital in 1993 found 90 infants with birth defects because of their mothers' exposure to chemicals and pesticides while working in fruit production (Green 1995, cited in Barrientos et al.1999).[22] Quisumbing and Yohannes (2004) found nearly 27 percent of women cite childcare as a reason for not

[21] Alternatives are leaving children at home or with another relative, which has repercussions for mixed feeding and overall child development. For example, in a survey of 50 women working in the sugar beet industry in Egypt, 12 percent reported leaving children alone at home, 70 percent left children with a grandmother or brothers, 10 percent left children with other relatives or neighbors, and 8 percent brought children to the fields with them (El-Eshmawiy, El-Shiraif, and El-Khafif, 2007).

Regardless of marital status, it is likely that many women engaged in agriculture have children. A study of fruit producers in South Africa found 90 percent of women had children, many younger than five years (Barrientos, McClenaghan, and Orton, 2001). Among 336 Kenyan tea and coffee farmers, 95 percent had children (average of 3.5 children), yet only 46 percent of women lived with cohabiting husbands (Karungu, 2006).

[22] Studies across different regions of the world have linked pesticide and insecticide use to adverse reproductive and health outcomes, including birth defects, infertility, premature birth, and menstruation difficulties (for review see Dolan and Sorby 2003, 41).

applying to public works (typically food-for-work) programs in rural Ethiopia in contrast to approximately 3 percent of men. A study that does address life-cycle challenges looked at 186 households in rural Kenya to examine the effects of pregnancy and lactation on time use (Baksh et al., 1994); however, this study is somewhat dated, as its fieldwork dates from 1986, and thus does not fit the inclusion criteria for our review. Using bivariate analysis, Baksh and colleagues found that women who are pregnant or lactating reduce time spent on subsistence agriculture and commercial and home work, especially during the third trimester and first period of lactation. Also, some interesting and promising interventions and programs are being developed to tackle life-cycle issues, and these efforts can be used as a starting point for thinking about life-cycle challenges. The Menstruation and Education in Nepal Project is testing the acceptability and impact on educational attainment and a range of human capital outcomes of randomly distributed menstrual cups to adolescent girls in Nepal (Oster and Thornton, 2009). The menstrual cup is reuseable and, compared with the cloths typically used during the menstrual cycle, increases mobility, cleanliness, and discretion and is expected to alleviate restrictions on young women, especially in schooling attendance, based on their cycle timing.[23] The Baby-Friendly Community Initiative, coordinated by Gambia's National Nutrition Agency, runs a demand-driven intervention to promote exclusive breast-feeding in rest houses located where women can breast-feed while working their fields. In addition some participatory communities have instituted policies of community assistance for women during the three months before and six months after delivery to mirror traditional government-provided maternity leave (Jallow, 2005, 2006). These two programs are examples of how studying life-cycle challenges clearly goes beyond simply measuring labor or access to education to include such aspects as mobility, benefits and workers' rights, discrimination and sexual harassment, occupational health, and other pregnancy-related concerns. Little research has examined the effects of pregnancy or the postpartum period on agricultural productivity or how the lack of mobility during menstrual cycles or the

[23] A menstrual cup is a small silicone bell-shaped cup that is inserted in the vaginal canal to collect menstrual blood. The brand used in the study is the Mooncup, although similar products are sold under the Keeper and Diva Cup brands. For most women the cup needs to be emptied approximately every 12 hours. For more information see Oster and Thornton (2009) or WWW.MOONCUP.CO.UK/.

lack of childcare affects the ability of women to work or transport goods to market. These topics are opportunities to collaborate with researchers and policymakers who work on reproductive and health issues and have long made efforts to improve maternal health outcomes.

We found few studies that focus on or include mechanization, tools, and other farming equipment disaggregated by gender.[24] This may be in part because modern farming equipment such as tractors and tillers are not commonly available to either gender or used in rural agricultural work, especially in Sub-Saharan Africa. Several studies from the late 1980s and early 1990s point to gender differences in tool ownership and access. In a Gambian irrigated rice scheme, less than 1 percent of women owned a weeder, seeder, or multipurpose cultivation implement, while 12 percent of men owned a weeder, 27 percent of men owned a seeder, and 18 percent of men owned a multipurpose cultivation implement (von Braun, Hotchkiss, and Immink, 1989). Further, only men (8 percent) owned any type of plow. In a household survey the value of farm tools and equipment owned by Kenyan women across three districts was 18 percent of the value of the same implements owned by male farmers (Saito, Mekonnen, and Spurling, 1994). In a more recent study of productivity differences by gender in a rice irrigation scheme in central Benin, researchers did not explicitly control for access to tools; however, Kinkingninhoun-Mêdagbé and colleagues (2008) note that equipment such as motor-cultivators used for plowing and transport is managed by groups. Since women's groups were not provided with operators, they could not start plowing until the drivers for men's groups completed work on the men's fields. This delayed the women's plowing and subsequent planting (Kinkingninhoun-Mêdagbé et al., 2008).[25] In addition, in a review of gender and agriculture inputs and productivity, Quisumbing (1994) concluded that farmers who use tools and other equipment may be more likely to adopt other technologies, which speaks directly to the interactive and synergetic aspects of agricultural inputs.

[24] However, there is more research on mechanization and technology applied to postharvest labor. See, for example, Mulokozi et al., 2000; Paris, Feldstein, and Duron, 2001; Singh, Singh, and Kotwaliwale, 1999).

[25] Using the age of a nursery as a proxy for the timing of planting, Kinkingninhoun-Mêdagbé et al. (2008) found that women plant their rice 25 days after seedling growth, while men plant 19 days after, and this difference is statistically significant at the 1 percent level. Women also did not participate in the second cropping season because of delays in plowing.

Although not included in this review, forthcoming research, policies, and programs address several challenges and opportunities in agriculture. One notable issue is the emergence of new agricultural product markets, especially in relation to high-value agricultural exports such as floriculture and organic products (World Bank, FAO and IFAD, 2009, Module 8, thematic note 3).[26] In a review of high-value agriculture, Dolan and Sorby (2003) found that women make up a proportionally larger share of specialized producers than they do general agriculture producers. For example, women are estimated to make up 79 percent of Zimbabwe's floriculture industry, which now accounts for nearly half the country's horticulture earnings. Similar statistics are provided for women's involvement in the cut-flower industries of Colombia (60 to 80 percent), Kenya (75 percent), and Uganda (75 to 85 percent) (Dolan and Sorby, 2003; see Friedemann-Sánchez, 2009 for in-depth exploration of women working in Colombia's cut-flower industry). Other notable high-value crops reviewed are spices (vanilla in Uganda), nontraditional vegetables (snow peas in Guatemala) and fruits (grapes in Brazil, Chile, and South Africa), and poultry in Thailand and Brazil (Dolan and Sorby, 2003). The authors review not only gender disaggregation in production but also issues related to seasonalities, working conditions, pay, and training opportunities. There is also increasing involvement and exposure of female farmers to organic and fair-trade agriculture (see Farm Radio Weekly, 2009). Movement toward fair-trade involvement in agricultural crops has potential benefits for women as many standards require specific attention to gender training, including sexual harassment policies in the workplace and gender representation in company leadership (Raynolds and Keahey, 2009).

Looking forward, several key issues are ripe for research, program implementation, and policy. First, we reiterate the need to collect and analyze gender-disaggregated data in agricultural research. If possible, data disaggregation at the plot level is preferred to disaggregation at the household or farm level, which may obscure intra-household dynamics. We also recommend the collection of several indicators of

[26] Other subjects that appear to be worthy of exploration are gender effects or components of environmental conservation in agriculture, role of gender and information and communications technologies (ITCs) in agriculture, and the interactions of weather shocks, gender, and climate change.

gender to provide more robust results (for example, female heads of household, female-owned plots, female-owned assets, female-managed plots, and so on). While the attention to gender-specific data is improving, some recent publications still do not disaggregate, analyze, or even control for gender indicators in their analyses.[27] Providing descriptive statistics or controlling for gender often involves fairly simple calculations and has the potential to build a more robust body of work identifying gender differences in access to agricultural inputs. Second, while a fair amount of attention has been paid to differential access to inputs in some areas (for example, seed varieties, inorganic fertilizer, fallow techniques, extension services), comparatively little evidence exists about several other inputs (such as life-cycle concerns, mechanization). Third, there is a lack of evidence of gender differences in input use from Middle Eastern, Latin/South American, and Eastern European regions, perhaps because of underlying assumptions regarding farm and family organization, such as the assumption that all farm output is pooled. Even in Asia, where there is a wealth of gender-disaggregated data on labor inputs, there is relatively little evidence from outputs on male and female plots because of the assumption that farming is conducted jointly and output is shared. But even in Asia there may be homestead plots or livestock that are women's exclusive responsibility.

As the success and sustainability of many interventions reflect, gaining access to productive resources is not just a legal, political, or economic issue; it is a matter of changing gender relations, views, and social institutions in many settings. Having adequate information to inform policy decisions across a variety of settings is crucial. In fact, without attention to the larger scope of gender relations, interventions to provide equal access to inputs and resources have in certain cases led to increased conflict (see, for example, Lastarria-Cornhiel, 1997; Tripp, 2004; Whitehead and Tsikata, 2003). It is our hope that

[27] Examples are numerous. Simmons, Winters, and Patrick (2005) present an econometrically rigorous two-stage analysis of contract farming among 800 households for seed corn, rice, and broilers in Java, Bali, and Indonesia, respectively. Although family labor disaggregated by sex is included as a determining factor in gross margins, no discussion or inclusion of gender is otherwise part of the analysis. Likewise, Enete, Nweke and Tollens (2004) examine labor decisions in cassava-producing households using survey data from six Sub-Saharan African countries. No mention or inclusion of gender is present in the analysis, which is puzzling because earlier analyses co-authored by Enete are gender focused (see Enete et al., 2001).

attention to gender in agricultural research, program implementation, and policy will gain increased attention and be further mainstreamed in the coming decade.

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Tables in text

Table 1. Gender differences in access to technological inputs: Fertilizer, insecticide, seed varieties, and other technological inputs

Authors (year)	Country (crop)	Sample size	Use of/access to input: Input type	Women	Men	Unit	Gender indicator	Outcome measure	Effect size	Comments	Pub-lshed
Atreya (2007)	Nepal	434 hhlds	Pesticides	-	-	-	Male respondents	Decisions of pesticide use in a household	0.425*** (nr)	Partial correlations among individual characteristics and pesticide use-knowledge, attitudes and practices (but not actual use) find almost all respondents of both genders were aware of negative impacts of pesticide use on human health and environment; however, females were at higher risk due to lower level of awareness of safe pesticide use practices.	x
				-	-	-		Proper practice: wind direction	1.03** (nr)		
				-	-	-		Knowledge of safety precautions	0.117*** (nr)		
Babatunde et al. (2008)	Nigeria	60 hhlds	Farm tools	5,946	75,706	Value in naira	Female heads	-	-	Bivariate analysis finds male-headed hhlds have significantly higher valued farm tools (access) as compared to female headed hhlds; however this study found no differences in farm output by gender.	x
Bourdillon et al. (2002)	Zimbabwe (maize)	136--200 hhlds[a]	Maize hybrid	-	-	-	Not specified[b]	Adoption	NS	Probit analysis finds that gender of hhld head has no significant impact on adoption rates; however statistics are not reported (sensitivity analysis discussed in text only).	
Chirwa (2005)	Malawi	156 hhlds	Fertilizer	-	-	-	Female plot owners	Adoption	-0.146 (-0.58)	Probit analysis finds that gender of plot owner farmer has no significant association with adoption rates.	x
			Maize hybrid	-	-	-			0.096 (0.37)		
			Fertilizer	-	-	-	Female heads	Adoption	-7.3*** (-2.57)	Probit analysis finds female-headed hhlds associated with lower adoption rates.	
			Maize hybrid	-	-	-			-0.23 (-0.85)	Probit analysis finds gender of hhld head insignificant in predicting adoption rates.	
Doss & Morris (2001)	Ghana (maize)	420 farmers	Modern seed varieties[c]	39	59	%	Female farmers	Adoption	-0.085 (0.200)	Two-stage probit models, find no significant difference in adoption rates between males and female farmers once access to complementary inputs (land, education, labor) are controlled for.	x
			Inorganic fertilizer	16.2	22.5				0.093 (0.225)		
Enete et al. (2001)	Nigeria (cassava)	62 hhlds	Inorganic fertilizer	19	14	%	Female plot owners	Cassava yields	-	Female-owned plots have significantly higher mean cassava yields; however, no multivariate analysis presented to attribute to inputs.	x
			Improved seed varieties	5	0				-		
Fisher, Warner, & Masters (2000)	Senegal	60 hhlds	Stabling technique[d]	-	-	-	Age of wives	Adoption	-1.77** (0.70)	Logitistic regression models factors related to the bargaining power of wives (proxied by age, number of wives and number of children of first wife) in hhld decision to adopt stabling (which is an intensive labor technique).	x
							# of wives		3.24* (1.68)		
							# of children of 1st wives		-0.67* (0.38)		

Freeman & Omiti (2003)	Kenya	399 hhlds	Fertilizer	-	-	%	Male heads	Adoption & intensity use	2.48 (10.212)	Tobit regression model finds no significant differences in adoption and intensity of use after controlling for other inputs.	x
Gilbert, Sakala, & Benson (2002)	Malawi (maize)	1,385 farmers	Inorganic fertilizer	36.0	66.2	kg	Gender stratified: female farmers	Use (pretreatment, high altitude zone)	-3.68*** (nr)	Descriptive statistics disaggregated by gender and agroecological zone show before treatment there were significant differences in fertilizer use based on the gender of farmer.	x
				20.4	28.9	kg		Use (pretreatment, low-med alt zone)	-2.03* (nr)		
				2,460	2,470	kg ha^{-1}		Yield (posttreatment, high alt zone)	NS (nr)	Descriptive statistics disaggregated by gender and agroecological zone show when female farmers were provided with seed and fertilizer inputs (access) for the trial, their farm management efforts (use) were equally as productive as the male farmers'.	
				2,540	2,560	kg ha^{-1}		Yield (posttreatment, low-med alt zone)	NS (nr)		
Horrell & Krishnan (2007)	Zimbabwe (primarily maize)	300 hhlds	Inorganic fertilizer	55 (de jure); 67 (de facto)	63	%	Female heads (distinction between de jure and de facto)	Usage	-0.03 (0.03) de jure; -1.90 (1.30) de facto	Sample of 300 hhlds distinguishes between de jure female-headed (widow headed, *n* = 52) and de facto headed (*n* = 17). Tobit regression analysis finds no significant difference in maize yields achieved or fertilizer usage by female-headed hhlds. However, further analysis finds de facto female heads of hhld receive low prices for their output and lack access to selling consortiums; thus disadvantages persist.	x
				137 (de jure); 175 (de facto)	156	kg/ha (among users)		Inputs/ha	NS (nr)		
			Seeds	13.4 (de jure); 17.7 (de facto)	14	kg/ha (among users)			NS (various)	Tobit regression models find no significant differences in use among de jure or de facto female-headed hhlds and male-headed hhlds for both maize and all crop samples.	
			Machinery	4.2 (de jure); 3.6 (de facto)	5.2	Owner-ship index		--	S** (nr)	Bivariate t-tests show significant differences in use between male and de facto female-headed hhlds only.	
Jagger & Pender (2006)	Uganda	451 hhlds	Inorganic fertilizer	-	-	-	Female heads	Adoption	0.136*** (nr)	Two-stage probit models used to look at impacts of programs and organizations on technology adoption. Control factors also include the number of males and females in the hhld. Number of males is weakly associated (10 % level) and number of females is significantly (5 % level) associated with fertilizer use, and both are insignificant in predicting pesticide use.	
			Pesticides	-	-	-			-0.087 (nr)		
Kinkingninhoun-Mêdagbé et al. (2008)	Benin (rice)	45 farmers	Inorganic fertilizer	406	361	kg/ha	Female farmers	Rice yield	0.062 (0.105)	Production function estimates indicate gender and quantity seeds insignificant but quantity fertilizer (access, use) significant in predicting yields after controlling for other inputs.	x
			Insecticide	0.84	0.95	l/ha					
			Seeds	134	215	kg/ha					

Nkedi-Kizza et al. (2002)	Uganda	18 farmers; 90 soil samples	Fertilizer	-	-	-	Female plot owners	Soil fertility indicators	NS (nr)	Chemical analysis of soil fertility indicators across male and female plots suggests that females are not allocated plots of inferior quality. Therefore, lower yields in female-owned plots are likely due to other socioeconomic factors (lack of access to fertilizer, extension, etc.) Actual differences in fertilizer use were not directly explored.	x
Oladele & Monkhei (2008)	Botswana	see note e below	Cattle (draft)	8,402	24,796	Number of holdings	Gender stratified: male farmers	Ownership	2.88 S (0.05)	Bivariate t-tests show across Botswana males own (access, use) significantly more draft animals than females do.	x
			Donkey (draft)	6,809	18,405				2.40 S (0.05)		
			Goat (nondraft)	11,177	23,514				2.16 S (0.05)		
Ouma et al. (2002)	Kenya (maize)	127 farmers	Improved seed varieties	-	-	-	Male farmers	Adoption	2.21 (1.06)*	Logit analysis finds gender has a significant association with adoption of improved seed, while OLS regression finds gender is insignificantly associated with fertilizer use.	
			Fertilizer					Use (kg/ha)	10.5 (39.9)		
Pender & Gebremedhin (2006)	Ethiopia	500 hhlds	Draft animal power (oxen)	-	-	-	Female heads	Input use	-0.207*** (nr)	In a study to inform sustainable land management practices, OLS regression finds female headed hhlds use significantly less draft animal power.	x
			Improved seed varieties	-	-	-			–0.002 (nr)		
			Fertilizer	-	-	-			–0.050 (nr)		
Sanginga et al. (2007)	Nigeria (soy beans)	203 hhlds	Improved seed varieties	-	-	-	Female farmers	Usage	–25.122* (nr)	Tobit model finds gender of farmer negatively associated with usage of improved seed. Qualitative evidence is also presented by gender on welfare and distributional effects.	
Shankar & Thirtle (2005)	South Africa (cotton)	91 small-holders	Improved seed varieties[f]	-	-	-	-	-	-0.19 (0.30)	Probit model of Bt. adoption finds no significant differences by gender.	x
SOAS et al. (2008)	Malawi	2,491 hhlds	Fertilizer subsidy coupon	-	-	-	-	Distribution of coupon by hhld head gender	-	Study of coupon distribution finds female-headed hhlds less likely to receive (access) fertilizer coupons of all types, and to receive fewer per household.	
Thapa (2009)	Nepal	2,360 hhlds	Inorganic fertilizer	1,428	2,119	Value in rupee	Female heads	Value of farm output	-0.018 (0.056)	Production function estimates give weak/little evidence for gender differences after controlling for other inputs (access).	

Tiruneh et al. (2001)	Ethiopia	180 hhlds	Inorganic fertilizer	4776	6456	Birr per ha	Gender stratified: female heads	Gross output value	-	Production function analysis suggests gender differences in output partly related to lower quantities of inputs used by females (fertilizer, extension and others).	
			Improved wheat technology	30	14	%	Not specified	Adoption	5.7 S (0.05)	Logit analysis shows a significantly higher proportion of male hhlds than female hhlds grew improved wheat varieties.	
Uttaro (2002)	Malawi	60 farmers	Inorganic fertilizer	62 spouses; 45 heads	67	%	Female farmers	Adoption	-	Study finds as a group, married women are more likely to have access to some fertilizer than are female-headed hhlds.	x
			Maize hybrid	39 spouses; 43 heads	69	%		Use of hybrid maize	-	Decision tree modeling finds women (both hhld heads and spouses) more constrained in access to fertilizer and seeds (partly due to price) than men. All three groups show little difference in preferences and beliefs regarding input use.	
van de Fliert et al. (2001)	Indonesia (sweet potato)	123 farmers	Fertilizer	-	-	-	Female participants	Profitability	NS (nr)	Study compares knowledge, skills, practices, input and output usage, and profitability of participants to nonparticipants of integrated crop management farmer field schools. Estimation of sweet potato profit function finds female indicator is not significant (and therefore is excluded from table results).	
World Bank and Government of Malawi (2007)	Malawi	11,280 hhlds[g]	Fertilizer	-	-	-	Female farmers	Decisions about input use & planting	-	Poverty vulnerability analysis finds women on average make half of the decisions on crops not requiring fertilizer, while only 10% of the time with crops requiring fertilizer.	

Note : Articles listed in alphabetical order of first author's last name; *Effect size* refers to gender indicator coefficients with standard errors in parenthesis unless otherwise noted; S = significant, NS = not significant, nr = not reported; * indicates significant at 10%; ** significant at 5%; *** significant at 1%. Outcome measures of *adoption* refer to rate of adoption of corresponding input type*; published* indicates the study is published in a peer reviewed journal.

[a] Analysis is stratified by village (Mupfurudzi village or other) and year (1994-95, 1995-96 and 1996-97), and sample sizes range from 136 to 200.

[b] Report discusses whether sex of hhld head affects adoption but does not report corresponding variable in statistical tables or explanations; it was not possible to ascertain whether *gender* indicated male or female.

[c] Modern varieties are improved open-pollinating varieties and hybrids developed by a formal breeding program.

[d] Stabling is a technological package consisting of a stable, a food supplement, an animal health care program, and an improved method of producing manure. A major benefit of stabling is increased milk production.

[e] Data used in this study comes from the 2007 Agricultural Census; livestock ownership across six regions was compiled. Though exact sample size was not provided, it is assumed to be significant.

[f] The *Bacillus thuringiensis* (Bt) gene in Bt varieties of cotton produces a natural insecticide.

[g] Sample sizes are not reported in World Bank and Government of Malawi (2007), however the referenced IHS2 survey Extract of Findings provides this information.

Table 2. Gender differences in access to natural resources: Water and soil fertility

Authors (year)	Country (crop)	Sample size	Use of/access to input: Input type	Women	Men	Unit	Gender indicator	Outcome measure	Effect size	Comments	Pub- lshed
Adesina et al. (2000)	Cameroon	255 farmers	Alley farming[a]	-	-	-	Male plot owners	Adoption	1.08 (0.61)**	Using logit regression and controlling for other inputs, men more likely to adopt alley farming, perhaps due to lack of land and tree rights.	x
de Brauw et al. (2008)	China	1,131 hhlds	Irrigated land	66.4	65.2	%	Female managers	Plot revenue	0.0019 (0.041)	OLS regression controlling for village-level fixed effects, authors find no evidence of female differences in productivity (results unchanged with use of female heads or female share of hours worked).	x
Enete et al. (2001)	Nigeria (cassava)	62 hhlds	Manure	19	71	%	Female owners	Cassava yields	-	Female-owned plots have significantly higher mean cassava yields; however, no multivariate analysis presented to attribute to inputs.	x
Goldman & Heldenbrand (2001)	Uganda	80 plots	Fallow period	15[b]	37.5	%	Female plot owners	Change in per capita output	-	Comparison of mean differences in production indicate women (especially single women) are disadvantaged and have lower outputs as compared to men.	x
			Manure	70[b]	62.5	%			-		
Hope, Dixon, & von Maltitz (2003)	South Africa	539 hhlds	Private piped water	21.8[b]	31.8	%	Female heads	# garden crops grown	S (nr)	Using bivariate analysis, the relationship between access to water and number of garden crops is significant at the 1% level.	
Horrell & Krishnan (2007)	Zimbabwe (primarily maize)	300 hhlds	Manure	1014 (de jure); 1094 (de facto)	1380	kg/ha	Female heads	-	NS (various)	Tobit models predicting logged values of kg/ha of manure inputs among maize and all crops show headship variables are insignificant.	x
				42 (de jure); 67 (de facto)	57	%		-			
Jagger & Pender (2006)	Uganda	451 hhlds	Animal manure	-	-	-	Female heads	Adoption of land management practice	0.106 (nr)	Study was conducted to evaluate the impacts of programs and organizations on technology adoption. In a two-stage probit analysis, although headship indicator insignificant (as well as control variable of number female hhld members), control of number of males is associated (1 % level) with adoption of crop residues and manure.	
			Crop residues	-	-	-			-0.024 (nr)		
			Mulching	-	-	-			-0.073 (nr)		

Kazianga & Masters (2002)	Burkina Faso	258 farmers	Field bunds[c] Micro-catchments	- -	- -	% %	Female farmers	Adoption & intensity	-0.093** (0.054) -0.256*** (0.061)	Approximately 16 % of cropland farmed by women. Analysis uses multivariate tobit regression; however, results are sensitive to choice of model.	x
Kinkingninhoun-Mêdagbé et al. (2008)	Benin (rice)	45 farmers	Distance to main irrigation channel	2.55	2.7	meters	Female farmers	Rice yield	0.062 (0.105)	Production function estimates indicate gender insignificant but irrigation level significant in predicting yields after controlling for other inputs.	x
Pender & Gebremedhin (2006)	Ethiopia	500 hhlds	Manure and composting Burning to prepare fields	- -	- -	- -	Female heads	Input use	-0.087*** (nr) 0.025 (nr)	Study conducted to inform sustainable land management practices and uses probit regression. Female-headed hhlds make up 21.8 percent of the sample and average use of manure/composting is 22.8 percent and of burning is 11.0 percent in total.	x
Phiri et al. (2004)	Zambia	218 hhlds	Improved tree fallows[d]	36	23	%	Female heads	Adoption	NS (nr)	Using log-linear models controlling for wealth, no significant differences in mean rates of adoption by gender were found.	x
Somda et al. (2002)	Burkina Faso	116 hhlds	Composting	40[b]	65	%	Female farmers	Adoption	-0.504 (0.83)	Logit models show women farmers equally likely to adopt composting when controlling for other inputs. However when stratifying by region (two regions), gender is significant in both, one positive and one negative, suggesting regional cultural or crop differences.	x
Swinkels et al. (2002)	Kenya	45 hhlds	Alley farming[e]	28	72	%	Female heads	-	-	All hhlds participated in trial, low mean acceptance rates among women attributed in part to reluctance to trim hedges due to physical strength and the view of hedges as men's crops.	x

Note: Articles listed in alphabetical order of first author's last name; *Effect size* refers to gender indicator coefficients with standard errors in parenthesis unless otherwise noted; S = significant, NS = not significant, nr = not reported; * indicates significant at 10%; ** significant at 5%; *** significant at 1%. Outcome measures of *adoption* refer to rate of adoption of corresponding input type; *published* indicates the study is published in a peer reviewed journal.

[a] Alley farming (or hedgerow cropping) involves planting of food crops between hedgerows of nitrogen-fixing leguminous hedgerow species, which have deep roots for nutrient capture and recycling. The technique requires the occasional trimming of hedgerows for application as mulch.

[b] Mean differences are not presented in article but were calculated by authors from disaggregated statistics.

[c] Field bunds (barriers to soil and water runoff) and microcatchments (small holes in which seeds and fertilizers are placed) are conservation techniques.

[d] Two-year tree fallows, mainly *Sesbana sesban* (requiring nursery) and *Tephrosia vogelii* (directly seeded).

[e] Types included *L. Leucocephala*, *Leucaena diversifolia*, *Calliandra calothyrus* or *Gliricidia sepium* planted from inoculated seedlings.

Table 3. Gender differences in access to human resources: Labor, extension services, and life-cycle

Authors (year)	Country (crop)	Sample size	Use of/access to input: Input type	Women	Men	Unit	Gender indicator	Outcome measure	Effect size	Comments	Pub-lshed
Babatunde et al. (2008)	Nigeria	60 hhlds	Labor	2,077	3,060	hours	Female heads	-	-	Using bivariate analysis, male-headed hhlds have significantly more hours of labor inputs than female-headed hhlds, however there were no mean differences in farm output by gender.	x
Davis et al. (2009)	Kenya	300 farmers	Farmer field schools (FFS, individual membership)	66.3	33.7	%	Female heads	Participation in FFS	-0.143 (nr)	Participation in FFS equally available to female community members in Kenya and Tanzania. In Uganda, female-headed hhlds are less likely to participate. Main reasons given for nonparticipation were lack of time, information, and distance. In addition, results suggest FFS have a higher impact in terms of productivity, crop, and livestock income for female-headed than for male-headed hhlds.	
	Tanzania	284 farmers		31.3	68.7	%			0.25 (nr)		
	Uganda	267 farmers		50.2	49.8	%			-3.470*** (nr)		
de Brauw et al. (2008)	China	1,131 hhlds	Labor	1,081	942	annual hours worked	Female hhld members	-	-	Using the last-round (2000) statistics, women are shown to work on average more hours than men, however this ratio or their role in management is not changing significantly over time. In addition, there are no productivity differences found between female-headed or -managed farms and those run by males.	x
Doss & Morris (2001)	Ghana (maize)	420 farmers	Extension services	50.43[a]	43.5	% with ≥ one contact	Female farmers	-	-	Authors use two-stage probit models to predict technology use, and use number of extension services as a control variable, which is a consistent positive predictor of use (note the different construction of extension as compared to mean statistics calculated here).	x
Enete et al. (2001)	Nigeria (cassava)	62 hhlds	Hired labor	76	57	%	Female owners	Cassava yields	-	Female-owned plots have significantly higher mean cassava yields; however, no multivariate analysis presented to attribute to labor inputs.	x
Fletschner (2008)	Paraguay	210 hhlds[b]	Labor	-	-	-	Additional male adults	Technical efficiency[c]	0.068*** (nr)	Individual level OLS (among spouses) finds hhlds with more male labor exhibit higher technical efficiency, whereas additional female labor is not associated with increased technical efficiency.	x
				-	-	-	Additional female adults		0.01 (nr)		
Gilbert, Sakala, & Benson (2002)	Malawi (maize)	1,385 farms	Extension services	19	81	%	Female farmers	-	-	Mean values show female farmers are disproportionately low percentage of those contacted by extension agents to conduct intercropping trail.	x

Horrell & Krishnan (2007)	Zimbabwe (primarily maize)	300 hhlds	Labor (economically active members of household)	3.97 (de jure); 3.12 (de facto)	4.14	people	Female heads	-	S** (nr)	Bivariate t-tests show significant differences between male and de facto female-headed hhlds only. These results are consistent with multivariate OLS results predicting log of household labor availability both for maize and all other crops.	x
Katungi, Edmeades, & Smale (2008)	Uganda (banana)	352 hhlds	Extension services	4.11	7.78	% with contact	Male heads	Information exchange	0.079 (0.029)**	Multinomial logit model suggests female-headed hhlds disadvantaged in formal/informal information exchange, and extension services contribute to informal exchange, controlling for other characteristics, and this effect is larger for women than for men.	x
Kinkingninhoun-Mêdagbé et al. (2008)	Benin (rice)	45 farmers	Labor	118	95	man days/ha	Female farmers	Rice yield	0.062 (0.105)	Production function estimates indicate gender and labor inputs are insignificant in predicting yields after controlling for other inputs.	x
Moore et al. (2001)	Senegal	694 husbands and wives	Knowledge nursery techniques Knowledge composting Knowledge forestry practices	1.15 0.25 2.28	1.12 0.71 2.87	1 to 3 know-ledge scale	Wives	-	-	Mean values show knowledge surrounding natural resource management is influenced by access to extension services in different ways for husbands and wives. Women are most responsive to female extension services, and men have more access to informal networks for information sharing.	x
Oladeebo & Fajuyigbe (2007)	Nigeria (rice)	100 farmers	Extension services Family labor Hired labor	5.18 6.25 21.33	6.28 9.01 13.30	# contacts man days man days	Female farmers	Stratified by gender: Productivity	0.176 (11.5) 0.006** (1.810) 0.0003* (3.384)	Regression coefficients reported from female farmer regressions. Productivity analysis finds female farmers have higher technical efficiency than male farmers.	x
Paolisso et al. (2002)	Nepal	264 hhlds	Time fruit and vegetables Time cereal and livestock Time under age 5 childcare	20.93 228.13 33.24	43.35 244.2 10.76	min/12 hour day	Male farmers	Cultivation and care activities	various	Evaluates effects of a vegetable and fruit cash crop program by gender and finds hhlds with a preschooler allocate more time to productive activities but decrease childcare, while hhlds with more than one do not face this tradeoff.	x
Pender & Gebremedhin (2006)	Ethiopia	500 hhlds	Labor	-	-	person days/ha	Female heads	Input use	-0.415*** (nr)	Study conducted to inform sustainable land management practices and uses OLS regression. Female headed hhlds made up 21.8 percent of the sample, and average person-days per ha was 86.4 in total.	x
Rola Jamias, & Quizon (2002)	Philippines	68 farmers	Farmer field schools (FFS)	57.35	42.65	%	Female farmers	FFS graduate	S** (nr)	Females higher proportion of FFS graduates using bivariate z-tests. Qualitative components of the study indicate women are more likely to attend FFS because they have more free time and more patience to sit through classes, not necessarily because they make farming decisions.	x

Thapa (2009)	Nepal	2360 hhlds	Own male labor (> 16 yrs) Own female labor (> 16 yrs) Hired labor	1,450 6,858 227	3,923 5,105 226	hours	Female heads	Value of farm output	-0.018 (0.056)	Production function estimates give weak/little evidence for gender differences after controlling for other inputs.	
World Bank (2007)	Malawi	11,280 hhlds	Extension services	7	13	%	Female heads	-	-	Summary of key gender differences show females are disadvantaged in access to extension, possibly due to smaller average farm size.	
	Ethiopia	1,753 hhlds	Extension services	20	27	%	Male farmers	Contact with agent in last year	0.158 (0.121)	Probit analysis suggests female-headed hhlds are not disadvantaged in access to services when controlling for other factors, specifically regional variation.	
World Bank & IFPRI (2010)	Ghana	861 hhlds	Extension services	0--2.1 (by zone)[d]	10.9--12.3 (by zone)	% with ≥ one contact	Male heads	Contact with agent	0.044 (0.030)	Probit analysis suggest that female hhlds are not disadvantaged in access to services while controlling for other factors; however coefficent on male head is larger than other control factors (none of which is significant with the exception of asset indexes in variations of main model).	x
	India	676 hhlds	Extension services	20	27	% with ≥ one contact	Female heads	Contact with agent in last year	1.099 (0.716)	Probit analysis suggests female-headed hhlds are not disadvantaged in access to services when controlling for other factors, specifically, assets.	

Note: Articles listed in alphabetical order of first author's last name; *Effect size* refers to gender indicator coefficients with standard errors in parenthesis unless otherwise noted.
S = significant, NS = not significant, nr = not reported; * indicates significant at 10%; ** significant at 5%; *** significant at 1%. Outcome measures of *adoption* refer to rate of adoption of corresponding input type; *published* indicates the study is published in a peer reviewed journal.

[a] Mean differences are not presented in article but were calculated by authors from disaggregated statistics.

[b] Within each household, both husbands and wives were interviewed.

[c] By definition a household is considered technically efficient if no other household (or combination of households) produces more output with a similar level of inputs (Paris 1991).

[d] Percentages are by zone: male-headed hhlds (11.7 in forest, 12.3 in transition and 10.9 in savannah); female-headed hhlds (0 in forest, 2.1 in transition and 0 in savannah).

Table 4. Gender differences in access to social and political capital

Authors (year)	Country (crop)	Sample size	Use of/access to input: Input type	Women	Men	Unit	Gender indicator	Outcome measure	Effect size	Comments	Pub-lshed
Agrawal & Chhatre (2006)	India (forest)	95 village forest management groups	Forest committees	-	-	-	Gender relations scale (1--3)	Forest condition scale (1--5)	0.235** (0.108)	Gender relations scale (measuring whether women hold positions of power in village organizations) is significantly associated with better forest condition using OLS regression. Qualitative evidence suggests women gain decision-making positions after local forests were viewed as deteriorating.	x
Agrawal et al. (2006)	India (forest)	673 heads of forest protection committees	Forrest committees	-	-	-	Female participamts	Control of illicit grazing	0.241 (4.35)***	Probit analysis finds women's participation has substantial positive effects on regulating illicit grazing and felling, even after controlling for the effects of a range of independent variables.	
				-	-	-		Control of illicit felling	0.275 (4.95)***		
Beard (2005)	Indonesia	10,098--11,000 women	Civil society organizations[a]	-	-	-	Female respondents	Knowledge	1.676 (0.179)***	Logistic regression model finds married women are significantly more likely then nonmarried women to know about and participate in civil society organizations.	x
								Participation	2.884 (0.205)***		
Davis & Negash (2007)	Kenya	88 farmers	Dairy goat organization	52	48	%	Stratified by gender: female farmers	Participation	0.18 (0.67)	Descriptive analysis finds gender has a significant impact on type of group farmers participate in. Males dominate agricultural-oriented groups, while females dominate women/clan/village groups.	
			Water group	9	33				8.09 (0.00)***		
			Farm group	2	12				3.24 (0.07)**		
Fletschner & Carter (2008)	Paraguay	213 couples	Social network	-	-	-	Female respondents	Probability woman will demand capital	0.621 (nr)***	Probit analysis finds woman's demand for entrepreneurial capital is positively and significantly affected by the behavior of her reference group (social network). Women are more likely to demand entrepreneurial capital the larger the proportion of cooperative members in their reference group demand capital.	x
Godquin & Quisumbing (2008)	Philippines	304 hhlds	Group membership (general)	63.2	58.7	%	Female respondents	Participation	0.144 (0.97)	Simple model of participation in a group finds that gender does not impact group participation; however, there are gender differences in the types of groups to which men and women belong, and significantly more men are members of production-oriented groups.	x
			Production groups	14.5	22.4	%			-4.20 (-2.31)*		

Jagger & Pender (2006)	Uganda	451 hhlds	Agriculture & environmental organizations	-	-	-	Female heads	Involvement in organization	0.128 (nr)	Probit regression finds that female head is not significantly associated with participation in agricultural/environmental NGOs and CBOs.	
Kariuki & Place (2005)	Kenya	442 hhlds	Collective action via group membership [b]	(nr)	(nr)	-	-	-	-	Descriptive analysis suggests that men and women participate in similar groups but the motivation for joining groups and extent of participation are not the same. Women (subsistence farmers) join for social insurance and building assets; men join for commercialization and marketing.	
Katungi, Edmeades, & Smale (2008)	Uganda (bananas)	351 heads	Agricultural information	-	-	-	Male heads	Informal exchange of information	0.079 (0.029)***	Multinomial logit model used to analyze multiple participation choices of information exchange. Findings demonstrate social capital is an important factor in information exchange, with men generally having better access to social capital than women.	x
Leino (2007)	Kenya	168 respondents	Water user committees	-	-	-	Female committee members	Number of women on committees	1.060 (0.159)***	Study evaluated randomized intervention across 334 communities where 50% of water user groups were given training designed to increase female participation. Analysis using instrumental variable approach finds number of females on committees increased, which did not, however, translate to changes in water source maintenance outcomes.	
		805 respondents		-	-	-	Treatment group	Overall maintenance quality	0.023 (0.079)		
Perdana, Matakos, & Radin (2006)	Indonesia	7,200--10,000 hhlds	Government	-	-	-	Female heads	Assistance received	0.039 (0.135)	Probit regression used to explore whether hhld head gender impacted access to assistance from a variety of groups in wake of the 1998 economic crisis.	
			NGOs	-	-	-			0.126 (0.115)		
			Community	-	-	-			0.290** (0.130)		

	India	966 hhlds	Community based organizations[c]	-	-	-	Female heads	Number of institutions hhld belongs to	0.033 (0.086)	OLS regression shows gender of head insignificant in determining number of institutional memberships per hhld; however, women participate mainly in self-help groups/women's groups, while men participate in forest groups, cooperative societies, caste associations.	
World Bank & IFPRI (2010)	Ghana	1,168 heads	Farmer-based organizations	-	-	-	Male heads	Membership	0.079 (0.029)**	Probit regression shows that male heads are significantly more likely to belong to/participate in groups than are female heads (controlling for ecological zone, literacy of head, and hhld wealth proxy).	x
	Ethiopia	1,761 heads & spouses	Agricultural cooperatives	4	24	%	Male heads	Involvement	S*** (nr)	Descriptive and bivariate analysis shows a significantly higher proportion of male than female respondents participate in agricultural cooperatives.	

Note: Articles listed in alphabetical order of first author's last name; *Effect size* refers to gender indicator coefficients with standard errors in parenthesis unless otherwise noted; S = significant, NS = not significant, nr = not reported; * indicates significant at 10%; ** significant at 5%; *** significant at 1%. Outcome measures of *adoption* refer to rate of adoption of corresponding input type; *published* indicates the study is published in a peer reviewed journal.

[a] Civil society organizations are defined as those that deliver public goods and services to territory-based communities. Men usually participate in civil society organizations related to community-level governance, physical infrastructure, environmental improvements, and neighborhood security, whereas women participate in organizations focusing on family welfare, economics ,and health. As a result the survey asked men and women about participation in different organizations.

[b] Self-help groups (building hhld assets, social/economic support), water groups, dairy goat groups, and coffee groups were the four most common types of groups. Descriptive statistics reported in graphic form, but numbers were unassigned.

[c] Including agricultural CBOs.

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