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Economic Benefits of Empowering Women in Agriculture: Assumptions and Evidence

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Contents

Executive Summary

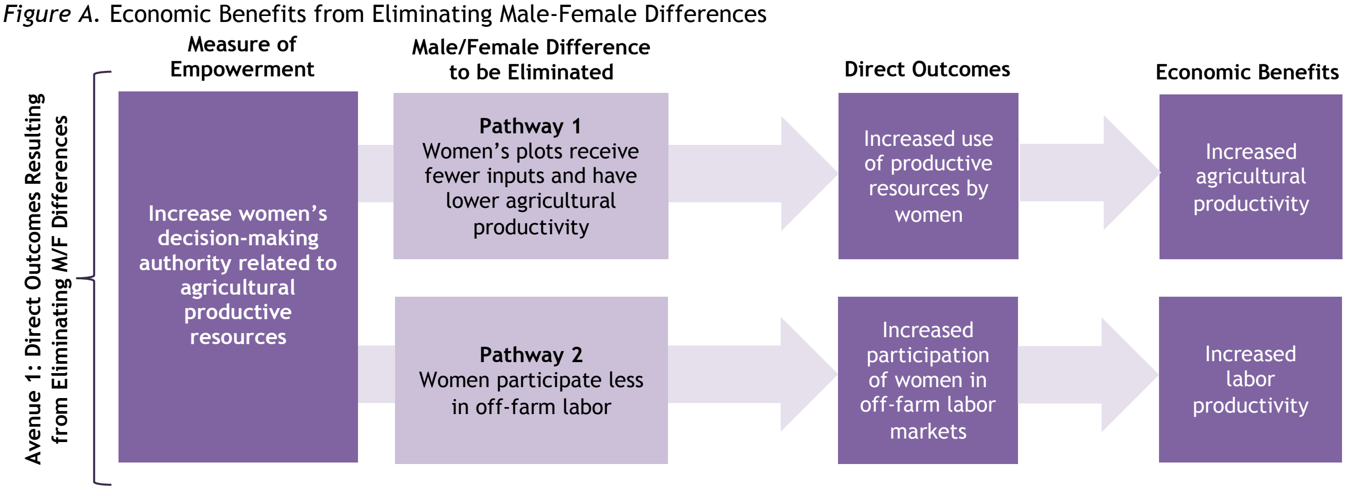
A growing body of evidence suggests that empowering women may lead to economic benefits (The World Bank, 2011; Duflo, 2012; Kabeer & Natali, 2013). The 2016 Africa Human Development Report finds that gender inequality costs Sub-Saharan Africa approximately $95 billion per year, and a 2015 study from the McKinsey Global Institute estimates that $12-$28 trillion could be added to the global economy if women achieved parity with men in economic outcomes. Little work, however, focuses specifically on the potential impacts of women's empowerment in agricultural settings. Through a comprehensive review of literature this report considers how prioritizing women's empowerment in agriculture might lead to economic benefits. With an intentionally narrow focus on economic empowerment, we draw on the Women's Empowerment in Agriculture Index (WEAI)'s indicators of women's empowerment in agriculture to consider the potential economic rewards to increasing women's control over agricultural productive resources (including their own time and labor), over agricultural production decisions, and over agricultural income. While we recognize that there may be quantifiable benefits of improving women's empowerment in and of itself, we focus on potential longer-term economic benefits of improvements in these empowerment measures.

Were resources unlimited, contending that investing in female farmers could have economic benefits is a low risk proposition. Instead, we consider the case for spending the marginal dollar on empowering female farmers as a means of increasing household productivity, either prioritizing women for new investments or re-allocating existing resources. The literature suggests at least two distinct avenues via which economic benefits from investing in women's empowerment in agriculture might arise. The first is by equalizing access to productive resources (including access to and control over land, labor, and other inputs) between men and women, and the second by leveraging differences between men and women that might lead to improved household outcomes:

1. *Equalizing access* assumes that men and women have similar potential productivity but differ in access to and control over resources – i.e., given the same access to and control over agricultural inputs and technologies, on average male and female farmers would be equally productive. Under the common assumption that initial input applications have a higher return than subsequent applications (diminishing marginal returns), and that women start from lower levels, then marginal productivity gains from increasing women's use of inputs would be higher than investing in more of the same inputs for men.
2. *Leveraging differences* assumes that for a given set of household resources, men's and women's choices differ – i.e., on average, male and female choices surrounding crop management, input use, childcare and other investments differ, possibly due to differences in risk, time, and social preferences. Under the common assumption that men and women, on average, differentially prioritize resource expenditures, increasing a women's share of household decision-making authority would be expected to change household economic outcomes.

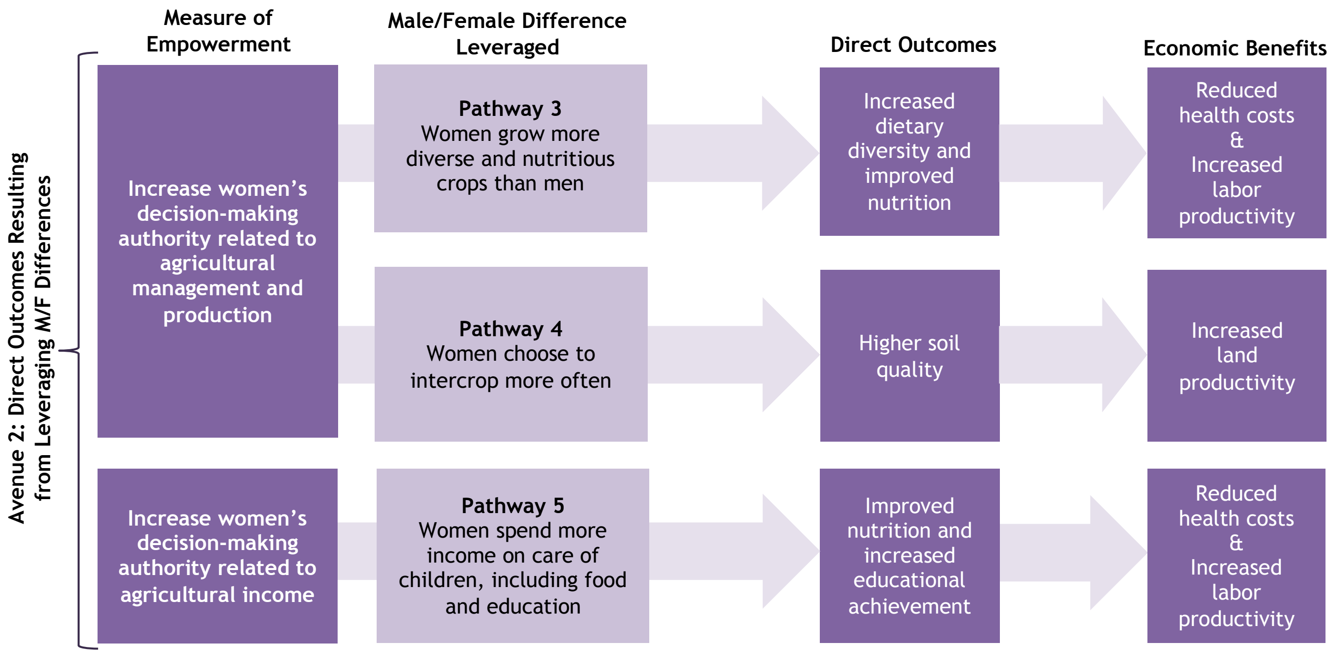
For the first avenue (Figure A), we consider two theorized pathways to economic benefits from women's empowerment in agriculture that posit reducing female farmers' constraints would allow them to be as productive as equivalent male farmers. Pathway 1 focuses on empowering women through increasing their access to and control over agricultural inputs, thereby increasing overall agricultural productivity by reducing gender productivity gaps. Pathway 2 focuses on women's control over their own time and labor, hypothesizing that removing constraints to women's mobility would increase overall household labor productivity.

Figure A. Economic Benefits from Eliminating Male-Female Differences



In the second avenue (Figure B), we consider three further theorized pathways from increasing women's decision-making power over agricultural decisions to economically beneficial individual and household outcomes, given assumed male-female differences in decision-making under similar circumstances. Pathway 3 connects differences in men's and women's decisions of what crops to grow with household nutrition outcomes. Pathway 4 hypothesizes that differences in plot management between men and women, specifically women's greater likelihood of intercropping, influence farm soil quality and long-term household agricultural productivity. Finally, Pathway 5 draws a connection between differences in how men and women spend income from agriculture to impacts on household nutrition and education outcomes. We note that any measured benefits from leveraging male-female differences in the resource choices they make may dissipate as women gain more access and control if the differences are not due to being a woman per se, but rather stem from being disempowered - since this would change the circumstances in which evidence of these differences in decision-making have been observed.

Figure B. Economic Benefits from Leveraging Male-Female Differences



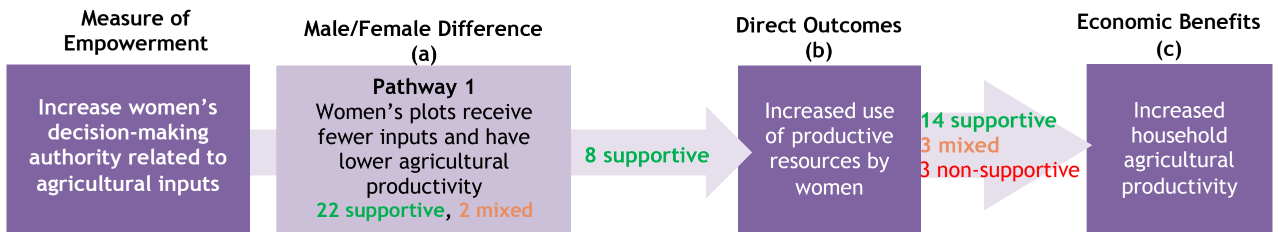
To investigate these two hypothesized avenues and five associated pathways for economic benefits of women's empowerment we conducted an extensive literature review of published work. A summary of findings for each pathway follows. Most pathways rest on assumptions about: (a) relative baseline conditions for men and women, (b) changes in adoption, use, or behavior arising from women's empowerment, and (c) the subsequent economic benefits. Findings are summarized with purple arrows, notated with the number of articles found supporting the pathway assumptions shaded in green. We do not distinguish across the quality of the peer-reviewed published literature, though each pathway includes evidence summary tables with information of study scale, sample size, data source, and methodology. A spreadsheet with detailed information coded for each of the studies reviewed is included as an attachment to this report. Brown-shaded text indicates that some conflicting or inconclusive evidence was also found (labeled "mixed"), and red-shaded text indicates evidence contradicting the assumptions in a pathway (labeled "non-supportive"). We found very limited evidence of estimates of economic benefits resulting from changes in women's empowerment along the theorized pathways, so in many cases we refer to more general supporting evidence for the economic benefits of particular outcomes, to illustrate the potential benefits of improving women's empowerment to achieve those outcomes.

Avenue 1: Eliminating Male-Female Differences

Pathway 1: Increased Women's Use of Productive Resources

The first pathway hypothesizes that an increase in women's relative decision-making power related to agricultural and productive resources (including both access to and control over agricultural inputs and technologies) would lead to a reallocation of household productive resources and an increase in their use by women, increasing household agricultural productivity. This pathway rests on the baseline, behavior, and economic impact assumptions that:

a. Women have lower access to and control over agricultural inputs, contributing to lower agricultural productivity for women,
b. Given greater access to and control over inputs, women's input use would increase, and
c. The marginal yield returns to increasing input use by women (as a result of equalizing access and control relative to men) are higher than for men, *ceteris paribus*, such that directing new resources to women and/or reallocating resources within the household would increase household productivity.



We find ample published evidence (20 studies) indicating that women in developing countries often have less access to inputs such as labor, farm equipment, draft animal power, fertilizer, land, extension services, and credit, in comparison with men, at either the plot, individual, or household level. We also find evidence (13 studies) of lower productivity for female-managed or –owned plots, female farmers, or female-headed households compared to their male counterparts. Five studies (Aguilar et al., 2015; Horrell & Krishnan, 2007; Kilic, Palacio-Lopez, & Goldstein, 2015; Palacios-Lopez, 2015; Tiruneh et al., 2001) show that this productivity differential between male and female farmers diminishes significantly once access to inputs is controlled for, and conclude that differences in use of inputs drive a portion of the gender productivity gap.

Eight studies report that empowering women by increasing their control over productive resources, generally through directly providing or lowering the costs of women obtaining them, increases women's use of inputs and technology (Beaman et al., 2013; Fisher & Kandiwa, 2014; Gilbert, Sakala, & Benson, 2002; Jagger & Pender, 2006; Karamba & Winters, 2015; Quisumbing et al., 2013; Santos et al., 2014; Van den Bold et al., 2013). A wealth of empirical studies suggest that increasing access to and use of productive resources leads to economic benefits from increased agricultural productivity generally (Chapoto et al., 2013; Elias et al., 2013; Emmanuel et al., 2016; Ghosh et al., 2016; Vitale et al., 2011; Wani et al., 2013).

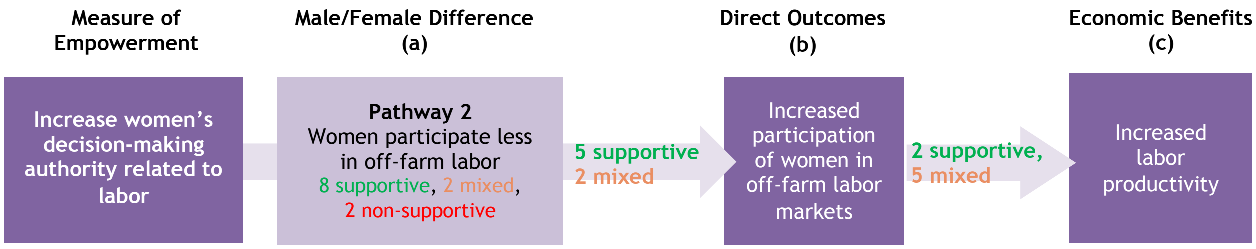
We identified 20 studies reporting on benefits specifically from increased women's productivity, but this evidence is not conclusive. Two studies find that an intervention to increase input use increased women's productivity more than men's (Davis et al., 2012; Vasilaky & Leonard, 2015), but one found no difference in productivity gains between women and men (Karamba & Winters, 2015). Six studies find that agricultural resources are inefficiently allocated at the household level (Aguilar et al., 2015; Andrews, Golan, & Lay, 2014; Chavas, Petrie, & Roth, 2005; Saito et al., 2014; Udry, 1996; Udry et al., 1995) and therefore argue that increasing women's control over agricultural resources will increase productivity, but do not demonstrate this empirically. Finally, while five studies find that women have equal or greater productivity than men when controlling for input use (Alene et al., 2008; Gilbert, Sakala, & Benson, 2002; Moock, 1976; Nwaru et al., 2011; Quisumbing, 1996) , six other studies find evidence that a gender productivity gap remains even after controlling for the gender gap in input access (Aguilar et al., 2015; Kilic et al., 2015; Kinkingninhoun-Mêdagbé et al., 2010; Oseni et al., 2015; Peterman et al., 2001; Slavchevska, 2015). These studies suggest that that even if women were given the same level of inputs as men, there would still be significant differences in productivity between men and women.

As a result, though empowering women by increasing their access to and control over agricultural productive resources may create economic benefits from increased productivity, these productivity gains may not be sufficient to close the gender productivity gap.

Pathway 2: Increased Women's Participation in Labor Markets

The second pathway hypothesizes that increasing women's decision-making authority over their own labor time and mobility would increase women's participation in markets, including off-farm labor markets, which would contribute to increased household labor productivity. While we recognize that not all women would choose to participate more in off-farm labor markets if given full control over their own time and labor, this pathway rests on the baseline, behavior, and economic impact assumptions that:

a. Women's labor choices and mobility are more constrained than men's, restricting access to off-farm income opportunities,
b. With more labor choices and mobility women would participate more in off-farm labor, and
c. There would be positive marginal returns to household labor productivity if women were more able to reallocate their labor, including expanding participation in off-farm labor markets.



We focus on off-farm labor rather than participation in, for example, farm product markets, but the causality in this pathway is not well tested. We find support in the literature for the assumption that women are less likely than men to participate in off-farm labor markets (Babatunde et al., 2010; Clay et al., 1997; Haggblade et al., 2010; Jost et al., 2016; Lanjouw, 2001; Lanjouw & Shariff, 2004; Matshe et al., 2004) and in non-farm enterprise activities (Rijkers et al., 2012), though participation rates are not attributed to women's decision-making authority related to their own time and labor. The evidence further indicates that where women do participate in non-farm employment it is generally in self-employment and activities with lower returns (Haggblade et al., 2010; Lanjouw, 2001). Three studies find that women in female-headed households are more likely to participate in off-farm work as compared male-headed households (Ackah, 2013; Beyene et al., 2008; Shehu & Abubakar, 2015), suggesting that different circumstances in female-headed households may be associated with increased women's participation in off-farm labor.

We find evidence from seven studies (Abdulai & Delgado, 1999; Beyene et al. 2008; Doss, 2013; Fafchamps & Quisumbing, 1999; Owusu et al.,2011; Qiao et al., 2015; Swaminathan, Du Bois, & Findeis, 2010) that women's education, access to credit, and income transfers—all of which increase women's relative capital and potentially their intra-household bargaining position and decision-making authority (Anderson, Reynolds, & Gugerty, 2017; Doss, 2013; Jejeebhoy et al., 2001)—are generally linked to an increased probability of women working in the non-farm sector. In Pakistan, education is associated with decreased female employment in farm and non-farm activities but better-educated women that do work are more likely to work in non-farm activities (Fafchamps & Quisumbing, 1999).

While a larger body of evidence reports on the circumstances in which higher returns are possible from non-farm compared to farm labor, we identified seven studies reporting on productivity effects of off-farm labor market participation for women in particular. most of the evidence from low- and middle-income countries suggests that while incomes are higher for non-farm employment compared to farm-employment, women earn lower wages than men (Lanjouw, 1999; Lanjouw & Shariff, 2004; Nerman, 2015; Owusu, Abdulai, & Abdul-Rahman, 2011; Yang, 1997) – potentially due to their concentration in less productive employment (Haggblade et al., 2010; Lanjouw, 2001) or to differences in education compared to men (Abdulai & Delgado, 1999; Qiao et al., 2015). As a result, it is not clear that interventions that increase women's control over their own time and labor by improving their education and access to credit, for example, will consistently lead to economic benefits from increased labor productivity for women.

Overall, the evidence suggests that participating in off-farm labor can increase labor productivity and economic benefits, hence to the extent that women would choose to participate more given the authority to do so, we would expect their own labor productivity to rise, conditional on context and the availability of off-farm labor opportunities.[1] It is more difficult, however, to understand how overall household labor productivity would change without knowing whether a woman's non-farm labor hours were in addition to, or instead of, previous farm,

[1] That said, although women's lower rates of participation in off-farm labor markets are assumed to be at least in part attributable to their lack of decision-making authority over their own labor and mobility, we did not search for evidence linking this to limited mobility.

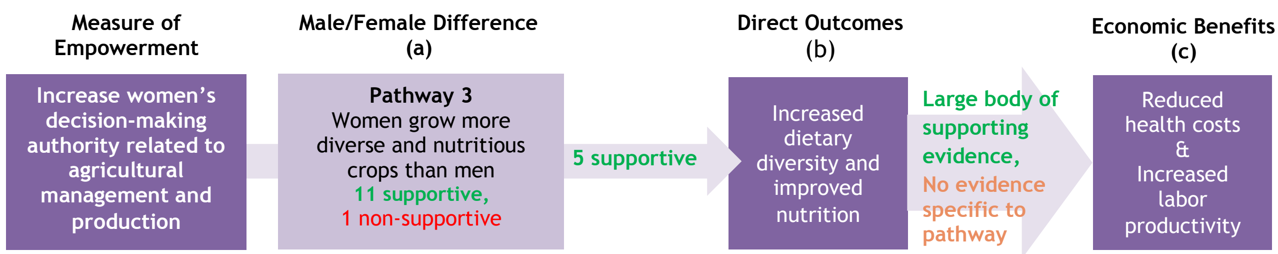
domestic, or leisure hours, and how household labor is re-allocated (e.g., to a spouse, other household adults, children, or market labor) in response to a women's non-farm work.

Avenue 2: Leveraging Male-Female Differences

Pathway 3: Improved Household Nutrition

The third pathway hypothesizes that increasing women's relative decision-making authority related to agricultural management and production will affect decisions of what crops to plant, increasing household dietary diversity and improving nutritional outcomes, thereby leading to reduced health costs and increased labor productivity. This pathway rests on the baseline, outcome, and economic impact assumptions that:

a. Women have less control over agricultural management and production decisions than men, favoring men's crop planting choices which on average are less diverse and nutritious,
b. Planting a greater diversity of crops and more nutritious crops improves nutrition, and
c. The marginal returns to household nutrition for subsistence households for crop planting decisions made by women (e.g., more nutrient-dense vegetables and legumes) would be higher than for crop planting decisions made by men, *ceteris paribus*.



We found a large body of evidence indicating that women plant a greater variety of crops than men at the individual level and as both heads of households and plot managers (e.g., Akhter et al., 2010; Benin, Smale, & Pender, 2006; Dillon, McGee, & Oseni, 2015; Peterman et al., 2011). The literature generally supports the assumption that women grow more vegetable and legume crops on average than men do (Mabhaudi et al., 2016; Peterman et al., 2011). Across a range of contexts women are the primary managers of home gardens, important sources of household food, including more nutritious vegetables and legumes (Akhter et al., 2010; Amri & Kimaro, 2010; Chambers et al., 2007; Ibnouf, 2009; Schadegan et al., 2013), but four studies report that households with female heads also grow more diverse (Benin, Smale, & Pender, 2006; Dillon, Mcgee, & Oseni, 2015; Saenz & Thompson, 2017) and nutritious (Peterman et al., 2011) crops than male-headed households, suggesting that differences in planting decisions are not solely based on allocation of certain crops to women.

The link between household crop diversity and positive nutritional outcomes in multiple contexts is relatively well-established in the literature (e.g., Ekesa, Walingo, & Abukutsa-Onyango, 2008; Jones et al., 2014; Kumar, Harris, & Rawat, 2015), though it may not hold for all contexts (Rajendran et al., 2014; Sibhatu, Krishna, & Qaim, 2015). Two studies suggests that the link between crop diversity and nutrition is stronger for female-headed households than male-headed households (Dillon, Mcgee, & Oseni, 2015; Jones et al., 2014), and two others report an important role of women in leveraging crop diversity for improved household nutrition (Oliver, 2016; Shively & Sununtnasuk, 2015). Pandey et al. (2016) find that women's empowerment interventions aimed at agricultural diversification to nutrient-rich crops can improve household nutritional outcomes.

Improved nutrition has further been associated with economic benefits, including reduced health costs (COHA Report, 2013; Darnton-Hill et al., 2005; Pelletier et al., 1995) and higher short-run and lifetime labor productivity (Aguayo et al., 2003; Behrman, 1993; COHA Report, 2013; Croppenstedt & Muller 2000; Deolalikar, 1988; Haddad & Bouis, 1991; The World Bank, 2006). We did not, however, identify any studies reporting on the longer-term economic benefits of women's decisions to plant more diverse and nutritious crops.

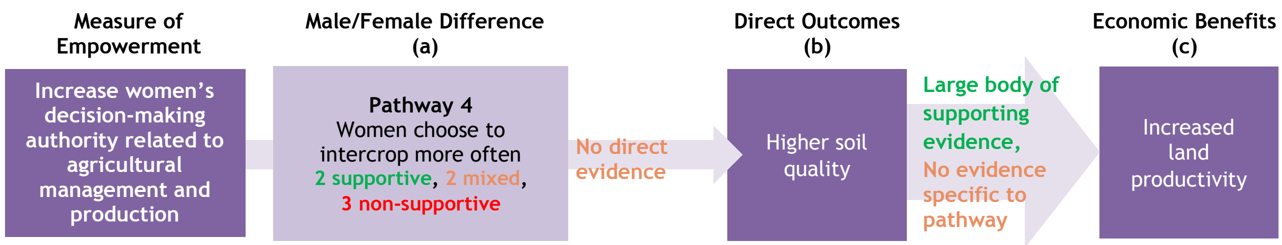
To the extent that vegetable and legume crops or home-garden crops contribute to household nutrition outcomes and that women choose to plant more of these crops than men, the evidence that increasing women's decision-making authority related to agricultural management and production might lead to economic benefits. It is not clear, however, that the difference between men's and women's crop planting decisions would hold if women were given more authority over household plots, as male/female differences in crops planted may be due to specialization in crop cultivation at the household level, with traditionally "women's crops" allocated to female-managed plots

(Akhter et al., 2010; Mabhaudi et al., 2016; Peterman et al., 2011). Whether or not households are net buyers or sellers of products and have market access also likely matters.

Pathway 4: Improved Cropland Soil Quality

The fourth pathway hypothesizes that increasing women's decision-making authority over farm management would result in improved on-farm soil management practices including higher rates of intercropping, leading to improved soil quality, and ultimately higher land productivity. This pathway rests on the baseline, outcome, and economic impact assumptions that:

a. Women have less control over agricultural management and production decisions than men, favoring men's management choices which involve less intercropping,
b. Intercropping improves soil quality, and
c. The marginal returns to household land productivity from women's greater proclivity to intercrop would be higher than management decisions made by men, *ceteris paribus*.



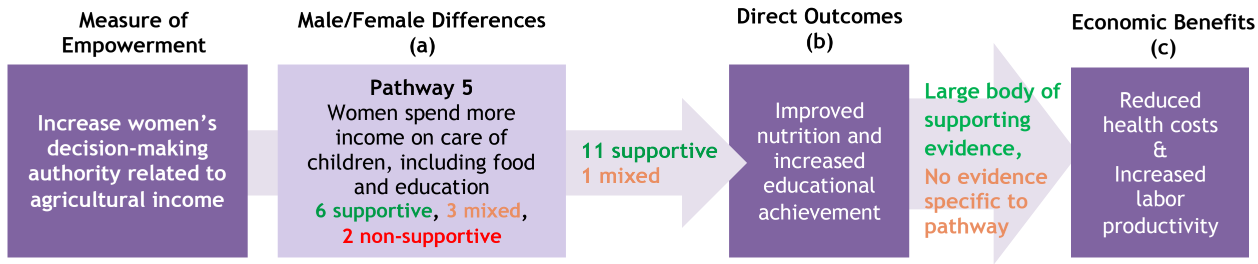
There is some evidence suggesting that women choose to intercrop more frequently than men, both as plot managers (EPAR, 2013; Mishra et al., 2009), as joint plot managers (EPAR 2013; Ndiritu, Kassie, & Shiferaw, 2014), and as heads of household (Khan et al., 2008), though another body of literature suggests this pattern does not necessarily hold across different contexts (Bezner-Kerr et al., 2007; Buyinza & Wambede, 2008; Chijikwa, 2013). The literature strongly supports the claim that intercropping can improve soil quality and can reduce soil erosion for a variety of intercropping systems (e.g., Blanchart et al., 2006; Dzung & Preston, 2007; Garland et al., 2016; Li et al., 2015; Odunze et al., 2008; Verma et al., 2014; Wu et al., 2016). While none of the evidence specifically reports on effects of women's intercropping on soil quality, there is no objective reason to believe the outcomes of intercropping would be different by gender.

Similarly, the link between soil quality and agricultural productivity is also relatively well-established in the field of soil sciences (e.g., Byiringiro & Reardon, 1996; Lal, 2009; Liu et al., 2015; Naylor, 1996), so for contexts in which women intercrop more than men, increasing women's control over agricultural management decisions might produce economic benefits. As a result, although the evidence on whether women choose to intercrop more often than men is mixed, for contexts in which women intercrop more than men the evidence suggests that increasing women's control over agricultural management decisions might produce positive economic benefits associated with greater agricultural productivity.

Pathway 5: Improved Nutrition and Educational Attainment

The final pathway hypothesizes that increasing women's control over agricultural income would change the allocation of household expenditures to improve household nutritional and educational outcomes. This pathway rests on the baseline, outcome, and economic impact assumptions that:

a. Women have less control over agricultural income than men, favoring men's spending choices, which on average involve less expenditure on food and education,
b. More spending on food and education (particularly for children) improves nutritional and educational outcomes, and
c. The marginal returns to household nutritional and educational outcomes for spending decisions made by women would be greater than for spending decisions made by men, ceteris paribus.



We find six studies conducted in low- and middle-income countries suggesting that women or female-headed households spend a greater proportion of household income than men on a variety of household goods, in particular food and education (Donkoh & Amikuzuno, 2011; Duflo & Udry, 2004; Handa, 1996; Hoddinott & Haddad, 1995; Quisumbing & de la Briere, 2000; Seebens, 2009). Five studies find that increasing women's income or assets or share of household income or assets is associated with increased household food or education expenditure (Doss, 2006; Duflo & Udry, 2004; Hoddinott & Haddad, 1995; Quisumbing & de la Briere, 2000; Quisumbing & Maluccio, 2003). However, five studies suggest that the differences in household expenditure patterns may not hold in all contexts, as they find no significant association between women's control of income and household food or education for lower-income households (Yabut-Bernardino, 2011) or urban households (Doss, 2006), in certain countries (Quisumbing & Maluccio, 2003), or when controlling for household income (Kenayathulla, 2016; Kennedy & Peters, 1992).

A large body of evidence connects household spending on food and education with improved nutrition and education outcomes for children. Four studies report a particular association between increased household food and education expenditure by women and improved outcomes for children (Davis et al., 2002; Johnson & Rogers, 1993; Maertens & Verhofstadt, 2013; Thomas, 1990), and Duflo (2000) find a particular association between income for maternal grandmothers and girls' nutrition. We find further evidence that women's greater control over household resources, in particular income, is associated with improved child nutrition and education outcomes (Amugsi et al., 2016; Bhagowalia et al., 2012; Duflo, 2000; Kennedy & Peters, 1992; Malapit et al., 2015; Rajendran et al., 2014; Smith et al., 2003; Sraboni et al., 2014; Yoong, Rabinovich, & Diepeveen, 2012), though these do not specify that this is accomplished through increased household spending on food and education.

A wealth of evidence demonstrates either significant increases in labor productivity (Aguayo et al., 2003; Deolalikar, 1988; Haddad & Bouis, 1991; Hoddinott et al., 2008; Lockheed, Jamison, & Lau, 1980; Phillips, 1994; Psacharopoulos & Patrinos, 2002; Van Den Boom, 1996; The World Bank, 2006; Weinberger, 2003) or reduced health costs (African Union Commission et al., 2014; Darnton-Hill et al., 2005; De Walque, 2004; The World Bank, 2006) from improved nutrition and additional years of schooling in a variety of contexts. For example, a study of households engaged in rural labor in India finds that wages are 5-17% lower on average due to micronutrient deficiency (Weinberger, 2003). A 2014 report by the African Union Commission and others finds that treatment of undernutrition is a recurring expense for health systems in low-income countries, costing between 1-11% of countries' total public health budgets (African Union Commission et al., 2014). A meta-analysis by Appleton, Hoddinott, & Knight (1996), incorporating studies from both high- and low-income countries, estimates a 10.5% increase in production for four years of schooling. An analysis of the International Income Distribution Database that includes nationally representative samples across 131 countries from 1970-2011 finds a 10.4% average rate of private return to another year of schooling, with average returns highest in Sub-Saharan Africa at 12.8% (Montenegro and Patrinos, 2013).

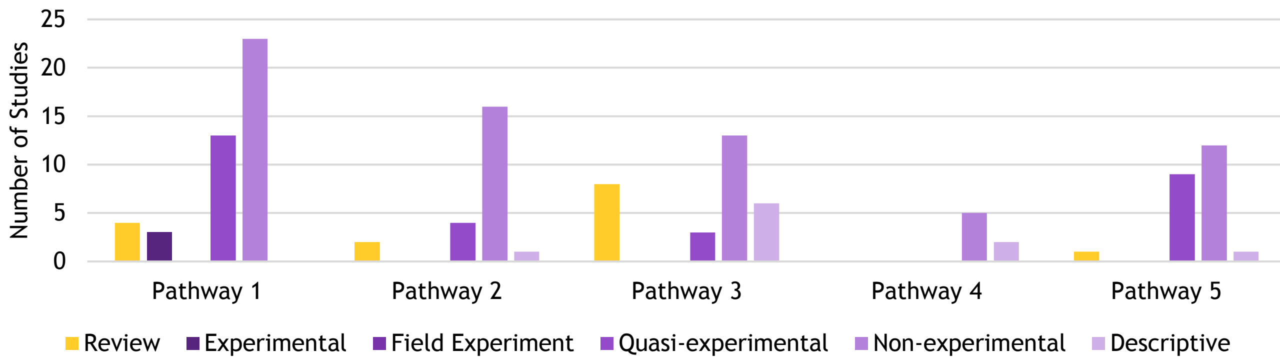
While we did not find any evidence specifically testing the longer-term benefits of women's control over household income or spending, this body of evidence suggests significant potential economic benefits of increasing women's control over agricultural income, in contexts where women are more likely than men to spend income on household food and education.

Returns to Women's Empowerment in Agriculture: Estimates and Data Limitations

This review of the literature ultimately shows some - but not conclusive - support for portions of all five theorized causal pathways between women's economic empowerment in agriculture and economic returns. The literature also provides some dissenting evidence surrounding women's constraints and preferences, most notably highlighting that results surrounding returns to empowerment can be context specific. We also note some inconsistencies in published methods and findings, and several key data gaps.

1. Published estimates of economic returns to empowering women in agriculture are still relatively rare, are mostly non-experimental, and are often limited in terms of data quality. Ultimately, due to the heterogeneity of study types, interventions, and indicators it is difficult to provide empirical evidence in support of all links within a specified causal pathway (Figure C). Direct evidence for some of these pathways – from women's empowerment to economic benefits - is limited, though we find supporting evidence when separately considering a) the associations between male/female differences and direct outcomes and b) the associations between those direct outcomes and long-term benefits without considering a gender element.

Figure C. Methods Applied in Published Evidence across All Pathways



2. Published estimates provide some indication that, in many contexts, economic returns to women's empowerment might be substantial – however differences in measurement and reporting impede readily comparing benefits across contexts. Several of the studies we reviewed include estimates of the potential returns to outcomes relating to the theorized pathways from women's empowerment. In most cases, however, studies do not calculate benefits of women's empowerment specifically, but rather provide a range of estimates of economic benefits from the outcomes in the pathways we evaluated. This is particularly true for pathways 3, 4, and 5 which consider the benefits of leveraging differences in decisions between men and women. Selected estimates of more general benefits drawn from the existing literature, summarized in Table I, suggest that investments in women's empowerment in agriculture through the five pathways we have described could be significant in contexts where the assumed male/female differences hold, though it is not clear how these differences might be affected if women were given greater control over agricultural productive resources, management, and income.

   For example, several studies estimate the benefits of increasing women's use of productive resource to close the agricultural productivity gap between men and women (Pathway 1). Published aggregate estimates of the gender gap in agricultural productivity point to potential gross gains of $100 million in Malawi, $105 million in Tanzania, and $67 million in Uganda per year (UN Women, 2015), while estimates from Burkina Faso and Uganda suggest aggregate household output could be increased by 10-19% by reallocating factors of production (including labor) used between plots controlled by men and women in the same household (Andrews, Golan, & Lay 2014; Udry et al., 1995). Others have suggested closing the gender gap in agricultural productivity could lead to a 0.72 percent reduction in the incidence of undernourishment, with an additional 80,000 people being sufficiently nourished every year in Tanzania (UN Women, 2015).

   A broad base of evidence reports on benefits from improved nutrition through improved labor productivity and reduced health costs. A 2014 report by the African Union Commission and others finds that treatment of undernutrition is a recurring expense for health systems in low-income countries, costing between 1-11% of countries' total public health budgets (African Union Commission et al., 2014). These increased health costs can also translate into reduced economic growth, with a World Bank (2006) estimate suggesting economic loss to malnutrition could amount to 2-3% of gross domestic product and individual productivity losses due to malnutrition globally are estimated at more than 10% of lifetime earnings. Hoddinott et al., (2008) report that Guatemalan young adults who had been enrolled in a village-based nutrition intervention benefitted from a 46% increase in average wages. To the extent that women's decisions to plant more diverse and nutritious crops and to allocate more household income to food, empowering women in agriculture could therefore have significant benefits through improved nutrition.

Table I. Selected estimates from the existing literature of economic benefits of pathway outcomes, indicating potential returns to women's empowerment in agriculture.					
Pathway	Source	Geographic Area, Scale	Methodology	Independent Variable	Valuation Estimate
1. Increased Women's Use of Productive Resources: Provide new agricultural resources to women or reallocate household resources to eliminate the yield gap between men and women	UN Women. (2015). *The Cost of the Gender Gap in Agricultural Productivity in Malawi, Tanzania, and Uganda.*	Malawi, Tanzania, Uganda - National	**Non-experimental:** Cost-benefit analysis	Agricultural productivity (measured as gross value of output per unit of land)	Estimates of the gender gap in agricultural productivity point to potential gross gains of $100 million in Malawi, $105 million in Tanzania, and $67 million in Uganda per year.
	Andrews et al. (2014). Inefficiency of Male and Female Labor Supply in Agricultural Households: Evidence from Uganda.	Uganda - National	**Quasi-experimental:** Regression analysis (OLS, household and parcel fixed effects) at plot level; demographic, socioeconomic, urban/rural controls included	Gender of plot manager	Total household output could be increased by 19% by reallocating male labor to female controlled plots
	Udry et al. (1995). Gender differentials in farm productivity: implications for household efficiency and agricultural policy.	Burkina Faso - Regional (6 villages in 3 agroclimatic zones)	**Quasi-experimental**: Regression analysis (OLS, fixed effect Tobit estimates, Cobb-Douglas) at household level; fixed effects are household-year-crop and household-year; labor, inputs, plot size, topography, and soil type controls included	Gender of plot manager	A loss of 10-15% of household output is due to inefficient factor allocation within a household, and the authors argue that a higher household output could be achieved through the reallocation of variable factors from plots controlled by men to plots controlled by women
2. Increased Women's Participation in Labor Markets: Eliminate the mobility gap between men and women to increase women's labor productivity	Doss, Bockius-Suwyn, & D'Souza (2012). Women's economic empowerment in agriculture: Supporting women farmers.	India - Regional (Uttar Pradesh)	**Review**: Review of 34 projects targeting target small-scale farmers or agricultural processors identified by experts in the field with knowledge of field-based interventions targeting rural women agriculturalists	Income-generating interventions for women	Participating in the Sunhara Wal-Mart Project which included interventions such as starting financial practices within groups and linking groups with large buyers, quadrupled beneficiary women's income to $4/day.

3. Improved Household Nutrition: Leverage women's preference for nutritious crops to improve household labor productivity and reduce health expenditures	African Union Commission et al. (2014). The Cost of Hunger in Africa: Social and Economic Impact of Child Undernutrition in Egypt, Ethiopia, Swaziland and Uganda	Egypt, Ethiopia, Swaziland, Uganda - Multi-national	**Non-experimental:** Cost-benefit analysis	Child undernutrition	Eliminating child undernutrition can reduce health costs by up to 11% of the total public budget allocated to health
	UN Women. (2015). *The Cost of the Gender Gap in Agricultural Productivity in Malawi, Tanzania, and Uganda.*	Tanzania - National	Not stated	Agricultural productivity (measured as gross value of output per unit of land)	Closing the gender gap in agricultural productivity could reduce undernourishment in Tanzania by 0.72%
	Horton & Hoddinott (2014). *Benefits and costs of the food and nutrition targets for the post-2015 Development Agenda.*	Global - Multi-country	**Non-experimental:** Cost-benefit analysis	Nutrition intervention treatment	Interventions reducing stunting by 59.4% have a benefit-cost ratio from 3.5 (Democratic Republic of the Congo) to 42.7 (Indonesia)
4. Improved Household Soil Quality: Leverage women's preference for intercropping to increase household land productivity	Kassie et al. (2008). Estimating returns to soil conservation adoption in the northern Ethiopian highlands.	Ethiopia - Regional (Tigray and Amhara)	**Quasi-experimental:** propensity score matching and regression analysis (OLS) at the household-level; household and plot-level controls included	Soil conservation (use of stone bunds)	Soil conservation has been linked to crop productivity gains of 18% to over 100% in smallholder contexts
	Crusciol et al. (2015). An innovative crop-forage intercrop system: early cycle soybean cultivars and palisadegrass.	Brazil - Local (Botucatu)	**Field Experiment**: Analysis of variance comparing treatment means; blocks and block interactions considered random effects; soil variable controls included	Maize intercropped with palisadegrass	Higher soil fertility resulting from maize-palisadegrass intercropping increased subsequent soybean yield by 14%, white oat yield by 24%, and maize yield by 12.7% over plots that had been previously treated with maize monocrop

	Lal (2009). Soil carbon sequestration impacts on global climate change and food security.	Global – Multi-country	<u>**Review:**</u> Review of literature on soil degradation and its effects on agricultural productivity and food security, summarized current state of the food security literature and connected that to environmental effects (namely soil degradation) that will intensify as a result of climate change	Soil degradation	Carbon sequestration via sustainable farming practices could offset 5-15% of global fossil-fuel emissions
5. Improved Household Nutrition and Educational Achievement: Leverage women's preferences for spending income on food and education to increase household labor productivity and reduce health expenditure	Montenegro & Patrinos (2013). Returns to schooling around the world: Background paper for the World Development Report 2013.	Global - Multi-country	<u>**Non-experimental:**</u> Survey of findings using data from standardized household surveys	Educational attainment	The average rate of private return to another year of schooling is 12.8% in Sub-Saharan Africa
	Van Den Boom, Nubé, & Asenso-Okyere (1996). Nutrition, labour productivity and labour supply of men and women in Ghana.	Ghana - National	<u>**Quasi-experimental:**</u> Panel data with fixed effects regression analysis (OLS) at the individual-level; individual and household demographic, socioeconomic, and geographic controls included	Food consumption	In Ghana, a 1% increase in food consumption is associated with 0.61% wage rate increase for men and 0.47% wage rate increase for women

3. <u>Key variables necessary for extrapolating study findings to broader estimates of the benefits of economic empowerment – including basic variables such as land area managed by women – are not readily available</u>. We found few readily available data sources on key variables such as women's land ownership, land management, input use, or labor necessary to calculate the household-level and aggregate net benefits of interventions increasing women's access to and use of inputs such as fertilizer, labor, or even land at the margin. Analysis of the marginal productivity returns to changes in women's access to agricultural productive resources (including land, labor, and fertilizer and other inputs) using LSMS-ISA data or other survey data could provide more refined estimates of the potential benefits to investments to women's empowerment in agriculture (see a sample analysis establishing the trends in women's behavior and decision-making in an analysis of the 2012-2013 Tanzania LSMS-ISA in Appendix B).

4. <u>Data on the costs of interventions addressing (eliminating or leveraging) the male-female differences in the five pathways are limited</u>, making calculations of potential returns per dollar of investment difficult. While estimates of the marginal benefits of interventions along these pathways are also limited, further research could help establish a range of potential benefits in different contexts.

Introduction

A growing body of evidence suggests that women's empowerment can play a vital role in promoting economic development (Duflo, 2012; Kabeer & Natali, 2013; The World Bank, 2011). The 2016 Africa Human Development Report finds that gender inequality is costing Sub-Saharan Africa some $95 billion per year, and a 2015 study from the McKinsey Global Institute estimates that $12-$28 trillion could be added to the global economy if women achieved parity with men in economic outcomes (such as participation in the workforce or presence in leadership positions). However, while there is a growing consensus that women's empowerment can have positive impacts on economic development, little empirical research has focused on the impacts of women's empowerment in agriculture specifically.

With an intentionally narrow focus on economic empowerment, we draw on the Women's Empowerment in Agriculture Index (WEAI)'s indicators of women's empowerment in agriculture to consider the potential economic rewards to increasing women's control over agricultural productive resources (including her own time and labor), over agricultural production decisions, and over agricultural income. While we recognize that there may be quantifiable benefits of improving women's empowerment in and of itself, we focus on potential longer-term economic benefits of improvements in these empowerment measures.

Were resources unlimited, contending that investing in female farmers could have economic benefits is a low risk proposition. Instead, we consider the case for spending the marginal dollar on empowering female farmers as a means of increasing household productivity, either prioritizing women for new investments or re-allocating existing resources. The literature suggests at least two distinct avenues via which economic benefits from investing in women's empowerment in agriculture might arise. The first is by equalizing access to productive resources (including access to and control over land, labor, and other inputs) between men and women, and the second by leveraging differences between men and women that might lead to improved household outcomes. This report explores the evidence base underlying these two hypothesized avenues:

1. *Equalizing access* assumes that men and women have similar potential productivity but differ in access to and control over resources – i.e., given the same access to, control over, and quality of agricultural inputs and technologies, male and female farmers would be equally productive. Under the common assumption that initial input applications have a higher return than subsequent applications (diminishing marginal returns), and that women start from lower levels, then marginal productivity gains from increasing women's use of inputs would be higher than more of the same inputs for men.

2. *Leveraging differences* assumes that for a given set of household resources, men and women differ in preferences – i.e., *on average*, male and female choices surrounding crop management, input use, childcare and other investments might differ, possibly due to differences in risk, time, and social preferences. Under the common assumption that men and women, on average, differentially prioritize resource expenditures, increasing a women's share of household decision-making authority would be expected to change household economic outcomes.[2]

The first avenue assumes that given equal access to inputs men and women's productivity would be the same, and that as a result investing in empowering women by increasing access to and control over agricultural resources would lead to economic benefits from productivity gains. Several recent studies using data from the World Bank's Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA) find evidence of significant and persistent gender gaps in agriculture in multiple Sub-Saharan African countries (e.g., Aguilar et

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[2] With the exception of child-bearing, it is entirely unclear what differences are innate, and which are a result of social and cultural environments. Further, certain differences such as mobility, could be considered an "input" to production, or a difference arising from physical or social considerations. Regardless, the important exercise of this report is to document the evidence relating to these two hypothesized avenues, and whether that supports, or not, an economic case for investing in women in agriculture.

al., 2015; Kilic, Palacios-Lopez, & Goldstein, 2015; Oseni et al., 2015; The World Bank, 2014). Estimates of the extent and the drivers of the gender gap in agricultural productivity are varied, but several studies also point to differences in use of inputs as driving a portion of this gap (Kilic, Palacio-Lopez, & Goldstein, 2015; Palacios-Lopez, 2015; Tiruneh et al., 2001), indicating that increased use of productive resources by women could help close this gap. A 2011 FAO study finds that the productivity gap is not due to lower efficiency of female farmers, but rather to differences in input use between the sexes. The authors report that, in comparison to male farmers, female farmers have smaller farms, own less and smaller livestock, have a greater workload and time burden, obtain less education, have less access to information and extension services, use less credit, are less likely to purchase inputs like fertilizer and seeds, if employed are more likely to be in lower-paying and part-time jobs, and receive lower wages for the same work. Croppenstedt et al. (2013) further find that historically economic growth in developing countries has not resulted in decreasing gender gaps in agricultural productivity. Some studies argue that that investing in access to agricultural inputs for women will result in higher marginal productivity gains than similar investments to men since men generally have greater access to existing household inputs (Andrews et al., 2014; Nwaru, 2011; Udry et al., 1996).

A 2011 FAO report on women in agriculture estimated that closing the gender gap in access to resources could increase yields on women's farms by 20-30%, resulting in a 2.5-4% increase in agricultural output in developing countries. A more recent 2015 study by UN Women using LSMS-ISA data from Malawi, Tanzania, and Uganda estimates the annual cost of the gender gap in agricultural productivity at $100 million, $105 million, and $67 million for each country respectively. The authors estimate that closing this gap would result in a $90 million increase in agricultural GDP in Malawi, an $85 million increase in Tanzania, and $58 million in Uganda.

The second hypothesized avenue for economic benefits of women's empowerment acknowledges that several empirical studies find that men and women in the same or similar circumstances make different decisions (Hoddinott & Haddad, 1995; Quisumbing & Maluccio, 2003) – including in smallholder farm households (Bhagowalia et al., 2012; Malapit & Quisumbing, 2015; Smith et al., 2003; Yoong, Rabinovich, & Diepeveen, 2012). A review of this research on risk and social preferences by Croson and Gneezy (2009) finds that women are more risk averse across certain domains, more sensitive to social connections, and more averse to competition than men. Other research suggests that men and women, on average, have different time preferences (Dittrich & Leipold, 2014), risk (Charness & Gneezy, 2012; EPAR, 2017; Fletschner, Anderson & Cullen, 2010; Gneezy, Niederle, & Rustichini, 2003; Niederle & Vesterlund, 2007), and social preferences (Anderson, Stahley, & Cullen, 2014; Croson & Gneezy, 2009; Eckel & Grossman, 1998; 2001), with some findings challenging earlier work (Booth & Nolen, 2009; Gneezy, Leonard, & List, 2008). We also note that measured benefits from leveraging male-female differences in resource choices may dissipate as women gain more access and control if differences are not due to being a woman per se, but rather stem from being disempowered - since this would change the circumstances in which these differences in decision-making have been observed.

These findings suggest that women's empowerment in agriculture, as measured by increases in women's decision-making power over various farm and household decisions, could lead to different individual and household outcomes in rural developing country contexts – though not always economically better outcomes. The only situations in which we can infer that a woman's choice may be economically preferable to a man's choice is if: 1. there is evidence that the woman's choice has a higher long run return (e.g. spending a marginal dollar on a nutritious food, rather than on non-nutritious food, alcohol, or tobacco items); or 2. there is evidence that a women's choice is more likely to support the provision of a household public good, such as shelter, water supply, soil quality on shared plots, or other home or farm infrastructure. If the baseline production of household public goods reflects the husband's choices given his decision-making authority and evidence that choices reflect spousal roles, household public goods preferred by women will be more underprovided (Chattopadhyay & Duflo, 2004). Since the consumption of these goods is non-rival, the marginal dollar spent on the wife's public good of choice could yield a higher household return, especially if household labor were correctly priced.

A growing body of literature suggests that women's empowerment contributes to a variety of long-term benefits, notably intergenerational benefits for children through impacts on health and nutrition (e.g., Carlson, Kordas, & Murray-Kolb, 2014; Malapit & Quisumbing 2015; Pratley, 2016; Smith et al., 2003). Several studies find generally positive and significant associations between the Women's Empowerment in Agriculture Index (WEAI) and nutritional outcomes (Malapit et al., 2013; Malapit & Quisumbing, 2015; Sraboni et al., 2014). However, in their review of 78 articles that outline six different pathways between agriculture and nutrition in India, Kadiyala et al. (2014) note there is limited evidence on pathways relating to women's empowerment.

In this report these two broad assumed distinctions between men's and women's constraints and behaviors are used to frame a series of five theorized causal pathways surrounding the potential for net economic gains from women's empowerment in agriculture. We outline the hypotheses underlying each causal pathway drawn from the peer-reviewed scholarship and grey literature on how women's empowerment in agriculture might lead to economic benefits through either giving women equal access to and control over productive resources (avenue 1) or through differences in decision-making between women and men (avenue 2). The five pathways focus on eliminating differences (avenue 1) in women's access to and control over agricultural productive resources (pathway 1) and in women's control over their own time and labor (pathway 2) relative to men, and leveraging women's decisions (avenue 2) to cultivate more diverse and nutritious crops (pathway 3), intercrop more often (pathway 4), and allocate more of household expenditures to food and education for children (pathway 5) relative to men.

Most pathways rest on assumptions about: (a) relative baseline conditions for men and women, (b) changes in adoption, use, or behavior arising from women's empowerment, and (c) the subsequent economic benefits. We review the available evidence to evaluate each assumption in these theoretical pathways, with the goal of evaluating the expected economic benefits to investing in empowerment of female farmers, and whether these benefits might be different from investing in male farmers. We find evidence from a variety of contexts that empowering women in agriculture might be expected to lead to various direct outcomes with longer-term quantifiable economic benefits, though the evidence base is limited and support for some theorized causal pathways is mixed, making it difficult to extrapolate general estimates.

Methods

The term "empowerment" is used in studies across multiple disciplines, resulting in varied definitions covering different aspects of empowerment. Most commonly, empowerment is defined as an individual's ability to make or express choices and decisions related to their own life (Alsop, Bertelsen, & Holland, 2006; Appleyard, 2002; Kabeer, 1999; Mahmud, Shah, & Becker, 2012; Mason & Smith, 2003; Mayoux, 2000; Narayan, 2005; Rowlands, 1997; Strandburg, 2001; Van Eyken, 1991). Similarly, ownership and control over one's own life and other situations is argued to serve as a relevant indicator of empowerment (Chambers, 1993; Mason & Smith, 2003; Narayan, 2005; Strandburg, 2001). In a World Bank sourcebook on empowerment and poverty reduction, they define empowerment broadly as the expansion of freedom of choice and action, and further consider institutional aspects of empowerment, defining it as "the expansion of assets and capabilities of poor people to participate in, negotiate with, influence, control, and hold accountable institutions that affect their lives" (p. vi) and pointing to needs to improve access to information, inclusion and participation in groups in institutions, accountability, and local organizational capacity (Narayan, 2002).

These conceptualizations of empowerment may be considered within a framework of power, moving from a "power over" situation, where one party benefits while the others loses to situations, to a "power to" or "power within" situation, where individuals have control over their own lives and enjoy self-worth and individual fulfillment (VeneKlasen & Miller, 2002). The "power within" structure also relates to an indication of self-reliance and internal strength, another conceptualization of empowerment (Moser, 1991; VeneKlasen & Miller, 2002). Further, empowerment is often considered in the context of social mobilization or collective action in order to influence authority and ensure accountability, whether authority refers to the government or some other entity or individual (Bennet, 2002; Craig & Mayo, 1995; Friedmann, 1992; Grootaert, 2005; Malhotra, Schuler, & Boender, 2002; Narayan, 2005; Oxaal & Baden, 1997; The World Bank, 2001). Empowerment related to group action relates to the "power with" expression of power where individuals join together to impact change (VeneKlasen & Miller, 2002). The "power to" situation relates to personal agency, which several others authors also consider as an important component (Alkire, 2005; Malhotra et al., 2002; Sundström et al., 2015), and which includes economic empowerment or an individual's ability to make decisions regarding resources, production, and income.

Translating these concepts of empowerment into measurable indicators with supporting data has been a challenge. Where feasible, researchers are using household and individual survey data, though Alkire et al. (2013) note that vagueness in questions can lead to biased and inaccurate results and that the inability to generalize many of the empowerment measurement tools across contexts results in limited usefulness. Many authors measure empowerment using indicators such as control over decision-making, the ease of a woman's mobility, and control over household income (Thorpe et al., 2016). Bandiera (2015) defines empowerment outcomes in terms of increases in profits due to changes in business practices brought about by business training, but does not consider control over that income. Buvinic & Furst-Nichols (2016) expand the definition of economic empowerment to include not only increases in productivity and income but also subjective dimensions experienced by individual women, including increased agency and well-being. Deininger & Liu (2009) use autonomy, political participation, social presence, and decision-making as measures of empowerment. Brody et al. (2015) consider three areas of empowerment outcomes, namely economic (e.g., independence in financial decision-making, participation in paid employment), political (e.g., the ability to own land legally or vote) and social (e.g., freedom from violence, access to education). The Women's Empowerment in Agriculture Index (WEAI) measures empowerment based on a set of five indicators: production, resources, leadership, income, and time (Alkire et al., 2013). Additionally, the WEAI considers the concept of gender parity. Gender parity analyzes the empowerment level of women to men within the same household by comparing the percentage of women who have achieved empowerment to the percentage of men. A gap between the genders in a household reveals an empowerment gap (Alkire et al., 2013).

In this paper, we follow Kabeer (1999) and others and define women's empowerment as their ability to make or express choices and decisions related to their own life. We focus on women's economic empowerment, noting that positive economic outcomes are generally associated with social (e.g., supportive community norms) and psychological (e.g., efficacy or self-perception) empowerment (Brody et al., 2015; Conger & Kanungo, 1988). We further narrow the scope of economic empowerment to only include measures that directly relate to gender and agricultural outcomes. Drawing from the WEAI, we include three measures: women's decision-making power related to 1) productive resources, 2) agricultural management, and 3) agricultural income. For each measure, we summarize theoretical causal pathways by which changes in women's empowerment in agriculture, owing to gender-based differences in constraints or in decision-making, are hypothesized to affect direct outcomes from agriculture and longer-term economic benefits. While we recognize that empowerment (in terms of agency or self-perception) is often considered a goal in itself, we do not focus on these benefits and instead explore the evidence of potential economic benefits resulting from improvements in women's empowerment, as measured by control over various agriculture-related decisions.

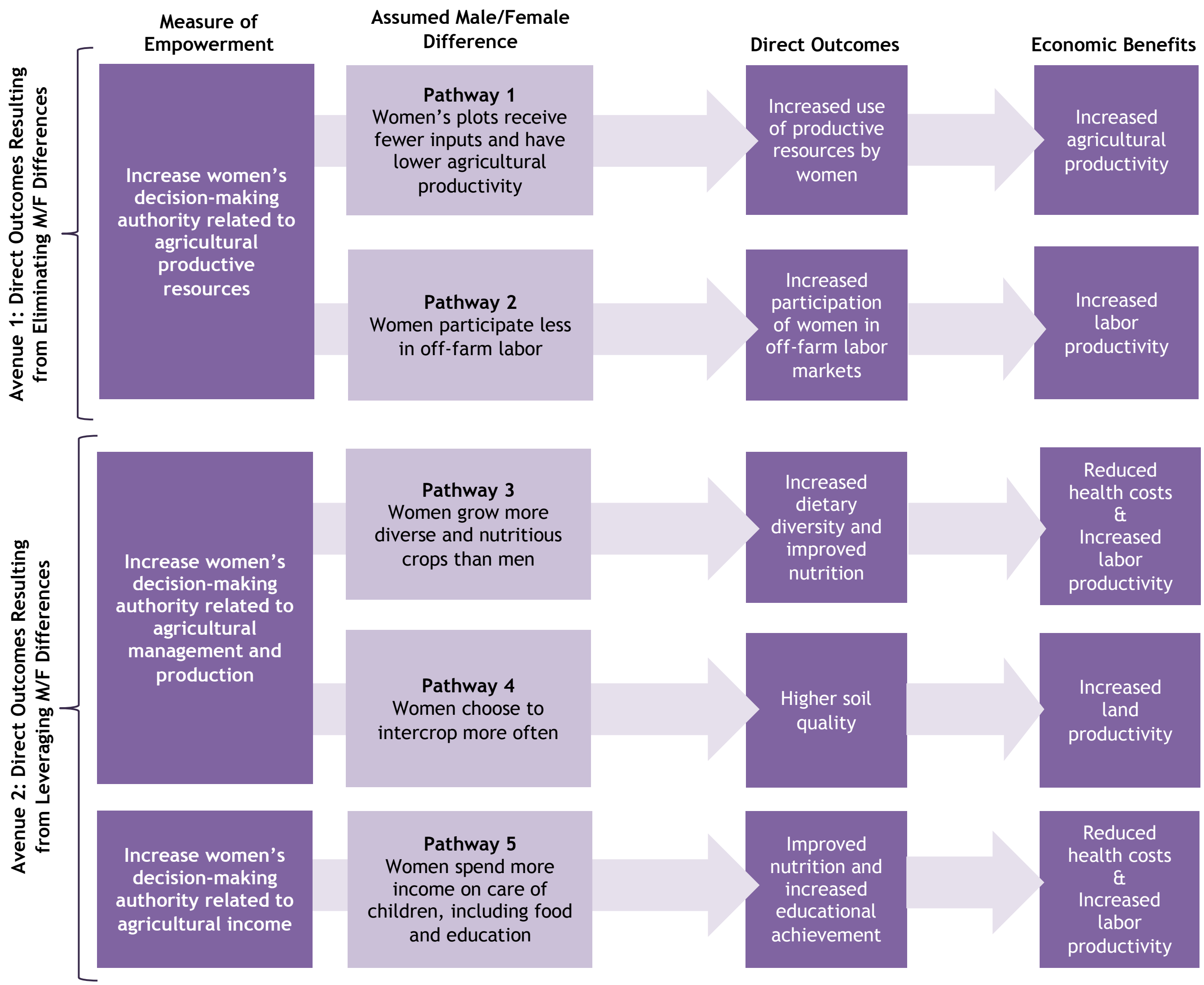
The first WEAI measure, decision-making power around productive resources, relates to the first hypothesized avenue to economic benefits of empowering women in agriculture: eliminating male/female differences in productivity. We identified two theorized causal pathways from changes in this measure of empowerment which focus on reducing constraints to female farmers to allow them to become as productive as male farmers, boosting overall agricultural productivity in an economy assuming men and women would be equally productive given the same access to and control over inputs. **Pathway 1** builds on Andrews, Golan, & Lay (2014), Croppenstedt, Goldstein, & Rosas (2013), Nwaru, Okoye, & Ndukwu (2011), Udry (1996), Udry et al. (1995), and others by considering effects of empowering women by increasing their access to and control over agricultural inputs, increasing overall agricultural productivity. **Pathway 2** focuses on women's control over their own time and labor (personal productive resources), noting that women's mobility is more constrained than men's, limiting their ability to participate in off-farm labor (Abdulai & Delgado, 1999; Owusu, Abdulai, & Abdul-Rahman, 2011), and hypothesizing that removing these constraints may increase overall labor productivity.

Two measures of economic empowerment, decision-making power around agricultural management and agricultural income, are related to the second hypothesized avenue to benefits of women's empowerment: leveraging effects of male/female differences in decision-making on household outcomes. **Pathway 3** connects differences in men's and women's decisions of what crops to grow (e.g., Oliver, 2016; Peterman et al., 2011) with household nutrition outcomes (e.g., Dillon, McGee, & Oseni, 2015; Malapit et al., 2013; Sibhatu, Krishna, & Qaim, 2015; Snapp & Fisher, 2015). **Pathway 4** assumes differences in plot management between men and women, specifically the likelihood of intercropping (e.g., Bezner-Kerr et al., 2007; EPAR, 2013; Khan et al., 2008; Mishra et al., 2009), and hypothesizes that these may influence farm soil quality and long-term agricultural productivity (e.g., Abebe et al., 2006; Samake et al., 2006; Zhou et al., 2011). Finally, **Pathway 5** draws a connection between differences in how men and women spend income from agriculture to impacts on household nutrition and education outcomes (Malapit & Quisumbing, 2015; Sraboni et al., 2014). A final caveat, however, is that the basis for these different choices may be innate attitudes, or differential access to resources that if equalized, could erase choice differences between women and men.

These five theorized causal pathways are summarized in Figure 1.

For each causal pathway, we assume that a given intervention leads to a change in the particular measure of empowerment. While we summarize available evidence from studies reporting on changes in indicators similar to the selected measures of women's empowerment in agriculture, this literature review focused on the differences in control over productive resources and in decision-making between men and women, on the direct outcomes resulting from either eliminating these differences (in the case of access to and control over resources – avenue 1) or leveraging them (in the case of control over agricultural management and income – avenue 2) by empowering women, and on the longer-term economic benefits of those direct outcomes. We reviewed evidence for the linkages between direct outcomes and economic benefits in a general sense, as the evidence did not always include a gender dimension in these linkages. We therefore interpret the long-term benefits of a change in women's empowerment as being mediated through particular direct outcomes, for which we have evidence of both an effect of women's empowerment and a long-term benefit.

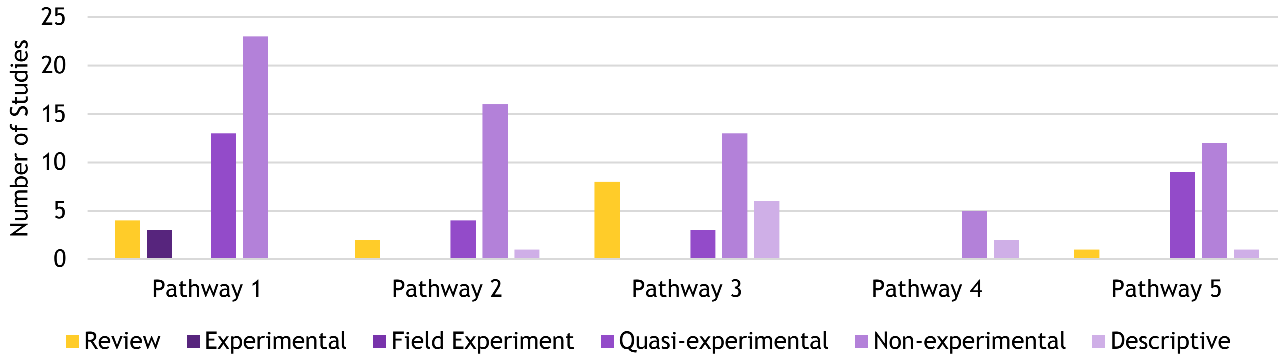
Figure 1. Theorized Causal Pathways for Economics Benefits of Women's Empowerment in Agriculture



To evaluate the hypothesized links in each causal pathway, we conducted a literature review to identify peer-reviewed articles and grey literature providing relevant empirical evidence. We considered studies to be relevant if they included empirical analysis specifically testing one of the assumed links in the five theorized causal pathways from women's empowerment in agriculture to various economic benefits. Most pathways rest on assumptions about: (a) relative baseline conditions for men and women, (b) changes in adoption, use, or behavior arising from women's empowerment, and (c) the subsequent economic benefits. As we identified little evidence of economic benefits directly related to the pathways, we also considered studies to be relevant if they provided more general estimates of economic benefits related to the direct outcomes outlined in the pathways.

We began by conducting literature searches in the academic database Scopus using multiple search strings targeting specific links in each causal pathway. We screened at least the first 40 results from all searches and retrieved all articles that related to the outlined causal pathways. Searches yielded 122 relevant papers; we supplemented these searches with results from targeted searches in Google Scholar to identify additional relevant literature. These supplementary searches yielded a further 112 articles providing relevant empirical results. See Appendix A for further details on literature search methods.

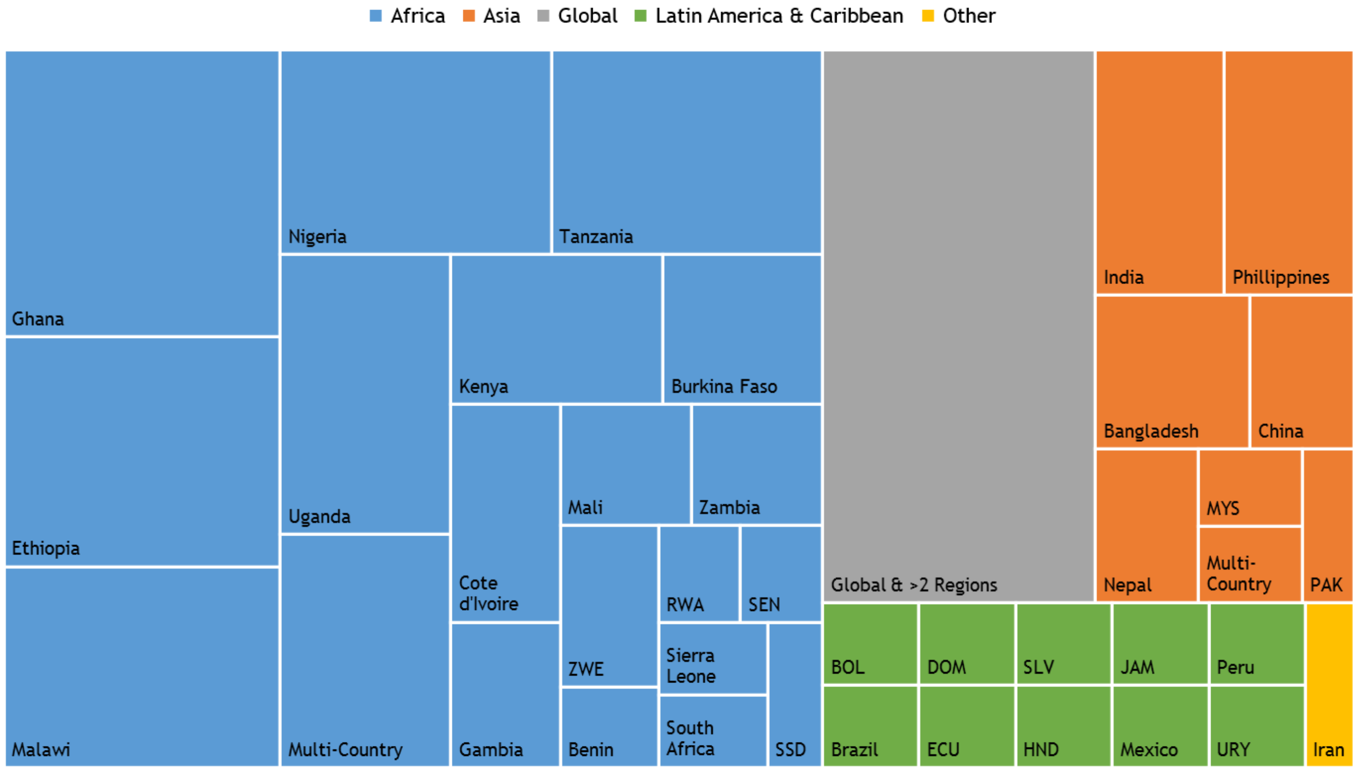
Figure 2. Methods Applied in Pathway-Specific Evidence across All Pathways



We categorize the wide variety of methods used by researchers into six types: (i) descriptive, (ii) non-experimental, (iii) quasi-experimental, (iv) field experiment, (v) experimental, and (vi) review. "Descriptive" evidence indicates that the study uses qualitative methods (e.g., interviews and focus groups) or descriptive statistics to suggest a correlation between two variables, but does not formally test this association. "Non-experimental" evidence indicates that the study uses regression-based analysis or other tests for associations between variables, but does not test for causality. "Quasi-experimental" evidence includes studies that use a variety of techniques to compare the effects of an intervention across treatment and comparison groups without random assignment, most commonly by using instrumental variables regression or panel data with fixed effects, in an attempt to evaluate causality of relationships. "Field experiment" studies use techniques from soil science to establish experimental plots to test an agricultural technology, often controlling for soil, plot, and environmental characteristics. "Experimental" studies use randomly assigned treatment and control groups enabling identification of causal average treatment effects. Finally, "review" evidence indicates studies that synthesize literature qualitatively (e.g., an extensive literature review) or quantitatively (e.g., a systematic review or meta-analysis).

The majority of studies were non-experimental, as the availability of experimental and quasi-experimental evidence was limited for most of the pathways (Figure 2). We focused on evidence from Sub-Saharan Africa and South Asia, and studies reporting findings from countries in these regions made up the bulk of the resulting evidence base, though we also included relevant evidence from other contexts, targeting low- and middle-income countries (Figure 3).

Figure 3. Geographic Distribution of Pathway-Specific Evidence Base for All Pathways by Region



For each theorized causal pathway, we separately reviewed: 1) evidence of male/female differences in either access to and control over productive resources (avenue 1) or decision-making (avenue 2); 2) associations between eliminating (avenue 1) or leveraging (avenue 2) these differences and direct outcomes that affect women, their households, or their farms; and 3) the economic benefits or costs of these direct outcomes. We summarize this evidence in the subsections below, organized by the measure of women's empowerment in agriculture at the beginning of the causal pathways. We found very limited evidence of estimates of economic benefits resulting from changes in women's empowerment along the theorized pathways, so in many cases we include more general supporting evidence for the economic benefits of particular direct outcomes, to illustrate the potential benefits of improving women's empowerment to achieve those direct outcomes.

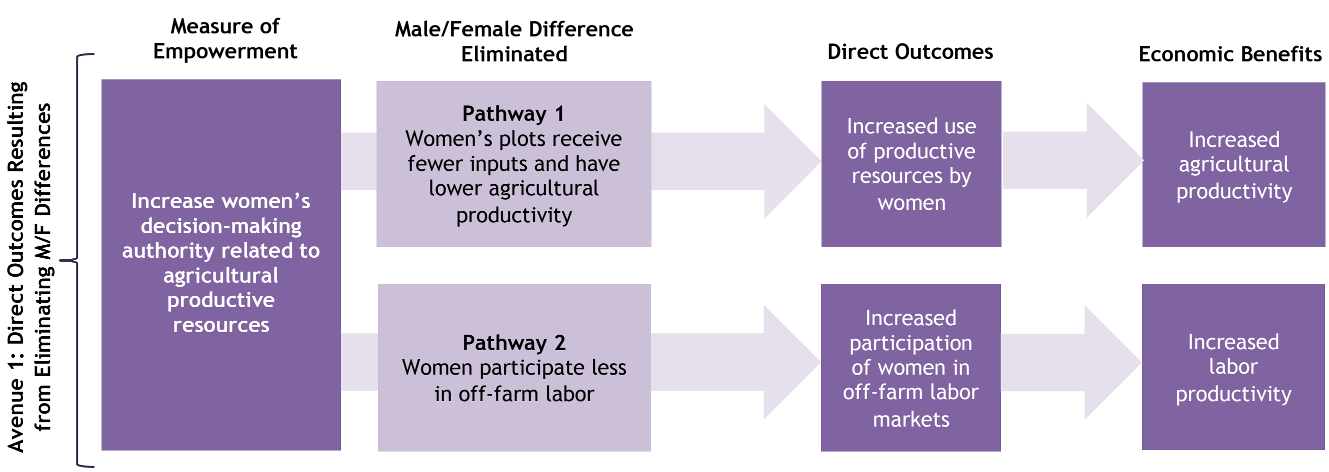
To further evaluate certain assumptions in the causal pathways, we also conducted statistical analyses using data from the 2012-2013 Tanzania National Panel Survey (a part of the World Bank's LSMS-ISA). The full results of these analyses are included in Appendix B. Future research building on this report may bring in multiple survey waves from Tanzania and other LSMS-ISA countries to further evaluate the theorized causal pathways for benefits of women's economic empowerment in agriculture.

Avenue 1: Eliminate Male/Female Differences in Access to and Control over Productive Resources

Measure of Empowerment: Increasing Women's Decision-Making Power around Agricultural Productive Resources

The first measure of women's empowerment in agriculture that we considered was women's decision-making power related to agriculturally productive resources, following the first hypothesized avenue for economic benefits of women's empowerment in agriculture. In this case, increasing decision-making power involves reducing male/female differences in accessing inputs and technology and increasing women's control over decisions on how to allocate these resources within the household. Under productive resources, we include farm inputs such as seeds, fertilizer, and herbicide, land, household and hired labor, technology such as animal-powered or mechanized tools, financial services (especially targeting agriculture), and extension services. Figure 3 presents a simplified model of the theorized causal pathways for economic benefits associated with increases in this measure of women's empowerment. These causal pathways draw on arguments that increasing access to and control over agricultural inputs for women will result in higher marginal productivity gains than similar investments to men since men generally have greater control over existing household inputs and these are often not efficiently allocated (Andrews et al., 2014; Nwaru, 2011; Udry et al., 1996) and that increasing women's control over their own mobility and labor time will increase labor productivity, specifically by increasing women's participation in off-farm labor markets where returns are higher than from domestic farm work (Owusu, Abdulai, & Abdul-Rahman, 2011) .

Figure 4. Economic Benefits of Increasing Women's Decision-Making Power Related to Access to and Use of Agricultural Productive Resources



We found some published evidence describing interventions that changed women's decision-making power related to productive resources in sub-Saharan Africa South Asia. Several of these relate to control over land. Following a low-cost community land registration process in Ethiopia, female heads of households became more likely to rent out land owing to tenure security (Holden, Deininger, & Ghebru, 2007). In Rwanda, a nationwide land tenure regularization (LTR) program aimed to formalize the legal recognition of rights to lands, including those of women. Following the implementation of this program, there was a significant increase in investment in soil conservation measures amongst female-headed households (Ali, Deininger, & Goldstein, 2011). In an observational study conducted in Ghana, Quisumbing et al. (2001) observe that a land transfer from husbands to wives (conditional on women and children helping the man plant cocoa trees on his own fields) increased women's control over land and bargaining power. In Nepal, an IFAD funded project promoted the formation of women leasehold groups (which rehabilitate land and are entitled to use forest products) for forest land. This enabled woman to exert their rights over forestry resources and increased women's leadership roles in the community (International Land Coalition, 2001). Action Aid’s WOLAR initiative in South Africa included interventions such as gender education programs for traditional and government leaders, improving women’s access to extension services and legal assistance and increased women’s control over land and decision-making power over land use, inputs and profits (Doss, Bockius-Suwyn, & D’Souza, 2012).

Other studies report on interventions providing inputs, subsidies, or extension directly to women. In Bangladesh, women’s groups disseminated improved vegetable varieties for homestead production to women in households with small amounts of land. This technology required a low level of investment and no agricultural land, and was successfully adopted by the targeted women (Hallman, Lewis, & Begum, 2007). Women farmers in Nigeria who were supervised by female extension agents had higher awareness and participation in extension activities, signaling a difference in the effect of male and female agents on women’s access to extension (Lahai et al., 1999). Roy et al. (2015) find women’s ownership and control over transferred livestock to have increased in response to a BRAC intervention that provided livestock and training to adult women in rural households in Bangladesh. Four studies (Beaman et al., 2013; Gilbert, Sakala, & Benson, 2002; Jagger & Pender, 2006; Karamba et al., 2015) report that input subsidies targeting female farmers increased the quantity of inputs – particularly fertilizer – used by women and reduced male/female gaps in input use in Mali, Malawi, Uganda, and Malawi respectively.

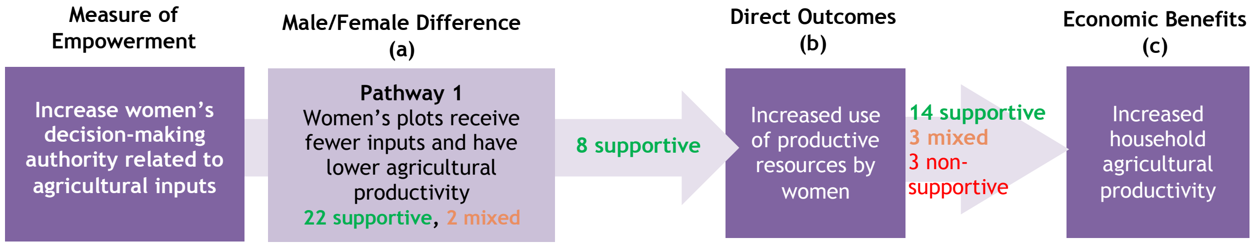
Quisumbing et al. (2015) analyze four dairy and horticulture projects in Africa and Asia and find that these interventions can involve women and increase production, income, and household assets. They report that in some cases women increased their control over production, income, and assets, but that men’s incomes usually increased more than women’s and the gender asset gap did not decrease. The authors pointed to “gender- and asset-based barriers to participation in projects as well as gender norms that limit women’s ability to accumulate and retain control over assets both contributed to the results” (p. 705).

<u>Pathway 1: Increased Women’s Use of Productive Resources</u>

The first pathway hypothesizes that increasing women’s control over agriculturally productive resources (including both access to and control over agricultural inputs and technologies) would contribute to more efficient allocation of inputs and technology across household plots, leading to longer-term benefits from increased agricultural productivity (Nwaru, 2011; Quisumbing, 1996; Udry, 1996). This pathway builds on evidence of differences in input use between plots managed by women and those managed by men, and argues that increasing women’s access to and control over inputs – either by providing new inputs or reallocating some existing inputs from men’s plots to women’s plots - could increase total household agricultural productivity. In the case of reallocating existing household resources, Nwaru et al. (2011) and others argue that additional input use by women in developing countries has higher marginal productivity gains than additional input use by men, such that that productivity gains on women’s plots would outweigh reductions in productivity on men’s plots arising from the shift in productive resource use. This pathway rests on the assumptions that:

a. Women have lower access to and control over agricultural inputs, contributing to lower agricultural productivity for women,
b. Given greater access and control, women’s input use would increase, and
c. The marginal yield returns to increasing input use by women (as a result of equalizing access and control relative to men) are higher than for men, *ceteris paribus*, such that directing new resources to women and/or reallocating resources within the household will increase household productivity *(see Figure 5)*.

Figure 5. Evidence Base Supporting Pathway 1



We identified 24 studies with evidence on differences by gender in either input access or use or productivity, usually measured by yield (Table 1.1). Eleven of these studies looked at differences at the individual level, eight looked at differences between female- and male-headed households, and six looked at differences between female- and male-managed plots (three studies considered multiple levels). We found 20 studies indicating that women in developing countries have less access than men to inputs including labor, farm equipment, draft animal power, fertilizer, land, extension services, and credit. Female-headed households have been empirically shown to receive fewer agricultural labor inputs than male-headed households in studies in Nigeria (Babatunde et al., 2008) and Ethiopia (Tiruneh et al., 2001). A study from Burkina Faso indicates that less male and non-household labor per hectare is allocated to plots controlled by women than to similar plots controlled by men (Udry et al., 1995). Male-headed households also have significantly more access to farm equipment as compared to female-headed households as reported in studies in Nigeria (Babatunde et al., 2008; Saito et al., 1994), Kenya (Saito et al., 1994) and Benin (Kinkingninhoun-Mêdagbé et al., 2010), and males also use more draft animal power according to a study in Ethiopia (Pender et al., 2006). Udry (1996) finds significantly higher fertilizer use on men's plots than on women's plots within the same household in Burkina Faso. Studies from Ghana (Doss et al., 2000) and Benin (Kinkingninhoun-Mêdagbé et al., 2010) find women farmers to have lesser access to land than male farmers, and evidence from multiple countries shows that rural female-headed households without a male member own less land than rural male headed households (Croppenstedt et al., 2013). A study from Ethiopia finds that female household heads receive fewer extension services compared to male household heads (Ragasa et al., 2013) and evidence from Cote d'Ivoire suggests that women farmers have lesser credit access than male farmers (Adesina et al., 1997). Rahman (2008) finds that women in Kaduna State of Nigeria had a low rate of involvement in farm decisions and had low access to productive resources in general.

Thirteen studies find that female-headed households, female farmers, or female-managed or –owned plots have lower productivity than their male counterparts. We find evidence of lower yields for women at one of these levels in Burkina Faso (Udry et al., 1995; Udry, 1996), Cote d'Ivoire (Adesina et al., 1997), Ethiopia (Tiruneh et al., 2001), Gambia (Von Braun et al., 1989), Ghana (Quisumbing et al., 2001), Kenya (Saito, Mekonnen, & Spurling, 1994), Malawi (Kilic, Palacio-Lopez, & Goldstein, 2015), Nigeria (Saito, Mekonnen, & Spurling, 1994; Peterman et al., 2011), and Uganda (Larson et al., 2016; Peterman et al., 2011). Five studies point to differences in use of inputs as driving a portion of the productivity gap (Aguilar et al., 2015; Horrell & Krishnan, 2007; Kilic, Palacio-Lopez, & Goldstein, 2015; Palacios-Lopez, 2015; Tiruneh et al., 2001), and argue that increased use of productive resources by women could help close this gap.

The evidence on women's empowerment in agriculture leading to increased input use is limited, but we identified eight studies reporting that empowering women by increasing their control over productive resources, generally through directly providing or lowering the costs of women obtaining them, increases their use of inputs and technology (Table 3.2). Beaman et al. (2013) find that a fertilizer subsidy for female rice farmers in Mali was associated with an increase in the quantity of fertilizer used on female farmers' plots. Santos et al. (2014) find in a study in India that women in households participating in a government program promoting the inclusion of women's names on land titles report significantly higher tenure security and are significantly more likely to participate in food and agricultural decision-making such as taking loans from self-help groups or microfinance institutions, purchasing productive assets, food purchase and consumption, and what to grow on family land, compared to women in non-participating households. Gilbert, Sakala, & Benson (2002) analyze a cropping system trial survey in Malawi and find a significant gender gap in fertilizer use pre-trial, which disappeared after female farmers were provided with seed and fertilizer. Van den Bold et al. (2013) report that an intervention to transfer agricultural assets and chickens to women in Burkina Faso increased women's assets and reduced the ratio of men's agricultural assets to women's from 14.6 to 5.9. Quisumbing et al. (2013) find that a dairy value chain project in Bangladesh helped women to build up assets by supporting them to acquire jointly-owned assets with their husbands. Karamba & Winters (2015) find female plot managers participating in Malawi's Farm Input Subsidy Program (FISP) to be more likely to use inorganic fertilizer than male participants. A study in Uganda (Jagger & Pender, 2006) finds female household heads more likely to adopt inorganic fertilizer in response to improved technology use promotion efforts by local organizations. Fisher and Kandiwa (2014) find that the receipt of subsidized input coupons (for seed and fertilizer) increased the probability of modern maize cultivation by 222% for female household heads, while this had no effect on male farmers.

A wealth of empirical studies suggest that increasing access to and use of productive resources leads to economic benefits from increased agricultural productivity generally (Chapoto & Ragasa, 2013; Elias et al., 2013; Emmanuel et al., 2016; Ghosh et al., 2016; Vitale et al., 2011; Wani et al., 2013). We identified 20 studies reporting on differences in productivity gains by gender of changes in access to and use of agricultural resources (Table 1.3). Thirteen reported effects at the individual level, three at the head of household level, and eight at the plot manager level. In a study in Bangladesh, Seymour (2017) finds a strong association between a woman's relative level of empowerment within the household and technical efficiency, with a 15% decrease in the empowerment gap (that closes the male-female empowerment gap) yielding a 2.2% increase in technical efficiency.

Three studies report on interventions increasing input access and use. Davis et al. (2012) report that Farmer Field Schools in Kenya and Tanzania positively impact female headed households' crop productivity and per capita agricultural income, while per capita agricultural income did not change significantly for male-headed households. Vasilaky & Leonard (2013) find that a social network-based agricultural training program in Uganda was associated with an average increase of 98 kg/acre in yield for female farmers, compared to 74 kg/acre on average for all participants. Karamba & Winters (2015) find female plot managers participating in Malawi's Farm Input Subsidy Program (FISP) to be more likely to use inorganic fertilizer than male participants, but report no difference between men and women in terms of productivity gains (17% for both). That FISP participation did not increase female productivity more than male productivity suggests that access to inputs alone cannot overcome gender disparities in agricultural productivity.

Six studies report on allocative inefficiency at the household level, and argue that significant productivity gains would be realized from reallocating inputs from male to female control (Aguilar et al., 2015; Andrews, Golan, & Lay, 2014; Chavas, Petrie, & Roth, 2005; Saito et al., 2014; Udry, 1996; Udry et al., 1995). For example, Udry (1996) estimates that in African farm households as much as 6 percent of output might be lost by inefficient factor allocation across plots controlled by husbands versus wives. Saito et al. (2014) report men's gross value of output per hectare to be 8.4% higher than women's gross value of output in a study in Kenya. Based on a simulation exercise, the authors conclude that given the same access to resources as men, women's value of output would increase by 22%, which would more than close the gender gap and indicate that women on average could potentially be more productive farm managers than men.

Five studies find that women and men have equal or greater productivity or efficiency when controlling for inputs, arguing that productivity would increase from giving women equal access to inputs as men (Alene et al., 2008; Gilbert, Sakala, & Benson, 2002; Moock, 1976; Nwaru et al., 2011; Quisumbing, 1996). For example, Moock (1976) finds women maize farmers in Kenya to be more technically efficient than male maize farmers, obtaining about 7% more output at the mean levels of input use. Nwaru et al. (2011) finds female sweet potato farmers in Nigeria to be more technically, allocatively, and economically[3] efficient than their male counterparts, making a case for encouraging policies that reallocate land and inputs particularly to the female farmers. Quisumbing (1996) reviews 52 studies on technical efficiency based on production function approaches, and reports that most studies find female farmers to be equally technically efficient as male farmers, controlling for input levels.

We also found six studies from Sub-Saharan Africa which indicate lower returns to productive resources for female farmers, in comparison with male farmers. These studies suggest that gender gaps along the productivity distribution also consist of a structural effect characterized by unequal returns to resources, indicating that equal access to factors of production may not be enough to close the gender gap in productivity. A study from Benin finds no statistically significant differences in technical efficiency between men and women, but men's marginal productivities are found to be higher than women's marginal productivities, mainly due to larger land holding sizes (Kinkingninhoun-Mêdagbé et al., 2010). Peterman et al. (2001) find that female-owned plots have the lowest productivity in Uganda even when household-level unobservables and other inputs are controlled for. In the northern region of Nigeria, Oseni et al. (2015) find that women produce 28% less than men, even after controlling for observed factors of production, suggesting that even if women were given the same level of inputs as men, there would still be significant differences in productivity between men and women. Slavchevska (2015) finds similar results in a study in Tanzania, where within the same household, plots managed by a sole woman are 21% less productive than those managed by a sole man, controlling for manager and plot characteristics, inputs and primary crops. In a study in Ethiopia, Aguilar et al. (2015) find 13.4 percentage points of a 23.4 percent gender differential in agricultural productivity in favor of male land managers to be explained by unequal returns to productive components, while 10.1 percentage points is explained by differences in access to resources, land and land manager characteristics. In a study in Malawi, Kilic et al. (2015) find female-managed plots to be on an average 25% less productive than male-managed plots and 18% of this differential to be driven by gender differences in returns to household adult male labor input and inorganic fertilizer application, which have significantly lower positive effects on the productivity of female managed plots.

[3] **Technical efficiency** is the ability to produce the maximum possible output from given inputs, or the minimum possible amounts of inputs needed to produce a given level of output. **Allocative efficiency** refers to the ability to use inputs in proportions that minimize production costs, given input prices. **Economic efficiency** is the product of the former two types of efficiency.

Table 1.1. Summary of Evidence of Male/Female Differences Related to Pathway 1: Women's Use of Agricultural Productive Resources							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Croppenstedt, Goldstein, & Rosas, 2013	Developing countries - Multicountry	72 sources	Literature review	**Review**: Literature Review (methodology not described)	Gender of individual	Yield, various inputs	**Supportive**: Female farmers have lower yields than male farmers due to lower use of inputs and services, and lack of control of resources; women less likely to use credit than men; gender gaps in yield do not decrease systematically with growth and may increase with GDP per capita growth and increased access to resources and inputs, but authors note evidence is not conclusive
Quisumbing & Pandolfelli, 2010	Ghana, Burkina Faso, Ethiopia, Uganda, India, Philippines, Malawi, Kenya, Zimbabwe, Gambia, and more - Multicountry	79 sources	Literature review (literature from 1998-2008)	**Review**: Literature Review (methodology not described)	Gender of individual	Land, soil fertility, water, labor, technology, credit, extension services	**Supportive**: FHH apply less fertilizer than MHH but lack of access to cash and credit are critical factors, not gender; Access to ag. resources and inputs is limited by weak land rights and low education levels; women's lack of access to credit also implies that they may be better able to adopt non-lumpy, divisible technologies or afford inputs purchased in smaller quantities.
Aguilar et al. , 2015	Ethiopia - National	3969 households (nationally representative sample)	2011-2012, Ethiopia Rural Socioeconomic Survey (ERSS)	**Quasi-experimental**: Oaxaca-Blinder mean decomposition; fixed effects model for crop products and different levels of geographical aggregation; Regression analysis OLS) at plot level; demographic, socioeconomic, input controls included	Gender of plot manager	Agricultural productivity (birr/Ha)	**Supportive**: 23.4% gender differential in agricultural productivity, in favor of male land managers; 10.1 percentage points explained by differences in access to resources, and land and land manager characteristics; 13.4 percentage points explained by unequal returns to productive component

Pender & Gebremedhin, 2006*	Ethiopia - Regional (100 villages in 50 administrative units in Tigray region)	500 households (random sample)	1999-2000, household and plot-level surveys conducted by authors	**Quasi-experimental**: Regression analysis (OLS and Instrumental Variables) at household and plot level: IVs were input use, land management practices, participation in programs and organizations, and use of credit; demographic, asset ownership, access to infrastructure controls included	Gender of individual and household head	Amount of inputs used/plot (draft animal power/labor/seeds), value of crop production on plot	**Supportive**: Female-headed households use much less labor and ox power, are less likely to apply manure/compost, contour plow, and obtain substantially lower crop yields and incomes (42% lower) than male-headed households; women are not usually included in agricultural extension programs
Ragasa et al., 2013	Ethiopia - Regional (4 major regions: Tigray, Amhara, Oromia, and SNNP)	7,530 households and a total of 31,450 plots (random sample)	2011, Central Statistical Agency (CSA) household survey	**Quasi-experimental**: Significance testing (t-test) and regression analysis (cross-sectional instrumental-variable regression (Instruments used include household and plot level factors), multivariate probit, tobit) at household and plot level; demographics and access to services controls included	Gender of household head	Access to extension, input use, production value	**Supportive**: Male household heads are more likely to be visited by and to receive advice from development or extension agents than female heads; female heads are less likely to use or adopt improved technologies and use fewer amounts of inputs; female-headed households have significantly less value of production (mean=9,898 Birr/ha) than male headed households (mean=11,273 Birr/ha); the amount of labor used is greater for male heads than female heads; plots of male heads are more likely to be applied with chemical fertilizer, while plots of female heads are more likely to be applied with manure
Udry, 1996	Burkina Faso - Regional (6 villages in 3 agroclimatic zones)	150 households covering 4655 cultivable plots	1981-1985, four year panel study- Burkina Faso farm household survey conducted by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	**Quasi-experimental**: Regression analysis (OLS fixed effects, Least Squares Tobit fixed effect estimates) at household level; fixed effects are household-year-crop and household-year; plot size, topography, and soil type controls included	Gender of plot manager	Plot yield, fertilizer use	**Supportive**: Plots controlled by women have significantly lower yields than other plots within the household planted to the same crop in the same year, but controlled by men; the effect of a female cultivator is a 30% reduction of yield in regard to average yield; output could be increased by reallocating fertilizer, virtually all of which is concentrated on men's plots

Udry et al., 1995	Burkina Faso - Regional (6 villages in 3 agroclimatic zones)	150 households covering 4655 cultivable plots	1981-1985, four year panel study- Burkina Faso farm household survey conducted by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	**Quasi-experimental**: Regression analysis (OLS, fixed effect Tobit estimates, Cobb-Douglas) at household level; fixed effects are household-year-crop and household-year; labor, inputs, plot size, topography, and soil type controls included	Gender of plot manager	Yield per ha; Labor hrs/ha	**Supportive**: Yields are about 18% lower on women's plots than on similar men's plots (same crop, simultaneously planted, same household); Much less male labor (679 hours less) and non-household labor (451 hours less) per hectare is devoted to plots controlled by women than to similar plots controlled by men
Babatunde et al., 2008	Nigeria - Regional (Kwara state in north central Nigeria)	60 farming households (random sample)	2005, cross section survey conducted by authors	**Non-experimental**: Significance testing (t-test) at household level	Gender of household head	Value of farm tools	**Supportive**: Household resources are more available in male- compared to female-headed households; male-headed households have significantly higher valued farm tools and receive more hours of labor inputs than female-headed households
Doss & Morris, 2000	Ghana - National (60 villages throughout the country)	420 maize farmers (three stage clustered randomized procedure, nationally representative sample)	1997-98, national survey conducted by authors	**Non-experimental**: Regression analysis (tobit) at individual farmer level; Controls for farmer's age, residence status, marital status, ecological zone and level of infrastructure	Gender of individual	Adoption of improved technologies	**Supportive**: Female maize farmers have significantly lower access to land and significantly lower extension service access than male maize farmers
Horrell & Krishnan, 2007	Zimbabwe - Regional (3 rural areas, Chivi in Masvingo province, Mutoko in Mashonaland East and Makoni in Manicaland)	300 households (stratified sample)	2001, household survey conducted by authors	**Non-experimental**: Regression analysis (OLS, tobit, probit) at household level; Controls for labor available to the household, the availability of draught power, manure and machinery, household characteristics	Gender of household head	Yield per acre of crop; assets	**Supportive**: Once inputs are accounted for, it is only for growing cotton that female-headed households' productivity is lower than male-headed households'; female-headed households do not have less income or education but have fewer assets and inputs for agricultural production than male-headed households

Kinkingninhoun-Mêdagbé et al., 2010	Benin - Local (Koussin-Le´le´ irrigation scheme in central Benin)	145 farmers out of which 23 women (stratified random sample)	2004, Institut National de la Recherche Agricole du Benin (INRAB) rice farmer survey	<u>**Non-experimental**</u>: Regression analysis (Production Frontier Model) at plot level; ag. input control included	Gender of individual farmer	Land productivity (tonnes/ha), Income (CFA)	<u>**Supportive**</u>: Women have significantly less access to land and equipment (in terms of quality and quantity) than men; women have lower average yield (3.89 tonnes/ha) as compared to men (4.95 tonnes/ha); larger marginal productivity among men is mainly due to the combined effect of larger land holding size and increasing marginal returns to land
Palacios-López & López , 2015	Malawi - National	12,271 households in 768 enumeration areas (nationally representative sample)	2010-2011, Third Integrated Household Survey (IHS3) conducted by the Malawi National Statistics Office	<u>**Non-experimental**</u>: Regression analysis (OLS) at plot level; demographic, labor, inputs controls included	Gender of plot manager	Ln[Plot Gross Value of Output per hectare]	<u>**Supportive**</u>: Female-headed plots have 44% lower productivity than male-headed plots, 34% of this gap is explained by differences in labour market access and 29% by differences in credit access; liquidity constraints, labour market discrimination and effective off-farm work time, which differ greatly between men and women, result in lower agricultural labour productivity in plots managed by female-headed households
Peterman et al. , 2011	Nigeria, Uganda - Multicountry (8 districts in Uganda and program areas of 12 states in Nigeria)	3750 households in Nigeria; 3625 plots in 851 households in Uganda (random sample)	2003, Uganda Natural Resource Management Linkage Study; 2005, Nigeria Fadama II evaluation of second national agricultural welfare programme	<u>**Non-experimental**</u>: Regression analysis (probit, Cragg's two-tiered unconditional tobit model, Honore's fixed-effects tobit estimator) at household level and plot level; demographic and input controls included	FHH; Crop ownership female	Value of crop yield per area unit	<u>**Supportive**</u>: There is significantly lower productivity on plots owned or managed by females, these results hold when accounting for background factors but vary across crops, by agro-ecological zone, and inclusion of biophysical characteristics, suggesting either cultural or regional gender differences or crop-specific comparative advantages

Quisumbing et al., 2001	Ghana - Regional (Western Region, Brong-Ahafo Region, and Ashanti Region)	60 villages	1997 household survey by authors	**Non-experimental**: Regression analysis (tobit, fixed effects) at household and parcel levels; village fixed effects at household level, household fixed effects at parcel level, random effects model; demographic and tenure system controls included	Gender of individual	Yield	**Supportive**: Female plot managers have lower cocoa yield than male plot managers from the same household. The lower yields of women parcel owners may reveal credit and other constraints faced by women, including their responsibility to provide food for their families.
Rahman, 2008	Nigeria - Regional (northern and southern Kaduna state)	180 farm households, 230 women (random sample)	2002, farm household survey conducted by author	**Non-experimental**: Regression analysis (logit) at household level; household characteristics, education, and access to credit controls included	Gender of individual	Access to resources, involvement in farm decisions	**Supportive**: Women have a lower rate of involvement in farm decisions and lower access to productive resources
Saito, Mekonnen, & Spurling, 1994*	Kenya, Nigeria - Multicountry (3 districts in Kenya and 3 states in Nigeria)	720 households in Kenya; 750 households in Nigeria (random samples)	1994, World Bank/UNDP household surveys	**Non-experimental**: Regression analysis (Cobb-Douglas Production Function) at plot level and household level; demographic and inputs controls included	Gender of individual	Gross value of output per ha, land size, input access	**Supportive**: Agricultural output is reduced owing to women's disadvantaged access to inputs (particularly land) and support services relative to men;
Thapa, 2008*	Nepal - National	2360 households in 275 wards (nationally representative sample)	2003-04, Nepal Living Standard Survey (NLSS II) conducted by Central Bureau of Statistics Nepal	**Non-experimental**: Regression analysis (Translog and Cobb-Douglas production functions) at household level; demographic, inputs, access to services controls included	Gender of household head and farm manager	Output per hectare, access to inputs	**Supportive**: Male-managed farms produce slightly more output per hectare than female-managed farms; male-headed households applied relatively more work hours of family male labour, while female headed households used more work hours of family female labor, and adult male labour is found to contribute more in production process than adult female labour; male-headed households have relatively better access to resources, particularly in access to new varieties of seeds, inorganic fertilizers, agricultural extension services, and farm credit

Tiruneh et al., 2001*	Ethiopia - Regional (Ada, Lume and Gimbichu woredas)	180 households (purposive sample)	1997, Household survey conducted by authors	**Non-experimental**: Regression analysis (logit) at household level; demographic and inputs controls included	Gender of household head	Gross value of farm output, input access	**Supportive**: Male-headed households (MHHs) owned more ox-plows and livestock and cultivated more area than female-headed households (FHHs); average per capita land holding was almost equal between MHHs and FHHs; the marginal value product (MVP) of family labor is higher in MHHs compared to its price (wage rate), but it is lower in FHHs, indicating that MHHs were able to increase their productivity by using more family labor; MVP of farm size was lower than its factor price for MHHs and higher for FHHs, indicating that FHHs could increase their productivity by cultivating more land
Von Braun & Webb, 1989	Gambia - Regional (10 villages in McCarthy island division in central Gambia)	1414 women and 1395 men from 200 households	1985-1986, household survey conducted by authors	**Non-experimental**: Regression analysis (OLS) at household level; demographic and socioeconomic controls included	Gender of individual and head of HH	Labor productivity; input use	**Supportive**: 24% of women's groundnut fields used a multipurpose implement for ploughing, seeding, weeding, compared to 43% of men's fields; Women's labor productivity in individual farming is on an average 70% lesser than men's productivity
Quisumbing, 1996	Kenya, Burkina Faso, Nigeria, Korea, Thailand - Multicountry	52 sources, 8 regression analyses	Literature review	**Review**: Meta-analysis (pooled regressions) at individual and plot levels; Controls for individual characteristics and inputs	Gender of individual and plot manager	Allocative efficiency, labor productivity	**Supportive**: Male-controlled plots have higher input intensity (labor and fertilizer) as compared to female-controlled plots.
Andrews, Golan, & Lay, 2014	Uganda - National	3665 male headed households (nationally representative sample)	2005-2006, Uganda National Household Survey	**Quasi-experimental**: Regression analysis (OLS, household and parcel fixed effects) at plot level; demographic, socioeconomic, urban/rural controls included	Gender of individual farmer	Annual value of plot output	**Supportive**: Women are less productive than men (female spouse-controlled parcels are much smaller (by 32%) and have a lower output value than male-controlled parcels (by 12%).
Gilbert, Sakala, & Benson, 2002	Malawi - National	1400 farms (not representative)	1998-1999, Maize Productivity Task Force (MPTF) impact survey	**Quasi-experimental**: Significance testing (t-test) at household and individual level; trial comparing legume cropping to fertilized and unfertilized maize cropping	Gender of individual farmer	Yield, input use	**Mixed**: women lack access to extension services and inputs; men used more fertilizer than women in high-altitude zones but use levels were similar in low-medium altitude

Adesina & Djato, 1997	Cote D'Ivoire - Local (3 districts in northern Cote D'Ivoire)	347 men and 63 women rice farmers (random sample)	1993-1994, field survey conducted by authors	**Non-experimental**: Regression analysis (simultaneous regression model) at individual level; wage rate, capital, land, fertilizer price, and labor/ fertilizer share controls included	Gender of individual farmer	Normalized profit function, allocative efficiency	**Mixed**: Agricultural efficiency of rice fields is based more on geography and context of the agricultural systems than gender of farmer (gender not statistically significant); women have allocation control of inputs but that does not translate to economic efficiency
Kilic, Palacios-Lopez, & Goldstein, 2015	Malawi - National (768 enumeration areas)	12,271 households (nationally representative sample)	2010-2011, Third Integrated Household Survey (IHS3) conducted by the Malawi National Statistics Office	**Non-experimental**: Regression analysis (recentered influence function (RIF) regression, Naïve regression) at plot level; Controls for factors of production	Gender of plot manager	Ln of gross value of plot output	**Supportive**: Female-managed plots are on an average 25% less productive than male-managed plots; 82% of this gap is due to different endowments

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Table 1.2. Summary of Evidence of Direct Outcomes Related to Pathway 1: Increased Women's Use of Agricultural Productive Resources							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Beaman et al. , 2013	Mali - Local (23 villages in Bougouni district in southern Mali)	383 female farmers randomly selected and then randomly assigned to 3 groups: 135 farmers received full recommended quantity of fertilizer per hectacre, 123 received half of recommnded amount, 125 received no fertilizer	2010 household survey (random sample) by authors to select control and treatment groups	**Experimental:** RCT, Regression analysis (OLS) at plot level; input use and asset controls included	Participation in intervention (fertilizer provision)	Fertilizer usage	**Supportive:** Women who received fertilizer increased both the quantity of fertilizer they used on their plots and complementary inputs such as herbicides and hired labor (17% and 31% in half and full treatment groups); no evidence that profits increased; farmers, regardless of gender, respond to an increase in availability of one input by re-optimizing other inputs, making it challenging to isolate the returns to any one input
Van den Bold et al., 2013*	Burkina Faso - Regional (eastern Gourma Province)	1,380 men and 1,380 women; 25 control villages and two groups of 15 treatment villages (cluster randomized)	2010-2012 cluster randomized control trial quantitative longitudinal impact evaluation by International Food Policy Research Institute (IFPRI) and Helen Keller International	**Experimental:** Regression analysis (difference in difference) at household level; qualitative interview data coded into similar response groups for analysis; ag. capital and asset controls inclded	Participation in intervention (direct transfer of agricultural assets and chickens to women)	Change in ownership of agricultural assets	**Supportive:** Men owned about 2.5 times as many agricultural assets as women at baseline in both intervention and control villages; for both men and women in intervention and control villages, the average number of agricultural assets increased between the baseline and endline surveys; women in intervention villages had a statistically significantly greater increase in the average number of agricultural assets owned than did women living in control villages; at endline, men in intervention villages still held a higher value of agricultural assets, but the ratio between men and women had fallen from 14.6 to 5.9

Fisher & Kandiwa, 2014	Malawi - National	12,271 individuals (nationally representative sample)	2010-2011, Third Integrated Household Survey (IHS3) conducted by the Malawi National Statistics Office	**Quasi-experimental:** Regression analysis (Multinomial logit with instrumental variables) at plot level; IVs were Parliament member residing in community and number of months the household head was away from the village during the previous year to control for selection into subsidy program; demographic, geographic, year, and information controls included	Gender of household head; input subsidy	Adoption of modern maize seed	**Supportive:** Probability of adopting modern maize was 12% lower for wives in male-headed households, and 11% lower for female household heads, than for male farmers; receiving a subsidy for both seed and fertilizer increased the probability of modern maize cultivation by 222% for female-headed households; reduced access to complementary inputs is only a partial explanation for why gender of the farmer influences adoption of modern maize
Gilbert, Sakala, & Benson, 2002	Malawi - National	1400 farms (not representative)	1998-1999, Maize Productivity Task Force (MPTF) impact survey	**Quasi-experimental:** Significance testing (t-test) at household and individual level; trial comparing legume cropping to fertilized and unfertilized maize cropping	Participation in intervention (provision of inputs)	Yield, input use	**Supportive:** There were no significant gender differences across crop yields when inputs were supplied; when female farmers were provided seed and fertilizer inputs, their farm management efforts were equally as productive as the male farmer
Karamba & Winters, 2015	Malawi - National	5656 rural farm households covering 10,210 plots (nationally representative sample)	2010-2011, Third Integrated Household Survey (IHS3) conducted by the Malawi National Statistics Office	**Quasi-experimental:** Regression analysis (OLS, probit, propensity scores for FISP participation) at plot level; demographic, geographic, climate, socioeconomic, and input controls included	Participation in Fertilizer Input Subsidy Program (FISP)	Fertilizer usage, productivity	**Supportive:** FISP participation increases agricultural productivity for both male and female farmers by 17% and increases the probability of using inorganic fertilizers by 21.8% for male farmers and 34.7% for female farmers
Quisumbing et al., 2013	Bangladesh - Regional (9 districts in northern Bangladesh)	1509 households	2008 and 2012 household surveys, longitudinal sample program evaluation	**Quasi-experimental:** Regression analysis (logit, propensity weighted) at household level; household and ag. asset controls included	Participation in SDVCP (dairy value chain project)	Women's ownership of assets, men's ownership of assets, and jointly held assets, women's mobility, and more	**Supportive:** Participation in the program increased the value of men's and jointly held assets; participation also had a modest impact on increasing participation of women in household decisions; women were able to build up assets, not by acquiring assets that they exclusively owned, but by acquiring jointly owned assets

Santos et al., 2014	India - Regional (Coochbehar, Bankura, and Jalpaiguri)	1035 households	2010-2011 household survey of Nijo Griha, Nijo Bhumi (NGNB) program participants	**Non-experimental**: Regression analysis (propensity-weighted-probability that an NGNB-eligible household becomes a beneficiary) at household level; use of credit and tenure controls included	Participation in NGNB program, gender of individual	Tenure security, women's participation in decision-making	**Supportive:** Compared to their non-NGNB peers, women in NGNB households are (1) 12% more likely to be involved in decisions to take loans from Self-Help Groups or microfinance institution; (2) 12% more likely to be involved in decisions on whether to purchase productive assets; (3) 9% more likely to be involved in decisions related to food purchase and consumption; and (4) more likely to be involved in decisions about the family land; the share of the family land over which they are involved in decisions increased by 15% for how to use the land, 14% for what to grow on it, and 11% for whether to sell produce from it
Jagger & Pender, 2006*	Uganda - National (survey data from most of Uganda)	451 households	1999-2011, community, village, and household level surveys conducted by various organizations	**Non-experimental**: Regression analysis (Probit) at household level; demographic, socioeconomic, and asset controls included	Participation in technology promotion efforts	Inorganic fertilizer adoption	**Mixed**: Female household were heads more likely to adopt inorganic fertilizer in response to improved technology use promotion efforts by local organizations

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Table 1.3. Summary of Evidence of Economic Benefits Related to Pathway 1: Increased Women's Use of Agricultural Productive Resources							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Vasilaky, & Leonard, 2013*	Uganda - Regional (villages in North and North-East Uganda)	13 villages received a Social Networking Intervention (SNI) and 17 villages received a standard extension training (TR)	2009-2010, household survey conducted by researchers	**Experimental:** RCT; difference-in-differences analysis ; regression analysis (probit) at plot level; intervention participation controls included	SNI (Social network based ag training)	Yield	**Supportive:** Average 98 kg/acre increase in yield for female farmers and 74 kg/acre increase across all intervention participants
Aguilar et al., 2015	Ethiopia - National	3969 households (nationally representative sample)	2011-2012, Ethiopia Rural Socioeconomic Survey (ERSS)	**Quasi-experimental:** Oaxaca-Blinder mean decomposition; fixed effects model for crop products and different levels of geographical aggregation; Regression analysis OLS) at plot level; demographic, socioeconomic, input controls included	Gender of plot manager	Agricultural productivity (birr/Ha)	**Mixed:** 23.4% gender differential in agricultural productivity, in favor of male land managers; 10.1 percentage points explained by differences in access to resources, and land and land manager characteristics; 13.4 percentage points explained by unequal returns to productive components; There is higher inequality in the middle of the productivity distribution; At lower levels of productivity, returns to factors of production are similar to men and women, the gender gap in productivity is mainly due to lower access to resources for women.
Davis et al., 2012	Kenya, Tanzania, Uganda - Multicountry	1126 (398 farmers from 4 districts in Kenya, 379 from 3 districts in Tanzania, 349 from 3 districts in Uganda)	Farmer field school (FFS) household survey conducted by authors (specific year of survey not given)	**Quasi-experimental:** Longitudinal impact evaluation; a double difference with matching estimators (propensity score matching for participants and non-participants based on characteristics affecting program participation and outcomes and covariate matching) at household level; demographic and socioeconomic controls included	Gender of household head	Crop productivity	**Supportive:** 80% increase in farm productivity in Kenya; 23% in Tanzania; no significant increase in Uganda; participation in FFS increased income by 61% and improved agricultural income and crop productivity overall for all countries combined; per capita agricultural income of female-headed FFS households increased by 187%, while per capita agricultural income of male-headed FFS households did not change significantly; FFS did not have a significant impact on agricultural income of participants with small land area

Gilbert, Sakala, & Benson, 2002	Malawi - National	1400 farms (not representativ e)	1998-1999, Maize Productivity Task Force (MPTF) impact survey	**Quasi-experimental:** Significance testing (t-test) at household and individual level; trial comparing legume cropping to fertilized and unfertilized maize cropping	Gender of individual	Yield, input use	**Supportive:** There were no significant gender differences across crop yields when inputs were supplied; when female farmers were provided seed and fertilizer inputs, their farm management efforts were equally as productive as the male farmer
Udry, 1996	Burkina Faso - Regional (6 villages in 3 agroclimatic zones)	150 households covering 4655 cultivable plots	1981-1985, four year panel study- Burkina Faso farm household survey conducted by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	**Quasi-experimental**: Regression analysis (OLS fixed effects, Least Squares Tobit fixed effect estimates) at household level; fixed effects are household-year-crop and household-year; plot size, topography, and soil type controls included	Gender of plot manager	Plot yield, fertilizer use	**Supportive**: Plots controlled by women have significantly lower yields than other plots within the household planted to the same crop in the same year, but controlled by men; the effect of a female cultivator is a 30% reduction of yield in regard to average yield; output could be increased by reallocating fertilizer, virtually all of which is concentrated on men's plots; the author estimates that as much as 6 percent of output might be lost by inefficient factor allocation across plots controlled by husbands versus wives
Udry et al., 1995	Burkina Faso - Regional (6 villages in 3 agroclimatic zones)	150 households covering 4655 cultivable plots	1981-1985, four year panel study- Burkina Faso farm household survey conducted by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	**Quasi-experimental**: Regression analysis (OLS, fixed effect Tobit estimates, Cobb-Douglas) at household level; fixed effects are household-year-crop and household-year; labor, inputs, plot size, topography, and soil type controls included	Gender of plot manager	Yield per ha; Labor hrs/ha	**Supportive:** A loss of 10-15% of household output is due to inefficient factor allocation within a household, and the authors argue that a higher household output could be achieved through the reallocation of variable factors from plots controlled by men to plots controlled by women

Alene et al., 2008	Kenya - Regional (Nyanza and Western Provinces, 32 villages in 8 major maize growing districts)	592 male-headed households and 208 female-headed households	2000-2005, household survey (source not described further)	<u>**Non-experimental**</u>: Regression analysis (Seemingly unrelated regression method (SUR)) at plot and individual level; demographic and geographic controls included	Gender of individual	Maize output	<u>**Supportive:**</u> Men and women have equal economic efficiency, controlling for inputs; Women may have high benefits from increased access to quality land; The elasticity of maize production with respect to land is 0.43 for women and 0.35 for men farmers, this implies that a 10% increase in land use would raise maize production by 4.3% for women and 3.5% for men farmers, holding other inputs constant; A 10% increase in land, holding fertilizer prices (not quantity) and wages (not amount of labor) constant, increases maize output by 6.2% for men and 6.6% for women; Regular contact with extension raised maize supply by 18% for men and 21% for women farmers
Andrews, Golan, & Lay, 2014	Uganda - National	3665 male headed households (nationally representative sample)	2005-2006, Uganda National Household Survey	<u>**Non-experimental**</u>: Regression analysis (OLS, household and parcel fixed effects) at plot level; demographic, socioeconomic, urban/rural controls included	Gender of plot manager	Annual value of plot output	<u>**Supportive:**</u> Total farm output could be higher and Pareto improvements could be possible if male labor was reallocated to female-controlled plots and/or female labor was reallocated to male-controlled plots; Total household output could be increased by 19% by reallocating male labor to female controlled plots, and by 9% through the vice-versa.
Chavas, Petrie, & Roth, 2005	Gambia - Local (3 peri-urban villages near the capital city of Banjul)	115 households	1993, household survey (source not described further)	<u>**Non-experimental**</u>: Regression analysis (Tobit) at household level; demographic, access to markets, and tenure controls included	Gender of household head	Technical efficiency, allocative efficiency	<u>**Supportive:**</u> Allocative inefficiency is high for farm households; for an average household, the cost of allocative inefficiency amounts to 43% of household income; A significant portion of this cost comes from inefficiency in labor allocation between farm and non-farm activities; male households head status is a significant barrier to allocative efficiency, strong negative relationship between AE and gender of household head; intra-household allocation of labor and land rights contributes to significant allocative inefficiencies in male-headed households

Moock, 1976	Kenya - Local (Vihiga division)	152 maize farmers	1971, survey conducted by author	Non-experimental: Regression analysis (OLS) at farm level; demographic, ag. input controls included	Gender of individual farm manager	Technical efficiency	Supportive: Women maize farmers are more technically efficient than male maize farmers, obtaining about 7% more output at the mean levels of input use
Seymour, 2017	Bangladesh - Regional (rural areas of seven administrati ve divisions	3119 households, 4026 plots of land	2011-12, Bangladesh Integrated Household Survey administered under IFPRI guidance	Non-experimental: Regression analysis (stochastic frontier analysis) at plot level;	Gender of individual	Technical efficiency	Supportive: a 15% decrease in the empowerment gap (which closes the male-female empowerment gap) yields 2.2% increase in technical efficiency. A woman's relative level of empowerment within her household is strongly associated with technical efficiency.
Nwaru, Okoye, & Ndukwu, 2011	Nigeria - Regional (Imo State)	120 sweet potato farmers (multi-stage sample)	2006 household survey by authors	Non-experimental: Regression analysis (Cobb-Douglas stochastic frontier production function) at household level; demographic, socioeconomic, access to credit controls included	Gender of individual	Allocative/Technical/Economic efficiency	Supportive:: Farm size and gender were negatively signed indicating that female farmers were more allocatively efficient than their male counterparts; sweet potato farmers in Imo State are predominantly women who are not fully allocatively, technically and economically efficient; important factors related to production efficiency were household size, farm size, farming experience, credit access and membership of cooperative societies, extension visits and gender of the farmer
Saito, Mekonnen, & Spurling, 1994*	Kenya, Nigeria - Multicountry (3 districts in Kenya and 3 states in Nigeria)	720 households in Kenya; 750 households in Nigeria (random samples)	1994, World Bank/UNDP household surveys	Non-experimental: Regression analysis (Cobb-Douglas Production Function) at plot level and household level; demographic and inputs controls included	Gender of individual	Gross value of output per ha, land size, input access	Supportive: Men's gross value of output per hectare is 8.4% higher than women's gross value of output in Kenya. Based on a simulation exercise, the authors conclude that given the same access to resources as men, women's value of output would increase by 22%, which would more than close the gender gap and indicate that women on average could potentially be more productive farm managers than men.
Quisumbing, 1996	Kenya, Burkina Faso, Nigeria, Korea, Thailand - Multicountry	52 sources, 8 regression analyses	Literature review	Review (Meta-analysis): (pooled regressions) at individual and plot levels; Controls for individual characteristics and inputs	Gender of individual and plot manager	Allocative efficiency, labor productivity	Supportive: Female farmers are equally technically efficient in terms of yields as male farmers, once individual characteristics and input levels are controlled for.

Karamba & Winters, 2001	Malawi - National	5,656 rural farm households covering 10,210 plots (nationally representative sample)	2010-2011, Third Integrated Household Survey (IHS3) conducted by the Malawi National Statistics Office	**Quasi-experimental:** Regression analysis (OLS, probit, propensity scores for FISP participation) at plot level; demographic, geographic, climate, socioeconomic, and input controls included	Gender of individual	Agricultural productivity	**Mixed**: FISP participation increases agricultural productivity for both male and female farmers by 17%
Kinkingninhoun-Mêdagbé et al., 2010	Benin - Local (Koussin-Le´le´ irrigation scheme in central Benin)	145 farmers out of which 23 women (stratified random sample)	2004, Institut National de la Recherche Agricole du Benin (INRAB) rice farmer survey	**Non-experimental**:	Gender of individual	Technical efficiency, labor productivity	**Supportive**: Men have higher productivity than women per unit of land, seeds, fertilizer and labor; average yield of men is 4.95 tonnes/ha and that of women is 3.89 tonnes/ha; the larger MP for men is mainly due to the effect of larger land holding size and increasing marginal returns to land, women too experience increasing marginal returns to land with same factors; those with larger land holdings will have higher marginal returns and higher productivity
Oseni et al., 2015	Nigeria - National	5,000 households, out of which 3,000 agricultural (nationally representative sample)	2010-2011, General Household Survey Panel, conducted by the Nigeria National Bureau of Statistics (NBS)	**Non-experimental**: Regression analysis (RIF decomposition, Oaxaca-Blinder mean decomposition) at plot level; demographic, socioeconomic, input controls included	Gender of individual and plot manager	Log[value of harvest per hectare]	**Mixed**: In the Northern region, women produce 28% less than men, even after controlling for observed factors of production; in Oaxaca-Binder decomposition results, the structural effect is larger than the endowment effect at the mean; if women were given the same level of inputs as men, there would still be significant differences in productivity between men and women; In the Southern region, the endowment effect is more important, access to resources explains most of the 24% of unconditional gender gap in productivity; If women were given the same level of inputs as men, the gap would be statistically insignificant

Slavchevska, 2015	Tanzania - National	3,265 households (nationally representative sample)	2008-09 and 2010-11, Tanzania National Panel Survey	**Quasi-experimental:** Regression analysis (plot, household, and village fixed effects) at household and village level; demographic , inputs, time controls included	Gender of individual	Ln value of harvest per acre (TZS)	**Non-supportive**: Gender gaps along the productivity distribution largely explained by unequal returns to resources, suggesting that equal access to factors of production may not be enough to close the gender gap in productivity; Unequal returns to factors of production, including male family labor and other unobservable factors (perhaps land quality) widen the gender differential in productivity; Within the same household, plots managed by a sole woman are 21% less productive than those managed by a sole man, controlling for manager and plot characteristics, inputs and primary crops; At all levels of productivity, sole female farmers obtain lower returns from the factors they apply on their plots.
Kilic, Palacios-Lopez, & Goldstein, 2015	Malawi - National (768 enumeration areas)	12,271 households (nationally representative sample)	2010-2011, Third Integrated Household Survey (IHS3) conducted by the Malawi National Statistics Office	**Non-experimental**: Regression analysis (recentered influence function (RIF) regression, Naïve regression) at plot level; Controls for factors of production	Gender of plot manager	Ln of gross value of plot output	**Non-supportive**: Household adult male labor input and inorganic fertilizer application have significantly lower positive effects on the productivity of female managed plots.
Peterman et al., 2011	Nigeria, Uganda - Multicountry (8 districts in Uganda and program areas of 12 states in Nigeria)	3750 households in Nigeria; 3625 plots in 851 households in Uganda (random sample)	2003, Uganda Natural Resource Management Linkage Study; 2005, Nigeria Fadama II evaluation of second national agricultural welfare programme	**Non-experimental**: Regression analysis (probit, Cragg's two-tiered unconditional tobit model, Honore's fixed-effects tobit estimator) at household level and plot level; demographic and input controls included	Gender of plot manager	Value of crop yield per area unit	**Non-supportive**: When household-level unobservables and other inputs are controlled for, female-owned plots have the lowest productivity in Uganda

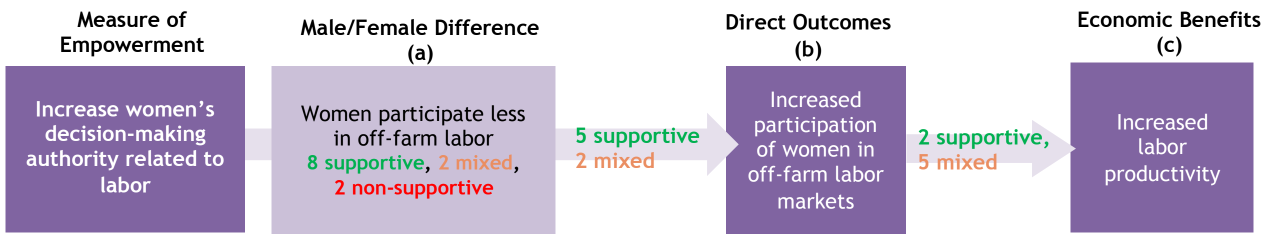
Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Pathway 2: Increased Women's Participation in Labor Markets

The second pathway hypothesizes that increasing women's decision-making authority over their own labor time and mobility would increase women's participation in markets, including off-farm labor markets, which would contribute to increased household labor productivity. While we recognize that not all women would choose to participate more in off-farm labor markets if given full control over their own time and labor, this pathway rests on the assumptions that:

a. Women's labor choices and mobility are more constrained than men's, restricting access to off-farm income opportunities,
b. With more labor choices and mobility women would participate more in off-farm labor, and
c. There would be positive marginal returns to household labor productivity if women were more able to reallocate their labor, including expanding participation in off-farm labor markets *(see Figure 6)*.

Figure 6. Evidence Base Supporting Pathway 2



We identified eleven studies with evidence on the difference between men's and women's participation in off-farm income work in low- and middle-income countries (Table 2.1). Haggblade et al. (2010) review women's share in rural non-farm employment in Sub-Saharan Africa, Asia, Latin America, West Asia and North Africa and find that among these regions, women's share of non-farm employment was highest at 39% in Sub-Saharan Africa, and lowest at 11% in West Asia and North Africa. The authors report that overall women accounted for only about 25% of the full-time rural non-farm employment workforce in most of the developing world. They further find that although women do dominate many cottage industries, these generally have lower returns than other off-farm labor opportunities. We found further evidence from Bangladesh, Indonesia, and Sri Lanka (Rijkers et al., 2012), India (Lanjouw & Shariff, 2004), Nigeria (Babatunde et al., 2010), Rwanda (Clay et al., 1997), Uganda and Ghana (Jost et al., 2016), and Zimbabwe (Matshe et al., 2004) that women are less likely than men to participate in off-farm labor markets. Lanjouw (2001) finds that in El Salvador, women participate less in non-farm labor than men overall, but economically active women are more likely to participate in off-farm work than men, though again mostly concentrated in low-productivity jobs. One study finds that the probability of participation drops further for women with infants (Matshe et al., 2004).

However, Shehu & Abubakar (2015) report a contrary result in Nigeria, where female-headed households were more likely to diversify into non-farm enterprises than male-headed households, similar to the finding of Beyene (2008) that in Ethiopia women in female-headed households were more likely to work in off-farm activities as compared to women in male-headed households. These studies suggest that different circumstances in female-headed households may be associated with increased women's participation in off-farm labor. Similarly, Ruben & Van den Berg (2001) report that in Honduras, households with more female adults report more participation in non-farm wage employment and self-employment. Ackah (2013) finds that female-headed households in Ghana were significantly more likely to be in non-farm self-employment. The higher participation of females in non-farm enterprises activities, where they are generally self-employed or conducting group-based income-generating activities, may indicate a gender bias against participation in employment in the formal off-farm labor market.

Theory suggests that increasing women's control over their own mobility or labor might increase their off-farm labor market participation if they are able to achieve higher returns. Though some women will prefer not to pursue off-farm labor opportunities, increasing women's ability to choose whether to pursue such opportunities would be expected to increase women's off-farm labor. We did not identify any studies reporting on the effects of giving women greater control over their time and labor, but we find evidence from seven studies that women's education, access to credit, and income transfers—all of which increase women's relative capital and potentially their intra-household bargaining position and decision-making authority (Anderson, Reynolds, & Gugerty, 2017; Doss, 2013; Jejeebhoy et al., 2001)—are generally linked to an increased probability of women working in the non-farm sector (Table 2.2).

Abdulai & Delgado (1999) find that in Ghana each additional year of schooling increased the probability of women's participation in non-farm labor by 0.51%, versus 0.30% for men. Similarly, Qiao et al. (2015) find each additional year of education for females in China was positively associated with an increase in the probability of local off-farm work participation by 0.94%. However, Fafchamps and Quisumbing (1999) find the contrary in a study in Pakistan, where better-educated women were less likely to work in both farm and non-farm sectors, though the more educated women that did work were primarily employed in non-farm work. We found evidence from Malawi (Swaminathan, Du Bois, & Findeis, 2010) that access to formal and informal credit was positively associated with the probability of participation in off-farm self-employed activities for women. Additionally, Owusu, Abdulai, & Abdul-Rahman (2011) find in a study in Ghana that a significantly higher proportion of women participating in off-farm work had access to credit (47%), than those who do not participate (27%). A study from Ethiopia (Beyene, 2008) finds the probability of working off-farm increased by 12% for a 10% increase in transfer income to women but no association between off-farm work and availability of credit. Doss (2013) in a review of 61 studies from multiple contexts find that in general there is evidence that women with more bargaining power may be more likely to participate in labor markets.

Gladwin et al. (2000) observe that rural women are not a homogenous group and may have different ability to respond to income-generating opportunities. They argue that younger women with young children and more demands on their labor may be less able to respond to opportunities than older women with grown children and more available labor, but that women in female-headed households may be better able to adopt income-generating activities than women in male-headed households despite having less adult labor available.

While a larger body of evidence reports on the circumstances in which higher returns are possible from non-farm compared to farm labor, we identified seven studies reporting on productivity effects of off-farm labor market participation for women in particular (Table 2.3). Five of these studies report that off-farm labor participation is associated with increased income, but that women may not experience the same income gains as men. Lanjouw (1999) finds that moving from traditional agricultural sector to all other non-agricultural employment sectors is associated with a rise in average income, but reports that women more commonly participate low labor productivity activities as a residual source of employment. Lanjouw & Shariff (2004) report that women in non-farm employment in India are expected to earn 64% less than men in non-farm employment. Yang (1997) finds the marginal labor productivity in farming was below the sample mean wage rate for non-farm work in China, but that women earn less than men for off-farm employment. Nerman (2015) similarly finds evidence of higher marginal returns to labor in households engaged in non-agricultural wage work in comparison with those engaged in agricultural wage work in Tanzania, but again that women have lower wages than men. Owusu, Abdulai, & Abdul-Rahman (2011) report that participation in non-farm employment in Ghana increases household income, but more so for male participants than for female participants.

Two studies suggest that male/female differences in education may explain part of the difference in returns to off-farm labor. Qiao et al. (2015) find that in China, education for females is associated with an increase in income from off-farm work. Similarly, Abdulai & Delgado (1999) report that in Ghana, increases in schooling lead to a greater increase in wages for women than for men.

Table 2.1. Summary of Evidence of Male/Female Differences Related to Pathway 2: Increased Women's Participation in Labor Markets							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Haggblade, Hazell, & Reardon, 2010	Global - Multi-country	96 sources	1973-2007 Literature Review	**Review**: review of literature (no methodology described)	Gender of individual	Non-farm income, rural non-farm income	**Supportive:** Women's share in rural non-farm employment (RNFE) was 39% in Africa, 36% in Latin America, 24% in Asia, and 11% in West Asia and N. Africa; Women account for about 25% of the full-time RNFE workforce in most of the developing world; Women dominate many of the low-return cottage industries
Ackah, 2013	Ghana - Regional (3 zones covering 23 districts in southern, middle and northern parts of Ghana)	9,310 households (nationally representative sample)	2008 Ghana Living Standard Survey Round Five Plus (GLSS 5+)	**Non-experimental**: Regression analysis (probit) at individual level; household demographic, socioeconomic, geographic, access to utilities controls included	Gender of individual and head of household	Non-farm wage employment, non-farm self employment	**Supportive:** "Women are significantly less likely than men to be in wage employment (-0.00792) and more likely than men to be in self-employment activities (0.0172)" (p. 337); "households headed by women gravitate toward nonfarm self-employment (0.220) and away from nonfarm wage employment(-0.501)" (p.336)
Babatunde et al., 2010	Nigeria - Regional (Kwara State)	220 farm households (multistage random sampling)	2006 household survey (no additional information)	**Non-experimental**: Regression analysis (multivarite probit) at household-level; demographic, socioeconomic, access to credit and to utilities controls included	Gender of head of household	Participation in different types of off-farm activities (agricultural wage employment, non-agricultural wage employment, and self employment)	**Supportive:** Male-headed households are more likely to participate in general off-farm employment (coefficient of 0.282 at 10% level) including off-farm agricultural wage employment (coefficient of 1.250 at 5% level) and off-farm non-agricultural wage employment (coefficient of 1.746 at 1% level) but not self-employment
Clay, Kampayana, & Kayitsinga, 1997	Rwanda - National	1,019 farm households (nationwide random sample)	1988 Non-farm Strategies Survey	**Non-experimental**: Regression analysis (multiple) at household-level; demographic and socioeconomic controls included	Gender of individual	Days of non-ag. and ag. employment, days of ag. labor worked	**Supportive:** 80% of off-farm employment is held by men; largest female job contribution are in jobs that have great flexibility as to either when or where they are performed, thereby permitting coordination between on- and off-farm responsibilities [also worth noting in text]
Matshe & Young, 2004	Zimbabwe - Local (Shamva District)	1,183 household members (random sampling)	1996-1997 meso-scale rural market changes household survey	**Non-experimental**: Regression analysis (Tobit, Double Hurdle Model) at individual and household levels; demographic, socioeconomic, geographic, access to credit controls included	Gender of individual household member	Off-farm market participation (binary and hours worked)	**Supportive:** Women, and especially women with infants, are less likely to participate in the off-farm labor market than men (-0.311) but more likely to work more hours

Rijkers & Costa, 2012	Bangladesh, Sri Lanka, Ethiopia, Indonesia - Multi-country	Not specified	2005 Rural Investment Climate Pilot Surveys conducted by World Bank	**Non-experimental**:: Regression analysis (probit, tobit) at individual and household levels; demographic, socioeconomic, geographic, access to credit and to utilities controls included	Gender of individual	Non-farm enterprise participation	**Supportive:** Women have lower participation rates in non-farm enterprise activities than men in Bangladesh, Indonesia and Sri Lanka. In Bangladesh, 8.6% of women are engaged in some non-farm enterprise activity (NFE), compared to almost 53% of men. In Indonesia, almost 10% of women engage in some NFE, compared to over 16% of men. In Sri Lanka, almost 25% of women engage in some NFE, compared to almost 37% of men. In Ethiopia, engagement is comparable at 9.53% and 9.88% for women and men, respectively.
Lanjouw & Shariff, 2004	India - National	35,130 rural households (multistage sample)	1994 National Centre of Applied Economic Research household survey	**Non-experimental**: Regression analysis (multinomial logit, OLS and censored least absolute deviation (CLAD) model) at individual level; demographic, socioeconomic, and geographic controls included	Gender of individual	Employment level in non-farm sector; log non-farm incomes	**Supportive**: Women are less likely to participate in farming and other occupations, non-farm casual wage employment , non-farm own enterprise, and non-farm regular employment across all regions studied with larger magnitude negative coefficients for non-farm participation
Jost et al., 2016	Uganda, Ghana, Bangladesh - Multi-country (3 total villages out of 20 for long-term research villages)	15-20 person focus groups from 1 village with > 50 hh per country (random sampling)	2010 Climate Change, Agriculture and Food Security (CCAFS) focus group interviews	**Descriptive:** Qualitative study; pilot phase evaluation of results for long-term (10-20 years) research	Gender of individual	Distance traveled, likelihood of travel	**Supportive:** Uganda: Men are twice as likely to travel for marketing than women; Ghana: Men are more mobile than women, travelling up to five times the distance for trade and multiple social reasons; Bangladesh: Women are limited to travelling up to 2 kms while men are reported to be more mobile
Lanjouw, 2001	El Salvador - National	4,229 households (EHPM); 630 households (FUSADES) (nationally representative sample)	1994 Encuesta de Hogares de Propositos Multiples 1994 (EHPM) and 1996 Fundacion Salvadorena Para el Desarollo Economico y Social (FUSADES) household surveys	**Non-experimental**: Regression analysis (tobit, OLS) at individual-level; household demographic, socioeconomic, and geographic access to utilities controls included	Gender of individual	Non-farm job (any, and high or low productivity)	**Mixed**: Women are far more likely to be active in non-farm labor than men (72.3% to 24.7% of populations, respectively); Women are 18% less likely than men to have primary non-farm employment when looking at the general population but 49.5% more likely to have primary non-farm employment when looking at the economically active population; women are significantly more likely to be employed in low-productivity jobs
Ruben & Van den Berg, 2001	Honduras - National	818 farm households and 2,584 economically active family members	1993-1994 Encuesta Nacional de Comsumo, Ingreso, Gasto y Nutrición	**Non-experimental**: Regression analysis (tobit, logit) at household level; demographic, geographic, and access to credit controls included	Gender of individual	Farm wage employment; nonfarm wage employment; self-employment	**Non-supportive**: Households with more female adults can participate more in nonfarm wage employment (2.005 coefficient) and self-employment (1.854 coefficient).

Shehu & Abubakar, 2015	Nigeria - National	3,257 farm households (nationally representative sample)	2010-2011 General Household Panel Survey	**Non-experimental**: Regression analysis (tobit) at household level; demographic, socioeconomic, access to credit and to utilities controls included	Gender of head of household	Non-farm enterprise participation	**Non-supportive**: "Female-headed households are more likely to diversify into NFE activity than their male-headed counterparts" (-.33 coefficient for male-headed households) (p. 66)

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Table 2.2. Summary of Evidence of Direct Outcomes Related to Pathway 2: Increased Women's Participation in Labor Markets							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Doss, 2013	Global - Multi-country	61 sources	1993-2011 published literature	Review: Literature Review (methods not stated)	Women's bargaining power	Labor force participation	Supportive: The authors find evidence of a cycle in which women with bargaining power may be more likely to work in the labor force, giving them more bargaining power through increased income and expanded networks
Owusu, Abdulai, & Abdul-Rahman, 2011	Ghana - Local (10 rural communities in Savelugu-Nanton district)	300 households (random sample)	2007 household survey conducted by authors	Quasi-experimental: Regression analysis (probit, propensity score matching) at individual level; PSM to control for self-selection that normally arises when participation in non-farm work is not randomly assigned and self-selection into participation occurs; demographic, socioeconomic, geographic, and access to credit controls included	Education, access to credit, livestock ownership	Non-farm employment	Supportive: Males are more engaged in farming activities, while females are predominantly engaged in non-farm activities; Education and access to credit were significantly associated with non-farm employment for women; Education, access to credit, and livestock ownership were significantly associated with non-farm employment for men
Qiao et al., 2015	China - National	11,744 individuals in 2,832 households (nationally representative sample)	2005 and 2008 household surveys by the Center for Chinese Agricultural Policy	Quasi-experimental: Regression analysis (probit) at household level using panel data; demographic, socioeconomic, time, and controls included	Education	Participation in and income from migration and local off-farm work	Supportive: Education for females positively associated with an increase in probability of local off-farm work participation by 0.94% and migration participation by 1.48%
Abdulai & Delgado, 1999	Ghana - Regional (27 villages in 4 districts in Northern Ghana)	256 households (stratified random sample)	1992-1993 household survey conducted by authors	Non-experimental: Regression analysis (probit) at individual level; demographic, socioeconomic, and geographic controls included	Education	Non-farm wage rate, non-farm work participation, nonfarm work hours (for husband and wife separately)	Supportive: "The marginal effect of a year of female schooling on the probability of participation in nonfarm work was greater than that of male schooling (0.51 versus 0.30)" (p. 124); "The presence of children had no significant effect on the participation decision of women in nonfarm work" (p. 124); "the pattern of dependency of women's participation on their husbands' participation is consistent with the view that women's nonfarm work in the study zone is more of a residual than is the case for men: (p. 128)
Swaminathan, Du Bois, & Findeis, 2010	Malawi - Regional (5 districts: Dowa, Mangochi, Nkhotakota, Rumphi, and Dedza)	404 households (stratified sample)	1995 Malawi Financial Markets and Household Food Security survey	Non-experimental: Regression analysis (bivariate probit), conditional recursive-mixed process (cmp) estimator at individual level; demographic, socioeconomic, and geographic controls included	Access to informal/formal credit	Off-farm work participation, participation in self-employment	Supportive: Marginal effect of formal credit larger than informal credit for women's participation in off-farm self-employment (0.821 to 0.566); "Formal credit is largely used for agricultural inputs by men (77%) and for off-farm income generation activities by women (46%)" (p. 559)

Fafchamps & Quisumbing, 1999	Pakistan - Regional (44 villages in 4 districts)	1,000 households (random sample)	1986-1989 International Food Policy Research Institute (IFPRI) Pakistan Panel Survey	**Quasi-experimental:** Regression analysis (tobit) at individual level using panel data; demographic, socioeconomic controls included	Education	Farm and non-farm labor days worked	**Mixed**: Better educated females are less likely to work in farm or non-farm activities, but if they do work, they provide more time in non-farm work
Beyene, 2008	Ethiopia - Regional (4 regions: Tigray, Amhara, Oromiya, and Nationalities and Peoples' region)	1,681 farm households (random sample)	1999 Ethiopian Rural Household Survey	**Non-experimental**: Regression analysis (probit) at individual level; demographic, socioeconomic, access to credit controls included	Gender of head of households, access to credit, income transfer	Participation in off-farm work	**Mixed**: Female household members are less likely to participate in off-farm activities in male-headed households as compared to female-headed households (coefficient -.01584); availability of credit has no significant effect on women's probability of working off-farm; probability of working off-farm [for females] increased by 0.12 for a 10% increase in transfer income to women

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Table 2.3. Summary of Evidence of Economic Benefits Related to Pathway 2: Increased Women's Participation in Labor Markets							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Owusu, Abdulai, & Abdul-Rahman, 2011	Ghana - Regional (10 rural communities in Savelugu-Nanton district)	300 households (random sample)	2007 household survey conducted by authors	**Quasi-experimental:** Regression analysis (probit, propensity score matching) at individual level; PSM to control for self-selection that normally arises when participation in non-farm work is not randomly assigned and self-selection into participation occurs; demographic, socioeconomic, geographic, and access to credit controls included	Non-farm employment participation	Household income	**Mixed:** Males' participation in non-farm employment results in an increase in household income by about ¢3,467,900 (US$367), while females' participation tend to increase household income by about ¢2,658,600 (US$281)
Qiao et al., 2015	China - National	11,744 individuals in 2,832 households (nationally representative sample)	2005 and 2008 household surveys by the Center for Chinese Agricultural Policy	**Quasi-experimental:** Regression analysis (probit) at household level using panel data; demographic, socioeconomic, time, and controls included	Education	Income from migration and local off-farm work	**Supportive:** Education for females positively associated with an increase in income from local off-farm work participation by 0.87% and income from migration by 3.90%;
Yang, 1997	China - Regional (Sichuan province)	204 households (random sample)	1990 household survey (no additional information)	**Quasi-experimental:** Instrumental variable analysis (instrument = number of household members in the labor force), correlation analysis; demographic controls included	Sector of employment; gender	Wage rate	**Mixed:** The labor marginal productivity in farming is below the sample mean wage rate (4.65 yuan) for non-farm work; positive relationship between education and off-farm wage rates; women earn less than men for off-farm employment (-0.298 coefficient)
Abdulai & Delgado, 1999	Ghana - Regional (27 villages in 4 districts in Northern Ghana)	256 households (stratified random sample)	1992-1993 household survey conducted by authors	**Non-experimental**: Regression analysis (probit) at individual level; demographic, socioeconomic, and geographic controls included	Education	Non-farm wage rate, non-farm work participation, nonfarm work hours (for husband and wife separately)	**Supportive:** "A one-year increase in schooling was found to increase the wage rate of women by 6.9% and that of men by 4.9%" (p. 128); "the own-wage elasticities for males and females are, respectively, 0.32 and 0.66, suggesting that females are more responsive to changes in the marginal returns to their labor than are males" (p. 126-127)

Lanjouw , 1999	Ecuador - National	5,760 households (nationally representativ e sample)	1995 Encuesta de Condiciones de Vida household survey	**Non-experimental**: Regression analysis (OLS, probit) at individual level; demographic, socioeconomic, and geographic controls included	Industry of employment in non-agricultural wage labor	low/high productivity non-ag job; (log) annual nonfarm labor income	**Mixed:** Moving from traditional sector employment to most non-agricultural sectors analysed is associated with a rise in average incomes (true for all industries except mining and extraction); low-labor-productivity activities that act as residual source of employment are common among women; women and other groups who are not able to enter ag. wage employment can gain means to economic security through nonag. income (probit coefficient of .642 for all nonag. employment, 0.852 in low-productivity jobs, -0.248 in high-productivity jobs for probability of employment as primary occupation)
Nerman , 2015	Tanzania - National	3,200 households (nationally representativ e sample)	2008-2009 National Panel Survey (NPS-I)	**Non-experimental**: Regression analysis (OLS) at household level; demographic and access to credit controls included	Activity combination of Household (Ag+Non-Ag Wage Work)	Value of Marginal Product of Labor	**Supportive:** Being engaged in agricultural wage work is correlated with a lower marginal return in own farming; the average and median marginal returns in agriculture are less than 40% of their wage labour counterparts; men tend to have moderately higher wages than women, the different estimates are roughly 10–20% higher for men
Lanjouw & Shariff , 2004	India - National	35,130 rural households (multistage sample)	1994 National Centre of Applied Economic Research household survey	**Non-experimental**: Regression analysis (multinomial logit, OLS and censored least absolute deviation (CLAD) model) at individual level; demographic, socioeconomic, and geographic controls included	Gender of the individual	Log non-farm incomes	**Non-supportive**: Women in non-farm employment are expected to earn 64% less than men in non-farm employment

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

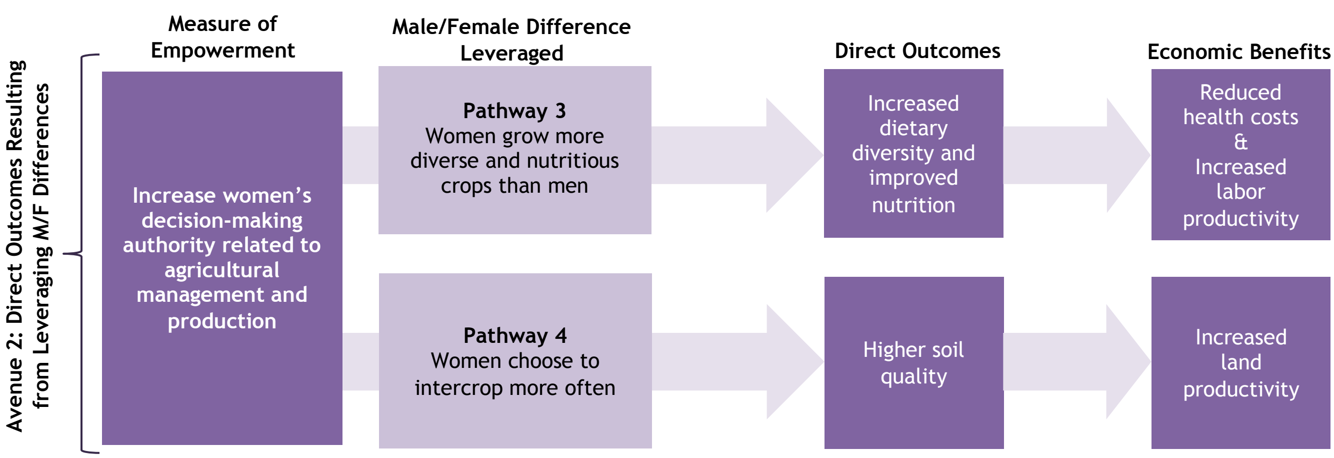
Avenue 2: Leverage Male/Female Differences in Decision-Making

Measure of Empowerment: Increasing Women's Decision-Making Power around Agricultural Management

The next three causal pathways relate to the second hypothesized avenue for economic benefits of empowering women by leveraging male/female differences in decision-making. We note that any measured benefits from leveraging male-female differences in the resource choices they make may dissipate as women gain more access and control if the differences are not due to being a woman per se, but rather stem from being disempowered - since this would change the circumstances in which these differences in decision-making have been observed.

We first considered pathways connected to increasing women's decision-making power related to agricultural management and production (Figure 7). Pathway 3 connects differences in men's and women's decisions of what crops to grow (e.g., Oliver, 2016; Peterman, 2011) with household nutrition outcomes (e.g., Dillon, McGee, & Oseni, 2015; Malapit et al., 2013; Sibhatu, Krishna, & Qaim, 2015; Snapp & Fisher, 2015), while Pathway 4 connects differences in decisions of whether to intercrop crops on a plot (e.g., Bezner-Kerr et al., 2007; EPAR 2013; Khan et al., 2008; Mishra et al., 2009) with farm soil quality (e.g., Abebe et al., 2006; Samake et al., 2006; Zhou et al., 2011).

Figure 7. Economics Benefits of Increasing Women's Decision-Making Power Related to Agricultural Management and Production



We found studies from a wide variety of developing countries reporting on interventions that changed measures of empowerment relating to women's decision-making power in household agricultural management. In Mozambique, the USDA-funded Manica Smallholder Dairy Development Project (MSDPP), a gender-blind asset transfer program where participants were provided with dairy cows and training in animal husbandry, was implemented from 2009 to 2012 in the Manica Province. Women's participation in the maintenance of cows increased due to the training, leading to more consultation with their husbands in production and household decision-making (Quisumbing et al., 2013). In Bangladesh, the Helen Keller International (HKI)-funded NGO Gardening for Nutrition Education Surveillance Project (NGNESP), a program targeted mainly at women, aimed at encouraging year-round vegetable production and Vitamin-A rich crop production amongst poor households with little land. A 2002 study showed that 78% of active participants in the NGNESP were growing fruits and vegetables year-round, compared with 15% of non-participants. Additionally, women participants learned new skills by participating in the NGNESP, perceived an increase in their contribution to household livelihood and economic well-being, and reported full decision-making power on a range of issues compared to women who did not participate (Iannotti, Cunningham, & Ruel, 2009). In Burkina Faso, Van den Bold et al. (2013) find that women's participation in the Helen Keller International (HKI) Enhanced Homestead Food Production (E-HFP) program (2010–2012) increased their participation in decision-making on agricultural production as well as women’s ability to use and own land.

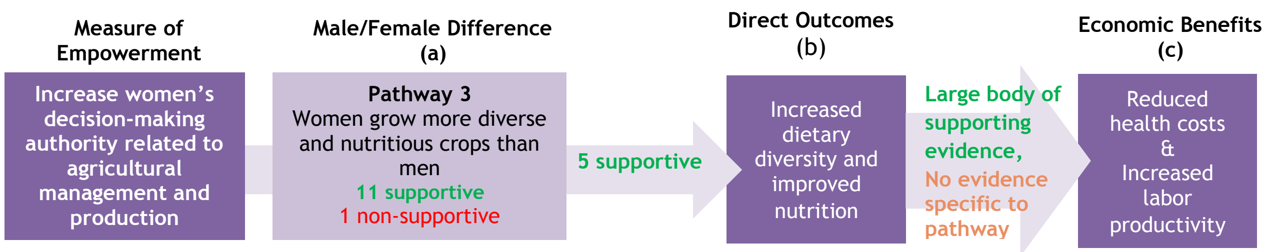
In Uganda and Malawi, the International Center for Tropical Agriculture (CIAT) implemented a participatory research approach that developed the capacity of rural women in accessing market opportunities for competitive products that increase farm income and employment. In both countries, the increase in women’s incomes from their new market opportunities led to an increase in household decisions being made jointly by men and women (Kaaria et al., 2008). In India, in the Participatory Varietal Selection (PVS) program, women were provided with training and seed testing opportunities. Women who participated in this program had an improved decision-making authority related to seed acquisition, exchange, storage and fertilizer application (Paris et al., 2008). In Niger, an intervention in which basic educational training and mobile phones were provided to students increased the variety of crops grown in households where the training was provided to a woman (Aker & Ksoll, 2016). Technoserve’s Coffee Initiative recruits local female extension agents and provides training for small scale coffee farmers in East Africa (Ethiopia, Kenya, Rwanda, Tanzania) with a focus on women farmers. The program has increased production expertise among female farmers and has started to change social perceptions of women (Doss, Bockius-Suwyn, & D’Souza, 2012). In India, farm women groups (Krishak Mahila Shakti Samuh) were formed to provide agricultural support services and training to poor female farmers. Women reported having a greater decision-making power over farm production, an increase in expertise and a gain in community respect post training (DANIDA, 2004). CAFEFEMININO is a program in Latin American countries that promotes women’s property rights over land, through convincing men in the household to transfer a portion of land to women. The program facilitates access to credit and technical support and aims to provide women control over coffee production and marketing. In the Dominican Republic, the active presence of women in the board of coffee producers’ organizations significantly increased as a result of this program (IFAD, 2009).

Pathway 3: Improved Household Nutrition

The third pathway hypothesizes that increasing women’s relative decision-making authority related to agricultural management and production will affect decisions of what crops to plant, increasing household dietary diversity and improving nutritional outcomes, thereby leading to reduced health costs and increased labor productivity. This pathway rests on the assumptions that:

a. Women have less control over agricultural management and production decisions than men, favoring men’s crop planting choices which on average are less diverse and nutritious,
b. Planting a greater diversity of crops and more nutritious crops improves nutrition, and
c. The marginal returns to household nutrition for subsistence households for crop planting decisions made by women (e.g., more nutrient-dense vegetables and legumes) would be higher than for crop planting decisions made by men, *ceteris paribus (see Figure 8)*.

Figure 8. Evidence Base Supporting Pathway 3



We found a large body of evidence indicating that women plant a greater variety of crops than men (Table 3.1) at the individual level and as both heads of households and plot managers. While Cafer et al. (2015) find that both women and men try to diversify their crops relatively equally in the South Wollo region of Ethiopia, studies in Bangladesh (Akhter et al., 2010) Ethiopia (Benin, Smale, & Pender, 2006), Iran (Schadegan et al., 2013), Mexico (Chambers & Momsen, 2007), Nigeria (Dillon, McGee, & Oseni, 2015; Peterman et al., 2011), Peru (Perrault-Archambault et al., 2008), Sudan (Ibnouf, 2009), Tanzania (Amri & Kimaro, 2010), Uganda (Peterman et al., 2011), and Zambia (Saenz & Thompson, 2017) find that women are associated with more crop diversity. In addition, some evidence suggests that the additional crops planted by women include more nutritious crops, such as vegetables and legumes (Peterman et al., 2011), "underutilized" nutritional crops (Mabhaudi et al., 2016) which are associated with positive nutritional outcomes. Amri & Kimaro (2010) Chambers & Momsen (2007) and Ibnouf (2009) explain women's interest in crop diversity and nutritional value by their important role in managing household food security. Oakley & Momsen (2007) find that women in Bangladesh help maintain agrobiodiversity through their responsibility for seed processing, storage, and exchange, and Tsegaye (1997) reports that women play a similar role in conserving crop genetic resources in Ethiopia.

It is not clear, however, that the difference between men's and women's crop planting decisions would hold if women were given more authority over household plots, as male/female differences in crops planted may be due to specialization in crop cultivation at the household level, with traditionally "women's crops" allocated to female-managed plots (Akhter et al., 2010; Mabhaudi et al., 2016; Orr et al., 2016; Peterman et al., 2011). In five studies, the greater variety of crops grown by women seems to be due to the diversity of crops on home garden plots, which are generally controlled by women (Akhter et al., 2010; Amri & Kimaro, 2010; Chambers et al., 2007; Ibnouf, 2009; Schadegan et al., 2013), although, a study from Peru finds that women plant more species on home garden plots than do men (Perrault-Archambault et al., 2008). Further, four studies look at differences in crop diversity by the gender of the head of household (Benin, Smale, & Pender, 2006; Dillon, Mcgee, & Oseni, 2015; Saenz & Thompson, 2017) and find that female-headed households are associated with more crop diversity, and Peterman et al. (2011) find that female-headed households in Nigeria are more likely to grow leafy green vegetables, cassava, and yams, but less likely to grow other main crops compared to male-headed households. These studies suggest that differences in planting decisions are not solely based on allocation of certain crops to women.

As a result of this male/female difference in crop planting decisions, increasing women's decision-making power related to agricultural management and production could in theory lead to increased dietary diversity and improved nutrition for household members. The link between household crop diversity and positive nutritional outcomes in multiple contexts is relatively well-established in the literature (Dewey, 1981; Dillon, McGee, & Oseni, 2015; Ekesa, Walingo, & Abukutsa-Onyango, 2008; Jones, 2014; Jones et al., 2014; Kumar et al., 2015; Marasinghe et al., 2015; Marten & Abdoellah, 1988; Oliver, 2016; Oyarzun et al., 2013; Snapp & Fisher, 2015; Thompson & Meerman, 2014; Torheim et al., 2004). Two studies, however, suggest that benefits of crop diversity may not exist in all contexts or extend to all household members. Rajendran et al. (2014) find no significant association between farm diversity and dietary diversity in Tanzania, and Sibhatu, Krishna, & Qaim (2015) come to a similar conclusion for Kenya and Ethiopia, which indicates that other factors may affect the relationship between crop diversity and nutrition outcomes.

We identified five studies reporting particularly on the role of women in the link between crop diversity and nutrition for women and men (Table 3.2). Pandey et al. (2016) find that women's empowerment interventions aimed at agricultural diversification to nutrient-rich crops can improve household nutritional outcomes. Jones et al. (2014) find that the association of increased farm diversity on dietary diversity is greater in female-headed households than in male-headed households in Malawi. Dillon, Mcgee, & Oseni (2015) report that in Nigeria, a 10% increase in crop diversity results in a 2.4% increase in dietary diversity and that female heads of household are associated with greater dietary diversity through their higher levels of diverse crops. Shively & Sununtnasuk (2015) find that in Nepal, the share of vegetables and roots among crops was negatively associated with stunting and argued that women's empowerment is critical for linking improvements in agriculture to improvements in nutrition. Oliver (2016) reports that women participating in a co-op in Uruguay increased the diversity of their crops rather than specializing, and attributed improvements in food security resulting from women's participation in the co-op to the greater crop diversity and to women's income diversification from sales through the co-op.

A large body of empirical evidence supports the assumption that improvements in household nutrition could lead to a variety of economic benefits through reduced health costs (Chen et al., 2009; African Union Commission et al., 2014; Darnton-Hill et al., 2005; Hoffman & Klein, 2012; Pelletier et al., 1995; The World Bank, 2006) and increased labor productivity (Aguayo et al., 2003; Agulanna et al., 2013; Behrman, 1993; Bhargava, 2016; African Union Commission et al., 2014; Croppenstedt & Muller, 2000; Deolalikar, 1988; Dinda et al., 2006; FAO, 2004; Haddad & Bouis, 1991; Harris, 2014; Jha et al., 2009; Popkin, 1978; Schultz, 2005; Strauss, 1986; Van Den Boom et al., 1996; The World Bank, 2006). For example, a study from Egypt, Ethiopia, Swaziland, and Uganda finds that eliminating child undernutrition can reduce health costs by up to 11% of the total public budget allocated to health (African Union Commission et al., 2014), and a World Bank (2006) report states that individual productivity losses due to malnutrition globally are estimated at more than 10% of lifetime earnings. We did not, however, identify any studies reporting on the longer-term economic benefits of women's decisions to plant more diverse and nutritious crops. General supporting evidence for the link from improved household nutrition to increased labor productivity and reduced health costs is summarized in Table 3.3.

Table 3.1. Summary of Evidence of Male/Female Differences Related to Pathway 3: Improved Household Nutrition							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Mabhaudhi et al., 2016	Southern Africa - Regional (South African Development Community)	43 sources	Literature review (literature from 1993-2016)	**Review**: Review of literature on under-utilised crops in Southern Africa	Gender of individual	Cultivation of underutilized nutritious crops	**Supportive:** A significant number of underutilized crops are cultivated in Southern Africa; typically these crops are managed by women, have greater nutritional value due to diversity, require less inputs, and are more resilient than market-oriented crops
Benin, Smale, & Pender, 2006	Ethiopia - Regional (Northern Ethiopia)	739 households (representative random sample)	1998-2001 survey conducted by the authors	**Quasi-experimental:** Regression analyses (OLS, SUR (seemingly unrelated regression), CLAD (censored least absolute deviations)), (no mention of controls). Instrumental variables: altitude, walking times to nearest mill, input supply shop, bus service.	Gender of individual and head of household	Inter-specific and infra-specific cereal diversity, as measured by the Margalef (richness of species) and Shannon (richness and relative abundance) indices	**Supportive:** Households headed by women grow more evenly distributed wheat varieties, while households with proportionately more women grow more varieties per unit area of wheat, barley and maize; households with higher proportions of females or female household heads are more likely than others to grow cereal crops with greater infra-specific diversity
Dillon et al., 2015	Nigeria - National	3,000 agricultural households (nationally representative sample)	2010/2011 General Household Survey-Panel conducted by the Nigeria national Bureau of Statistics	**Quasi-experimental:** Regression analysis (Two-stage and OLS) at household level; controls for economic welfare and household characteristics	Gender of head of household	Crop diversity	**Supportive:** Gender of head of household is found to have a significant effect on dietary diversity with female head of households being associated with higher levels of diverse crops.
Perrault-Archambault & Coomes, 2008	Peru - Local (Northeastern Peru, Amazonian region)	300 homegardens	2003 data collected by author	**Non-experimental:** Regression analysis (linear) at home garden level; village size and "other factors" controls included	Gender of plot manager	Number of species per garden	**Supportive:** Gardens tended by women are associated greater diversity (4 more species) than those tended by men

Peterman et al., 2011	Nigeria, Uganda - Multi-country (8 districts in Uganda and program areas of 12 states in Nigeria)	3750 households in Nigeria; 3625 plots in 851 households in Uganda (random sample)	2003, Uganda Natural Resource Management Linkage Study; 2005, Nigeria Fadama II evaluation of second national agricultural welfare programme	**Non-experimental**: Regression analysis (Tobit) at individual and household levels	Gender of plot manager and head of household	Crops produced	**Supportive:** In Nigeria, female-headed households are significantly more likely to grow leafy green vegetables (mean 0.05 vs. 0.03, SD 0.21 vs. 0.17) and less likely to grow nearly all other main crops save cassava and yams. Male-owned plots in Uganda are significantly more likely to contain banana, maize, and coffee while female-owned plots are significantly more likely to contain sweet potato, sorghum, beans and peas.
Saenz & Thompson, 2017	Zambia - National	4,286 households completing Waves I through III of the supplemental surveys (nationally representative sample)	1999-2000 Post-Harvest Survey and supplemental surveys conducted in 2001, 2004, and 2008.	**Non-experimental**: Regression analysis (logit) at household-level; controls for household, farm, and market characteristics	Gender of head of household	Crop diversity	**Supportive:** Input subsidies reduce crop diversification more in male-headed households than in female-headed households (Abstract, pg.1); authors conclude that "… greater cropland diversification will be maintained if input subsidy programs are accompanied by loan programs and other assistance which support leadership roles for women in farm households"
Schadegan et al., 2013	Iran - Regional (Basht District)	192 households (random sample)	2008 survey conducted by the authors	**Non-experimental**: Regression analysis (stepwise) at individual level	Gender of individual	Species richness (biodiversity)	**Supportive:** There is a positive relationship between women work in homegardens and extant species richness, and a strong correlation between women's decision-making ratio and species richness

Akhter et al., 2010	Bangladesh - Local (Sylhet Sadar District)	80 women from 4 different villages	2008 survey conducted by authors	**Descriptive:** Descriptive statistics (summary statistics, crosstabs) at individual level	Gender of individual	Agro-biodiversity in home gardens, women's socioeconomic well-being	**Supportive:** Women spend more time in the homegarden than men (6-8 hours/week vs 4-5 hours/week); 52% of women surveyed participate in decision-making in selecting species for homegardens. "… increased involvement of women in a broad range of homegarden management activities is not only beneficial for their own socio-economic well-being, but also imperative for sustaining the livelihoods of their communities and for preserving the agro-biodiversity in homegardens." The role of women management of agricultural management is greater than men in developing countries. Medicinal plants are an importantly gendered knowledge held by women.
Amri & Kimaro, 2010	Tanzania - Local (Bariadi District)	150 heads of household (stratified random sample)	Date not specified. Interviews conducted with heads of HHs, presumably by primary researchers/authors	**Descriptive:** Descriptive statistics (summary statistics, crosstabs) at individual level	Gender of individual	Seed diversity of crops and varietals	**Supportive:** "… women's exchange networks are vital to maintaining seed supply systems and trading crop genetic diversity." "Women also have a broader set of seed varietals selection criteria than men, since they use plant materials in more diverse ways…"
Chambers & Momsen, 2007	Mexico - Local (Bajío district)	140 households (representative stratified random sample)	2004 data collected by primary researchers/authors	**Descriptive:** Descriptive statistics (summary statistics, crosstabs) at individual level	Gender of plot manager	Crop diversity	**Supportive:** Farm labor is divided along traditional lines (men with cash crops, women with home crops); women tend to manage small plots and homegardens; women have more knowledge of, and interest in, conserving maize variety as they are primarily in charge of household nutrition and taste
Ibnouf, 2009	Sudan - Regional (Western Sudan region)	275 individuals (representative stratified random sample)	2003 survey of adult rural male and female farmers growing seasonal crops in Western Sudan conducted by authors	**Descriptive:** Descriptive statistics (summary statistics, crosstabs) at individual level	Gender of individual	Household agricultural activities	**Supportive:** Women are dominantly responsible for food securing activities, including homegarden maintenance, wild species collection, food preparation, daily food provision, and post-harvest activities), but share relatively equal roles with men in general farm and livestock activities

Cafer et al., 2015	Ethiopia - Regional (South Wollo, Amhara region)	120 households with 433 individuals	2010 data collected by primary researchers (enumerators took anthropometric measurements)	**Descriptive:** Descriptive statistics (summary statistics, crosstabs) at individual and household level; controlling for geographic region, village, rainy season duration, irrigated vs. rainfed, and cereal vs. cash crops	Gender of individual	Food security and nutritional outcomes (measured by BMI)	**Non-supportive:** Female-controlled resources were employed more successfully and efficiently for household purposes resulting in improved household well-being (measured by BMI).

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Table 3.2. Summary of Evidence of Direct Outcomes Related to Pathway 3: Improved Household Nutrition							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Pandey et al., 2016	South Asia - Multicountry	25 studies (out of 2080 original papers from "Agriculture nutrition South Asia" search)	2000-2014 literature review	**Review**: Literature Review based on search string "Agriculture nutrition South Asia" in Google Scholar	Crop diversification	Nutritional outcomes	**Supportive**: Women empowerment-based interventions aimed at ag. diversification to nutrient-rich crops, fruits, vegetables, and aquaculture can improve nutritional outcomes
Dillon et al., 2015	Nigeria - National	3,000 agricultural households (nationally representative sample)	2010/2011 General Household Survey-Panel conducted by the Nigeria national Bureau of Statistics	**Quasi-experimental:** Regression analysis (OLS) at household level; controls for economic welfare and household characteristics	Crop diversity	Dietary diversity	**Supportive:** A 10% increase in crop diversity results in a 2.4% increase in dietary diversity. Gender of head of household is found to have a significant effect on dietary diversity with female head of households being associated with higher levels of diverse crops.
Jones et al., 2014	Malawi - National	6,632 households (nationally representative sample)	2010-2011, Third Integrated Household Survey (IHS3) conducted by the Malawi National Statistics Office	**Non-experimental**: Regression analysis (OLS) at household level; controls for household (e.g., size, sex of head of HH), farm (e.g., farm size, cropped area), and socio-economic (e.g., off-farm income, non-food expenditures) characteristics	Farm diversity, based on three measures: 1) crop count, 2) crop and livestock count, 3) Simpson's Index	Dietary diversity, assessed by two measures: 1) modified Household Dietary Diversity Score, 2) household's Food Consumption Score	**Supportive:** All measures of farm diversity were strongly positively correlated with measures of dietary diversity with the exception of the Simpson's Index and the Food Consumption Score ($p = 0.126$). More diverse household diets positively influence the nutritional status of household members.
Shively & Sununtnasuk, 2015	Nepal - National	1,769 children 0-59 months (stratified random sample)	2010/2011 Nepal Living Standards Survey	**Non-experimental**: Regression analysis (OLS) at individual level; controls for socio-economic and household characteristics	Total agricultural diversity; Share of vegetables of total agricultural production	Height-for-age z-scores (measure of child nutrition)	**Supportive:** Total agricultural diversity was not associated with child nutrition, but vegetables and roots as a share of crops produced was negatively correlated with stunting. Women's empowerment has been recognized as a key pathway that links improvements in agriculture to improvements in nutrition.

Oliver, 2016	Uruguay - Local (Canelones region)	Case study of a single agroecological women led herb cooperative	Case study of a Uruguayan agroecological herb co-operative, Calmañana founded in 1980s	**Descriptive:** Case study of women's farming co-op that aims to empower women through income diversification, increased food security for the family, and by promoting group solidarity	Participation in farming co-op	Crop diversity	**Supportive:** Women's involvement through Calmañana has resulted in greater food security due to greater crop diversity, a diversified income base (products sold in local stores and markets and exported), and women social empowerment. Rather than specializing, the Calmañana farmers increased the diversity of their products with the technical assistance of researchers.

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Table 3.3. Summary of Evidence of Economic Benefits Related to Pathway 3: Improved Household Nutrition							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Aguayo, V. M., Scott, S., & Ross, J., 2012	Sierra Leone - National	22 cited sources	Literature review	**Review**: Review of literature based on PROFILES, a data-based approach to nutrition policy analysis	Malnutrition, anemia	Child mortality, agricultural productivity	**Supportive:** 46% of child deaths in Sierra Leone are attributable to malnutrition. "The analysis showed that, in the absence of adequate policy and programme action to reduce the unacceptable rates of anaemia in women, the monetary value of agricultural productivity losses associated with anaemia in the female labour force over the next five years will exceed $94.5 million" (Aguayo, Scott, & Ross, abstract).
Behrman, 1993	Developing countries - Multi-country	75 cited sources	Literature review	**Review**: Review of literature on effects of nutrition on productivity	Anemia	Marginal productivity of labor	**Supportive:** A range of studies investigated by this review suggest that there are important positive direct and indirect effects of nutrition on productivity; "Levin calculates that the benefit-cost ratios for anemia reduction may be substantial: ranges of 7-71 for fortification and 6-54 for supplementation in Indonesia, Kenya and Mexico" (Behrman, 1764).
Darnton-Hill et al., 2005	Pakistan, Vietnam, Ghana, Nepal, Zambia, Sierra Leone, India - Multi-country	56 sources	Literature review	**Review**: Review of literature on micronutrients and health	Presence of micronutrients (vitamin A, iodine, iron, zinc) in diet	Output (measured as GDP or GNP)	**Supportive:** Micronutrient deficiencies incur substantial economic costs. One study finds that the dominant effect for all countries is the loss associated with cognitive deficits in children. Citing Horton, this report notes that "… estimates that just 3 types of malnutrition - protein-energy malnutrition, iron deficiency and iodine deficiency - are responsible for 3% - 4% of GDP loss in Pakistan in any given year and 2% - 3% of GDP loss in Vietnam." And that, "Productivity of adult anemic agricultural workers (or other heavy manual labor) is reduced by 1.5% for every 1% decrease in hemoglobin (Hb) concentration below the established threshold for safe health" (Darton-Hill, 1200S).
FAO, 2004	India, Nigeria, Tanzania, Peru, Ghana and more - Multi-country	4 WHO/UNICEF/ ICCIDD studies	WHO/UNICEF/I CCIDD data	**Review**: Review of data from the WHO, UNICEF, and ICCIDD	Investments in nutrition	Nutritional status and economic productivity	**Supportive:** Investments in nutrition have direct and indirect causal effects on productivity and efficiency in laborers and, hence, labor productivity; this leads to increased economic growth and national development
Harris, 2014	-	0	0	**Review**: Examines gender differences in nutritional/health status on productivity	undernutrition, iron-deficiency anemia, HIV, malaria	Productivity and well-being of men and women in agriculture	**Supportive:** "These disorders have both direct and interacting impacts…"

Hoffman & Klein, 2012	Developing countries - Multi-country	55 cited references	Literature review	**Review**: Review of literature on the causes and long-term effects of poor nutrition	Stunting as measured in height-for-age z scores	Growth retardation and other nutrition-related chronic diseases as measured by "stunting"	**Supportive:** "The potential economic fallout of continued poor nutrition, poor growth and changing diets and activity patterns will be great given the healthcare costs and social problems associated with NRCD" (Hoffman & Klein, abstract). "... there are over 150 million children worldwide who are growth retarded and even if a small percentage of these children suffer from permanent metabolic changes that increase their risk for NRCD, the potential for a significant economic impact due to increased need to treat such diseases is staggering (Hoffman & Klein, 399).
The World Bank. , 2006	Countries in South Asia, L. America, MENA, East Asia, Eastern Europe, SSA - Multi-country	36 sources	Literature review	**Review**: Review of literature on micronutrient deficiencies	Micronutrient deficiencies, malnutrition	Productivity, output as measured by GDP	**Supportive:** Preventing micronutrient deficiencies in China will be worth between $2.5 -$5 billion in increased annual GDP; productivity losses in India due to malnutrition (iron, iodine, anemia) will amount to about $114 billion between 2003 and 2012
Bhargava, 2016	Philippines - Regional	3,080 children (cluster-randomized sample)	1983-2005 Cebu Longitudinal Health and Nutrition Survey (22 survey rounds)	**Quasi-experimental:** Regression analysis (OLS) with longitudinal data using two different models (cross-sectional, dynamic random-effects) at various time intervals in the children's lives (2, 8-19, 22 years) (instrumental variable = children's height at age 2.	Mother's BMI and energy intake at birth, morbidity index	Children's heights at 22 years	**Supportive:** Mothers' BMI and energy intakes were positively and significantly associated with children's heights; mothers' morbidity index was negatively associated with children's heights. Mothers' nutritional status and morbidity index have a significantly positive relationship with children's height and weight from birth through 19 years of age.
Croppenstedt, A., & Muller, C., 2000	Ethiopia - Regional	430 households sampled from 1,477 that were interviewed	1994 Ethiopian Rural Household Survey	**Quasi-experimental:** Instrumental variables regression analysis (instruments = composition, age and education of household head and members, household assets, distance to water and firewood), Stochastic frontier approach for measuring agricultural output, Cobb-Douglas production function; controls for farm and household characteristics	Weight-for-height	Agricultural labor productivity	**Supportive:** The output elasticity of weight-for-height is estimated at between 1.9 and 2.26. At the mean, a change in weight-for-height of one standard deviation will change output by 27 percent (paraphrased).

Schultz, 2005*	Ghana, Cote d'Ivoire, Brazil - National	9,686 households	1985-1989 LSMS data for Cote d'Ivoire and Ghana; 1989 Health and Nutrition Survey in Brazil	<u>Quasi-experimental:</u> Regression analysis (OLS) at individual level. Instrumental variables = prices of and access to health inputs	Height, BMI	Wages	<u>Supportive:</u>: In Ghana, a one cm. increase in height is associated with a six to eight percent increase in wages. A one unit increase in BMI is associated with a nine percent increase in wages for men in both Ghana and Cote d'Ivoire compared with seven and 15 percent for women in Ghana and Cote d'Ivoire, respectively. In Brazil, height was associated positively with wages with an increase of one cm. in height for men and women associated with 3.9 and 5.6 percent wage increases, respectively.
Strauss, J., 1986	Sierra Leone - Regional (3 enumeration areas)	125 households (stratified random sample)	1974-75 survey conducted by authors	<u>Quasi-experimental:</u> Instrumental-variables regression analysis (instruments = farm assets, household size, and number of adults) at household level	Caloric consumption	Agricultural Productivity	<u>Supportive:</u> At the sample mean, a one percent increase in caloric intake is associated with a 0.33 percent increase in output and with a 0.19 percent increase in marginal product.
African Union Commission, NEPAD Planning and Coordinating Agency, UN Economic Commission for Africa, and UN World Food Programme , 2014	Egypt, Ethiopia, Swaziland, Uganda - Multicountry	N/A	Data are broad and collected at the national level: Annex 5 which summarizes the sources is missing from this report.	<u>Non-experimental</u>: Study based on concept of differential probabilities, nationally representative survey datasets.	Child malnutrition	Losses in productivity, child mortality	<u>Supportive:</u> Economic cost of child undernutrition: Egypt = EGP 1.1 billion, Ethiopia = ETB 1.8 billion, Swaziland = SZL 60.7 million, Uganda = UGX 525.8 billion (Table 1.2, pg. 5)
Agulanna et al. , 2013	Nigeria - Regional	470 rural farmers	No date specified, field survey conducted by authors	<u>Non-experimental</u>: Regression analysis (Tobit) at individual level; controls for socioeconomic characteristics	BMI and Dietary Diversity scores	Frequency of sickness, representing a direct link to adverse effects on labor productivity	<u>Supportive:</u> BMI and Dietary Diversity scores have an effect on the frequency of occurrence of sickness in rural farmers
Chen et al., 2009	Taiwan - National	764,526 elementary children born between 1 Jan. 1997 and 31 Aug. 1999	1997-1999, Taiwan National Health Insurance Scheme data	<u>Non-experimental</u>: Difference-in-difference analysis comparing children from four income level bands; regression analysis (random-effects logit) at individual level	Weight at birth, malnutrition	Ambulatory visits linked with various diseases	<u>Supportive:</u> Low birth weight was substantially associated with higher ambulatory care expenses among children; Children living in poverty were more likely to receive ambulatory care for nutrition-related diseases (e.g., iron deficiency, and other ill-defined diseases related to nutrition).
Deolalikar, 1988	India - Regional	40 households randomly selected from 240	1975- panel data from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Village -Level Studies (VLS) data	<u>Non-experimental</u>: Semi-log wage equation estimated for wage and a Cobb-Douglas production function used to measure the value of crop output, using random effects and panel fixed effects	Caloric intake; weight-for-height	Individual wage and farm production	<u>Supportive:</u> Neither market wages nor farm output are observed to be responsive to changes in the daily energy intake of workers; both are highly elastic with respect to weight-for-height. Weight-for-height has a very strong positive effect on farm output with an output elasticity ranging from 1.3 (random effects) to 1.9 (fixed effects).

Dinda et al., 2006	India - Regional (Eastern region)	3,567 coalminers from a sample of 5,777 underground and 1,236 surface coalminers	1986-1993 Regional Occupational Health Centre data	**Non-experimental**: Regression analysis (OLS) at individual level; controls for duration of work and environmental conditions	Individual height	Logarithm of monthly wage earnings	**Supportive:** "Height is the result of complex biological and nutritional processes" (Dinda, et al., 343). Adult height is realized in part by nutritional status. Workers of average height earn 9-17 percent more than their shorter counterparts and 6-13 percent more than average reference height
Jha et al., 2009	India - Regional	6,594 households from a total sample of 35,130 households out of 1,765 villages, 195 districts, 16 states (multi-stage stratified random sample)	1994 National Council for Applied Economic Research survey	**Non-experimental**: Regression analysis (Tobit) at individual level	Levels of micronutrients in diet	Wage earnings	**Supportive:** In all but one of 5 of the micronutrients tested, marginal effects are significant on wage earnings for rural farmers
Popkin, 1978	Philippines - Regional	157 workers	Survey conducted by authors	**Non-experimental**: Regression analysis (OLS) at individual level; controls for individual and household characteristics	Anemia	Labor productivity	**Supportive:** Anemia significantly affected the work output per day in each occupational group with non-anemic workers significantly more productive than anemic workers
Van Den Boom et al., 1996	Ghana - National	1,147 adults (643 men, 504 women) (nationally representative, no mention of sampling procedure)	1987-88 Ghana Living Standards Survey	**Non-experimental**: Regression analysis (multivariate)	Weight, BMI, food consumption	Labor productivity	**Supportive:** A one percent increase in of weight or BMI translates into a 0.8 percent increase in their labor productivity. The effect is smaller for women - around a 0.1 percent increase for each percent increase in weight or BMI.
Pelletier, D. L., Frongillo Jr, E. A., Schroeder, D. G., & Habicht, J. P. , 1995	Developing countries - Multi-country	Not specified; nationally representative data on child weight-for-age from 53 developing countries	International prevalence data based on cite: UNICEF. Child malnutrition: progress toward the World Summit for Children goal. New York, UNICEF, 1993.	**Descriptive:** Descriptive statistics, Epidemiological statistic of population attributable risk (PAR)	Malnutrition	Child mortality	**Supportive:** In the 53 countries surveyed, child deaths due to malnutrition average 56% with a median of 36% as a weighted percentage of total children's deaths.

Haddad, L. J., & Bouis, H. E. , 1991	Philippines (Mindanao, Southern Ph.) - Local	448 rural households	1990 survey conducted by authors	<u>**Quasi-experimental:**</u> Regression analysis (OLS, 2SLS, within fixed effects, Hausman-Taylor random-effects technique) at individual level(instrumental variables = household size, non-labor income, distance to nearest market)	Height	Farming wage rate	<u>**Mixed**</u>: For adults, the elasticity of height on wage at the mean of the data is between 1 (at the mean) and 1.38 (H-T estimate). Elasticity estimates generated using the two panel techniques are quite stable across specifications, but are quite different across techniques suggesting the possible existence of time-varying unobservable effects. Estimated elasticity is not statistically significant for adolescents. A 15 centimeter difference in height is associated with a 13 percent increase in wage rate.

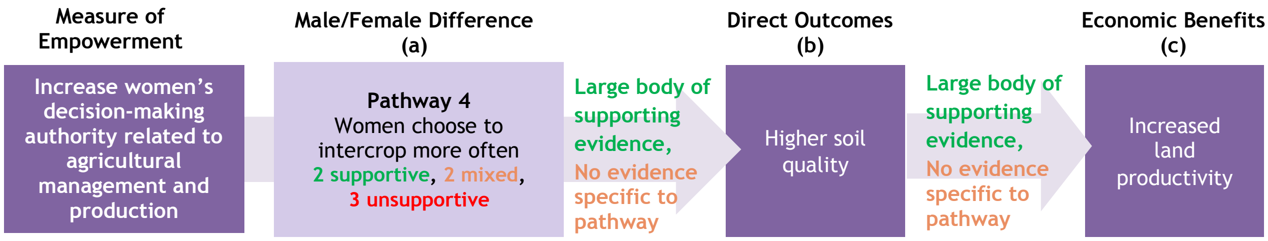
Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Pathway 4: Improved Cropland Soil Quality

The fourth pathway hypothesizes that increasing women's decision-making authority over farm management would result in improved on-farm soil management practices including higher rates of intercropping, leading to improved soil quality, and ultimately higher land productivity. This pathway rests on the assumptions that:

a. Women have less control over agricultural management and production decisions than men, favoring men's management choices which involve less intercropping,
b. Intercropping improves soil quality, and
c. The marginal returns to household land productivity from women's greater proclivity to intercrop would be higher than management decisions made by men, *ceteris paribus (see Figure 9)*.

Figure 9. Evidence Base Supporting Pathway 4



Previous research had suggested that female managed plots are intercropped more frequently than male managed plots in India (Mishra et al., 2009) and Tanzania (EPAR, 2013), but the overall evidence on gender differences in the likelihood of intercropping is mixed (Table 4.1). Ndiritu, Kassie, & Shiferaw (2014) find that more female-managed plots are intercropped, but that after controlling for demographic, socio-economic, and geographic and plot characteristics there is no significant difference in intercropping between male- and female-managed plots, though jointly-managed plots were significantly more likely to use maize-legume intercropping in Kenya. Bezner-Kerr et al. (2007) found that after a participatory research intervention teaching farmers the benefits of legume intercropping, male and female farmers were equally as likely to expand intercropping practices from the baseline measurement. A study by EPAR (2013) using data from Tanzania finds that gender of the household head made no significant difference for intercropping. Three studies report on the likelihood of adoption of intercropping methods by gender, with mixed results. Khan et al. (2008) find that female-headed households were significantly more likely to adopt a specific intercropping method in Kenya. But Buyinza & Wambede (2008) find that female headed households were 5% less likely than male headed households to adopt agroforestry intercropping methods in Uganda, and Chijikwa (2013) finds that female farmers were significantly less likely to express willingness to adopt intercropping than male farmers in Zambia.

An abundance of empirical evidence supports the hypothesis that intercropping leads to improved soil quality (Table 4.2). The various mechanisms for improvement of soil quality through intercropping include: greater availability of nutrients including organic carbon, nitrogen, and phosphorus (Crusciol et al., 2015; Dahmardeh et al., 2010; Dzung & Preston, 2007; Garland et al., 2016; Ilany et al., 2010; Li et al., 2015; Odunze et al., 2008; Samake et al., 2006; Verma et al., 2014; Wu et al., 2016); increased diversity and activity of soil biome, including bacteria (Sun et al., 2009; Wu et al., 2016), microfauna (Blanchart et al., 2006), and other microbes (Verma et al., 2014); reduced soil erosion (Dzung & Preston, 2007; Garland et al., 2016; Li et al., 2015; Odunze et al., 2008); and lowered levels of acidification and salinization (Wu et al., 2016). Eight of these studies reported benefits of intercropping legumes with cereal crops specifically; for example, Jakhar (2012) finds that in Orissa, India, intercropping finger millet with legumes (pigeonpea) was associated with a 14% improvement in phosphorous in the soil, compared to mono-cropping of finger millet. While none of the evidence specifically reports on effects of women's intercropping on soil quality, there is no objective reason to believe the outcomes of intercropping would be different by gender.

The link between soil quality and agricultural productivity is also relatively well-established in the field of soil sciences (Table 4.3), and we found evidence that soil degradation negatively affects agricultural productivity across the globe (Lal, 2009; Naylor, 1996). Other studies examine this connection within the context of Sub-Saharan Africa, arguing that farmers' investments in soil conservation can pay off in low-resource settings (Byiringiro & Reardon, 1996; Tittonell & Giller, 2013; Tittonell et al., 2008). Two studies used Principal Component Analysis (PCA) to examine which variables affect the variance in crop productivity and found that soil attributes explained 70% of the variance in rice yield in India (Chakraborty & Mistri, 2015) and 88% of the variance in rice yield in China (Liu et al., 2015). Six studies find that the gains in soil quality from intercropping specifically lead to greater agricultural productivity (Abebe, Tadesse, & Tola, 2016; Crusciol et al., 2015; Rusinamhodzi et al., 2016; Samake et al., 2006; Smith et al., 2016; Zhou, Yu, & Wu, 2011). For example, Crusciol et al. (2015) conducted a field experiment in Brazil to test whether plots previously intercropped with maize and palisadegrass (Brazilian native plant) were more productive than plots previously planted with sole maize. They find that the intercropped plots had higher soil pH, greater soil nutrient content, and led to a 14% increase in soybean yield, a 24% increase in white oat yield, and a 12.7% increase in maize yield over the previously monocropped plots.

Table 4.1. Summary of Evidence of Male/Female Differences Related to Pathway 4: Improved Household Soil Quality							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Khan et al., 2008	Kenya - Regional (15 districts in western Kenya)	923 farmers: 478 adopters of PPT intercropping, 445 non-practicing farmers (control)	2005 survey of farmers conducted by study authors and Kenya's Ministry of Agriculture	**Non-experimental**: Regression analysis (logit) at the plot level; household demographic and geographic controls included	Gender of head of household	Adoption of the push-pull (PPT) intercropping method	**Supportive**: Male-headed households are significantly less likely (coefficient = -0.58) than female-headed households to adopt the push-pull (PPT) intercropping method.
Mishra et al., 2009*	India - Local (Koraput district, Orissa)	7 tribal villages with farm families	Focus groups and field visits conducted by study authors	**Descriptive**: No methods specified for analysis of focus group and survey information	Gender of household member	Responsibility over mixed cropping systems	**Supportive**: "Unlike other cropping systems, mixed cropping in uplands is the prime responsibility of tribal women, especially when landholdings are small. Though men possess knowledge of this native cropping system, it is women who carry out all the practices in the field, except land preparation" (pp. 49).
Bezner-Kerr et al., 2007	Malawi - Local (Ekwendeni)	350 households (purposeful sample); 5 focus groups with 4-10 farmers in each	2000-2005 Soil, Food and Healthy Communities Project conducted by Ekwendeni Hospital and study authors	**Non-experimental**: Chi-squared test for associations at individual level; qualitative interview data analyzed using Miles & Huberman technique	Gender of farmer	Plot area with legume intercropping after intervention; whether plot manager expanded legume intercropping	**Non-supportive**: After a participatory research intervention teaching farmers the benefits of various agricultural technologies, male farmers expanded legume intercropping across larger plot areas (though male farmers' plots were larger on average than female farmers'), but male and female farmers were equally as likely to expand intercropping methods.
Buyinza & Wambede, 2008	Uganda - Local (Kabale district)	60 farmers	2004 survey conducted by study authors	**Non-experimental**: Regression analysis (dichotomous logistic model) at the household level; household demographic and socio-economic controls included	Gender of head of household	Adoption of agroforestry intercropping technique	**Non-supportive**: Female-headed households are associated with a 5-percentage point decrease in the likelihood adopting agroforestry intercropping compared to male-headed households.

Chijikwa, 2013*	Zambia - Local (Magoye)	80 smallholder cotton farmers	2010 survey conducted by the Cotton Development Trust	**<u>Non-experimental</u>**: Chi-squared test for associations at individual level	Gender of farmer	Reported willingness to adopt intercropping	**<u>Non-supportive</u>**: 92% of male farmers reported being willing to adopt intercropping compared to 70% of female farmers, a significant difference.
Ndiritu, Kassie, & Shiferaw, 2014	Kenya - Regional (western and eastern regions)	2,687 plots from 578 households	2011 survey conducted by the International Maize and Wheat Improvement Center and the Kenya Agricultural Research Institute	**<u>Non-experimental</u>**: Regression analysis (probit) at the plot level; household demographic, socio-economic, and geographic and plot characteristic controls included	Gender of plot manager	Maize-legume intercropping	**<u>Mixed</u>**: "About 42% and 32% of plots managed by females and males, respectively, are covered by maize-legume intercropping, with a statistically significant difference" (pp. 119). There was no significant difference between female- and male-managed plots when controlling for other variables (probit regressions), but jointly-managed plots are more likely to adopt maize-legume intercropping (coefficient = 0.161) than are male-managed plots.
EPAR, 2013*	Tanzania - National	5,285 plots from 2,298 households	2008/2009 Tanzania LSMS-ISA	**<u>Descriptive</u>**: T-tests for associations at plot and household level	Gender of plot manager; gender of head of household	Intercropping on household plots	**<u>Mixed</u>**: Plots with a female decision-maker or shared decision-making between a male and female were more likely to intercrop than plots where a male makes the decision alone. At the household level, gender of the household head was not significantly related to the use of intercropping.

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Table 4.2. Summary of Evidence of Direct Outcomes Related to Pathway 4: Improved Household Soil Quality							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Blanchart et al., 2006	Benin - Local (Cotonou)	3 experimental plots: 3 treatments, no replications	1988-1999 field experiment conducted by study authors	**Field Experiment**: Mann-Whitney U-test for differences between treatments; Principal Component Analysis with soil variable controls included	Maize intercropped with Mucuna legume	Composition and activity of soil biota	**Supportive**: "Macrofauna density and biomass were two to fourfold higher in the plot with Mucuna than in plots without Mucuna" (pp. S141)
Crusciol et al., 2015	Brazil - Local (Botucatu)	24 experimental plots: 12 replications of 2 treatments	2002-2007 field experiment conducted by study authors	**Field Experiment**: Analysis of variance comparing treatment means; blocks and block interactions considered random effects; soil variable controls included	Maize intercropped with palisadegrass	Soil nutrient content	**Supportive**: The plots with previous corn intercropped with palisadegrass exhibited higher soil pH and exchangeable calcium and magnesium in the 0- to 0.20-m depth compared with crop monoculture
Dahmardeh et al., 2010	Iran - Local (Zabol)	64 experimental plots: 4 replications of 16 treatments	2007-2008 field experiment conducted by researchers at Research Center at University of Zabol	**Field Experiment**: Analysis of variance comparing treatment means; soil variable controls included	Maize intercropped with cowpea	Soil nutrient content	**Supportive**: Higher ratios of intercropping maize and cowpea significantly increased the nitrogen, potassium and phosphorus content of soil comparing to maize monoculture
Dzung & Preston, 2007	Vietnam - Local (Sontay)	20 experimental plots: 4 replications of 5 treatments	2003-2004 field experiment conducted by the Goat and Rabbit Research Center	**Field Experiment**: Analysis of variance (general linear model) and Tukey's pair-wise comparison to compare treatment means; soil and plot variable controls included	Cassava intercropped with Flemingia (legume)	Biomass content, soil fertility	**Supportive**: Biomass yield of cassava and Flemingia in an inter-cropping system was improved by increasing the number of cassava rows relative to cassava in the first year, but decreased slightly in the second year; the crude protein content of the cassava foliage deceased as the area of cassava relative to Flemingia increased; soil fertility over a 24 month period increased in the plots with the highest ratio of Flemingia and decreased as the ratio of cassava to Flemingia was increased.

Garland et al., 2016	Malawi - Local (Linthipe)	12 experimental pots: 3 replications of 4 treatments	Controlled greenhouse experiment in Switzerland with Malawaian soil	**Field Experiment**: Tukey's Honest Significant Difference (HSD) test to compare treatment means, controlled lab environment	Maize intercropped with pigeon pea with no barrier, maize intercropped with pigeon pea with a mesh barrier between plants	Soil nutrient content	**Supportive**: Intercropping maize with pigeon pea increased the proportion of macroaggregates and microaggregates increased by 52 and 111%, respectively, compared to sole maize.
Jakhar et al. , 2012	India - Local (Koraput)	30 experimental plots: 3 replications of 10 treatments	2007-2010 field experiment conducted by researchers at the Central Soil and Water Conservation Research and Training Institute	**Field Experiment**: Analysis of variance comparing treatment means	Intercropping systems of finger millet with legumes (pigeonpea), ginger, and papaya	Soil nutrient content, soil erosion	**Supportive**: Multitier cropping of papaya and Gliricidia with ginger/pigeonpea intercropping recorded the highest enrichment ratio, signifying reduced nutrient loss compared to ginger and pigeonpea monocultures
Li et al., 2015	China - Local (Chongqing City)	36 soil samples: 3 replications of 12 treatments	2000-2005 field experiment conducted by study authors	**Field Experiment**: Regression analysis (OLS) at the plot-level; one-way analysis of variance used to compare treatment means; soil variable controls included	Maize and sweet potato plots intercropped with hedgerows	Soil erosion, soil nutrient content	**Supportive**: Soil volumetric fractal dimension significantly increases for land within hedgerows uphill, under, and downhill from the hedgerow compared to land between hedgerows.
Odunze et al., 2008	Nigeria - Local (Zaria)	20 experimental plots: 4 replications of 5 treatments	1991-1992 field experiment conducted by study authors at the Ahmadu Bello University farm	**Field Experiment**: Comparison of treatment means (test not stated)	Maize intercropped with four different legume species	Soil moisture content, soil nutrient content	**Supportive**: Maize-legume intercropping treatments increased soil organic carbon between 8.2 and 47.2 percentage points compared to control; increased soil total nitrogen between 14.3 and 29.3 percentage points compared to sole maize

Sun et al., 2009	China - Local (Inner Mongolia Autonomous Region)	12 experimental plots: 3 replications of 4 treatments	2006 field experiment conducted by researchers at the Experimental Agricultural Ecosystem Station of Inner Mongolia Agricultural University	**Field Experiment**: Analysis of variance comparing treatment means, Principal Component Analysis	Siberian wild rye intercropped with alfalfa	Siberian wild rye yield, alfalfa yield, soil biological factors, soil enzyme activities	**Supportive**: Alfalfa-Siberian wild rye intercropping significantly increased soil enzyme activities and microbial biomass compared to Alfalfa and Siberian wild rye monocultures
Verma et al., 2014	India - Local (Purara)	36 experimental plots: 4 replications of 9 treatments	Field experiment conducted by the Central Institute of Medicinal and Aromatic Plants	**Field Experiment**: Analysis of variance comparing treatment means	Geranium and potato intercropping, spacing between plant specimens	Soil nutrient content; soil microbial biomass	**Supportive**: Intercropping geranium and potato produced soil respiration rates up to 85.3% greater, soil microbial biomass levels up to 36.4% greater, soil organic carbon levels up to 36.6% greater, and soil nitrogen levels up to 25% greater than geranium monoculture
Wu et al. , 2016	China - Local (Harbin)	360 experimental pots: 3 replications of 3 treatments with 40 test pots each	2013 controlled greenhouse experiment conducted by reserachers at the Experimental Center of Northeast Agricultural University	**Field Experiment**: One-way analysis of variable and Tukey's HSD compared treatment means; principal component analysis	Tomato intercropped with potato onion	Soil nutrient content, soil microbial health, soil acidification, soil salinization	**Supportive**: Intercropping tomato with potato onion increased soil fertility by reducing the levels of soil acidification and salinization compared to tomato and potato onion monocultures
Zhou, Yu, & Wu, 2011	China - Local (Harbin)	9 experimental plots: 3 replications of 3 treatments	2006-2007 controlled greenhouse experiment conducted by researchers at the Experimental Center of Northeast Agricultural University	**Field Experiment**: Tukey's test to compare treatment means and principal component analysis	Cucumber intercropped with onion, cucumber intercropped with garlic	Soil enzyme activity, soil bacterial and fungal health	**Supportive**: Intercropping cucumber with onion or garlic increased cucumber productivity and improved soil quality, including increases in soil urease, soil catalase, and bacterial and fungal community structures compared to monocropped cucumber

Ilany et al., 2010	Argentina - Regional (Monte Carlo, Misiones province)	80 study plots on 20 plantations: 10 plantations for both control and treatment	Field experiment conducted by study authors	**Field Experiment**: Multivariate analysis of variance and analysis of variance to compare treatment means; soil and plot variable controls included	Yerba mate intercropped with fir trees	Soil nutrient content	**Mixed**: Intercropping I.paraguariensis, a major South American crop, with tree plantation systems produced lower nutrient levels than I.paraguariensis monoculture, but were better at maintaining soil quality over time
Samake et al., 2006	Mali - Local (Lagassagou)	48 experimental plots: 4 replications of 12 treatments	1998-2001 field experiment conducted by study authors	**Field Experiment**: Analysis of variance comparing treatment means	Millet intercropped with cowpea; millet monocropped after cowpea monocrop; fallow duration	Soil nutrient content, resistance to striga weeds	**Mixed**: Intercropping a cowpea crop in the first year followed by 3 years of a pearl millet/cowpea intercrop reduced the decline in soil carbon and nitrogen content compared to a cowpea crop in the first year followed by 3 years of pearl millet monocrop, but these differences were not consistent over time

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Table 4.3. Summary of Evidence of Economic Benefits Related to Pathway 4: Improved Household Soil Quality							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Chakraborty & Mistri, 2015	India - Local (West Bengal)	20 soil samples (random sample)	Field experiment conducted by authors	**Field Experiment**: Principal component analysis at the plot-level; soil characteristic controls included	Soil pH	Land productivity	**Supportive**: Among the studied six variables, 70 per cent of variance has been explained by P, OC and K in the productivity of paddy. Other physical and chemical properties of soil is also important for crop yield. As range of organic matter content and electrical conductivity in the soil is low, there is no such strong influence in productivity. But, soil pH is the most influential factor in the crop production.
Liu et al., 2015	China - Regional (Hunan and Jiangxi provinces)	84 soil samples (randome sample from study sites)	Field experiment conducted by authors	**Field Experiment**: Principal component analysis at the plot-level; soil characteristic controls included	Soil quality index comprised of biological, chemical, and physical soil parameters	Rice yield	**Supportive**: A soil quality index derived from PCA of 28 soil attributes that explained about 88% of soil variability was significantly correlated with rice yield.
Tittonell et al., 2008	Kenya - Regional (Teso, Vihiga, and Kakameha districts)	522 farmers' fields on 60 farms paired with data on maize yield and agronomic management for a sub-sample of 159 fields	Field experiment conducted by authors	**Field Experiment**: Regression analysis (classification and regression trees analysis) at the field-level; household, management, soil, and landscape characteristics included as controls	Soil fertility	Crop yield	**Supportive**: Resource use intensity, planting date, and time of planting were the principal variables determining yield, but at low resource intensity, total soil N and soil Olsen P became important yield-determining factors. The results suggest that soil fertility variability patterns on smallholder farms are reinforced by farmers investing more resources on already fertile fields than on infertile fields.
Crusciol et al., 2015	Brazil - Local (Botucatu)	24 experimental plots: 12 replications of 2 treatments	2002-2007 field experiment conducted by study authors	**Field Experiment**: Analysis of variance comparing treatment means; blocks and block interactions considered random effects; soil variable controls included	Soil nutrient content after maize and palisadegrass intercropping treatment	Maize yield, soybean yield, white oat yield	**Supportive**: Higher soil fertility resulting from maize-palisadegrass intercropping increased subsequent soybean yield by 14%, white oat yield by 24%, and maize yield by 12.7% over plots that had been previously treated with maize monocrop
Rusinamhodzi et al., 2016	Mozambique - Local (Manaca)	12 randomly chosen plots on 3 case study farms	Field experiment conducted by authors	**Field Experiment**: Crop model (field-scale resource interactions, use efficiencies and long-term soil fertility development model, non-regression) analysis at the plot-level; soil and crop characteristic and household characteristic controls included	Maize-legume intercropping	Crop yield	**Supportive**: The modelling output suggested that intensifying maize production through maize-legume intercropping can raise maize yields in spite of the smaller net area cropped with maize.
Samake et al. , 2006	Mali - Local (Lagassagou)	48 experimental plots: 4 replications of 12 treatments	1998-2001 field experiment conducted by study authors	**Field Experiment**: Analysis of variance comparing treatment means	Soil nutrient content after millet and cowpea intercropping treatments	Millet yield	**Supportive**: Millet yields were not significantly lower in millet-cowpea intercropping treatments compared to controls, and after third planting season, millet yields on millet-cowpea incropped plots increased by 22% due to higher soil fertility gained from intercropping.

Zhou, Yu, & Wu, 2011	China - Local (Harbin)	9 experimental plots: 3 replications of 3 treatments	2006-2007 controlled greenhouse experiment conducted by researchers at the Experimental Center of Northeast Agricultural University	**Field Experiment**: Tukey's test to compare treatment means and principal component analysis	Soil enzyme activity and soil bacterial and fungal health after cucumber and onion/garlic intercropping treatments	Cucumber yield	**Supportive**: Cucumber-onion and cucumber-garlic intercropping treatments significantly increased yields over cucumber monocropping and also significantly reduced loss in cucumber productivity from planting over three consecutive growing seasons.
Byiringiro & Reardon, 1996	Rwanda - National	1,240 farm households operating 6,464 plots (stratified random sample)	1990-1991 weekly survey of farmers in Rwanda	**Non-experimental**: Regression analysis (log-log transformation of linear model) at the plot-level; farm use, farm & plot characteristics, labor controls included	Soil conservation	Marginal value product (MVP) of land	**Supportive**: Farms with greater investment in soil conservation have much better land productivity than average. Those with very eroded soils do much worse than average.
Tittonell & Giller, 2013	Africa (select countries, including Kenya, Uganda, Zimbabwe, Tanzania, Mozambique, Ghana, Ivory Coast, Togo, Mali, Malawi, and Benin) - Multicountry	Data on soil and crop samples from 11 African countries	Literature review	**Non-experimental**: Simulation crop model created from existing literature and data at the crop-level; crop, farm, and environmental characteristics included as controls	Soil quality and fertility	Crop yield	**Supportive**: Degraded and poorly responsive soils cover large areas of Africa, and represent the majority of poor farmers' fields in certain regions. The fertilizers that are generally available simply do not work on degraded soils. Substantial investment to build soil organic matter is needed to restore such soils to a responsive state.
Lal, 2009	Global - Multicountry	150 sources	Literature review	**Review**: Review of literature on soil degradation and its effects on agricultural productivity and food security, summarized current state of the food security literature and connected that to environmental effects (namely soil degradation) that will intensify as a result of climate change	Soil degradation	Crop yield	**Supportive**: In SSA, an estimated 95 million hectares of arable land are severely degraded. Between 1975 and 2005 the annual rates of soil nutrient depletion in SSA were 22kg of Nitrogen, 2.5kg of Phosphorus, and 15kg of Potassium per cultivated hectare of land, an annual loss of $4 billion in fertilizers. Similarly high rates of soil degradation persist in South Asia, especially India.

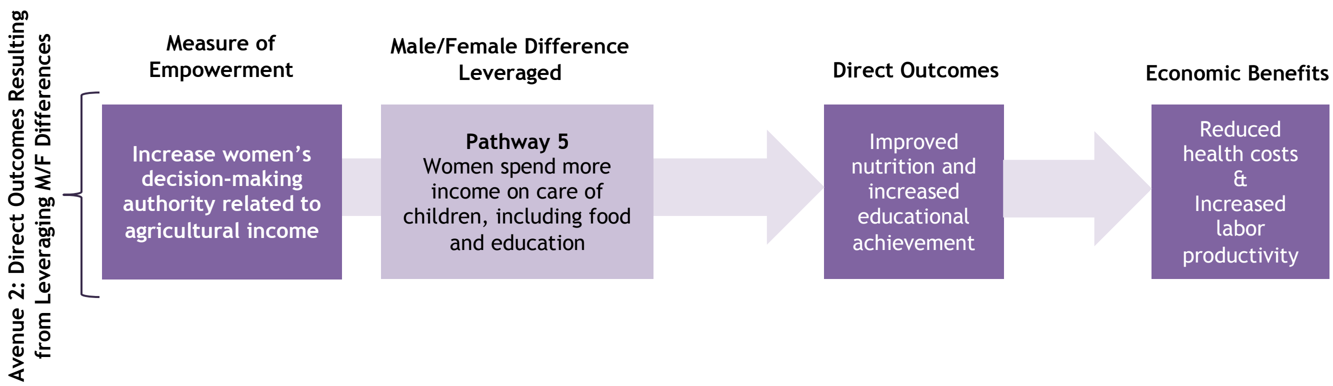
Naylor, 1996	Philippines, Bangladesh, India, US, Sub-Saharan Africa - Multicountry	104 sources	Literature review	**Review**: Review of literature on soil degradation around the world, extracted information on results of field experience and analyzed by location	Soil erosion	Agricultural productivity	**Supportive**: "Although the effects of soil erosion on global agricultural productivity are difficult to isolate empirically, Pimentel et al (49) provide examples of a 20% or more loss in maize yields on severely eroded land in the United States, and an 80% reduction in maize yields in some degraded areas of the Philippines during the past 15 years. They also present a model of erosion impacts on US agriculture as a whole, which shows an 8% reduction in crop productivity in the short term (1 year) and a 20% reduction over the long term (20 years)" (pp. 110).
Abebe, Tadesse, & Tola, 2016	Ethiopia - Local (Bako)	36 experimental plots: 3 replications of 12 treatments	2010-2013 field experiment at Bako Agricultural Research Center conducted by study authors	**Field Experiment**: Analysis of variance comparing treatment means; soil variable controls included	Soil nutrient content after maize and climbing bean intercropping treatments	Maize yield	**Mixed**: In high rainy season maize-climbing bean intercropping treatment increased maize yield 17% over maize monocropping, but in low rainy season maize-climbing bean intercropping treatment reduced maize yield by 14% over maize monocropping
Smith et al., 2016	Malawi - Regional (central Malawi)	26 growing seasons in three agroecologic zones with two doubled-up legume rotation (DLR) systems tested	2013 Survey of agricultural households and soil and yield data from field experiments in central Malawi	**Non-experimental**: Agricultural Production Systems Simulator (crop model, non-regression) at the plot-level; soil and crop characteristic controls included	Crop rotation systems	Crop yield	**Mixed**: Both doubled-up legume rotation (DLR) and traditional rotation systems increased maize grain yields when compared with monoculture maize or maize pigeonpea intercrops receiving the same fertilizer rate. Grain yields of soybean and groundnut were unaffected by pigeonpea intercrops across the full range of sites and season. Stover production was much higher in DLR systems and maize/pigeonpea intercrops than in other cropping systems.

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Measure of Empowerment: Increasing Women's Decision-Making Power around Agricultural Income

The final measure of women's empowerment in agriculture that we considered was women's decision-making power related to agricultural income. The theorized causal pathway for benefits of improving this measure of women's empowerment, illustrated in Figure 10 draws a connection between differences in how men and women spend income from agriculture to impacts on household nutrition and education outcomes.

Figure 10. Economics Benefits of Increasing Women's Decision-Making Power Related to Agricultural Income



We found studies reporting on interventions that changed outcomes similar to women's decision-making power related to agricultural income from South Asia (Bangladesh and India), and Sub-Saharan Africa (Ghana, Kenya, Uganda, and Zambia). A study from Bangladesh reports that participation in the Smallholder Livestock Development Project (SLDP), a program started by the Department of Livestock Services (DLS) in collaboration with three NGOs led to an increase in women's control over earned income and improved social status (Alam, 1997). The Strengthening the Dairy Value Chain (SDVC) project in Bangladesh increased the proportion of households where the wife decides on dairy expenses. Participation in the program also had impact on increasing women's participation in household decision-making and increasing women's mobility. However, the effects on decision-making and mobility were not sustained after exiting the program (Quisumbing et al., 2013). NGOs in India have helped landless women to form groups to purchase and cultivate land. Women have been able to hire tractors and travel large distances to market their produce. These interventions increased women's control over income (Agarwal, 2003).

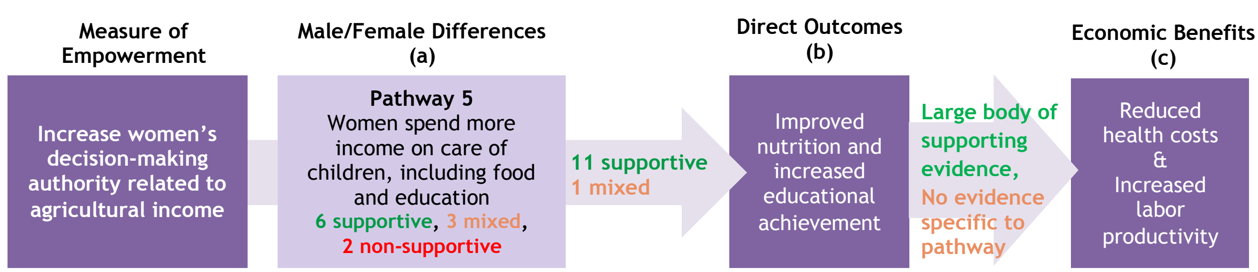
Doss, Bockius-Suwyn, & D'Souza (2012) analyze projects in India, Ghana, Kenya, and Uganda. The Sunhara Wal-Mart Project in India targeted women farmers and included interventions such as starting financial practices within groups and linking groups with large buyers. The authors find that income increased for the beneficiaries and women reported an increase in household decision-making power. The USAID Green Belt Movement program in Kenya provided tools and training for women to grow seedlings on community lands, and for rainwater harvesting. The authors report that this program increased women's income and beneficiary women used this income to access more financial services, and that female leadership in politics also increased. Technoserve Ghana's Shea Project provided business and technical training for shea nut processing and marketing to economically marginalized women. Women participating in this program not only increased their income and production of shea butter, but also started using banks, saving in cash instead of in kind and contributing to paying for medical and educational expenses of their families. In the Agricultural Support Program (ASP) in Zambia, meetings between participating households (husband, wife, children) and extension program workers take place. Participating in this program improved gender relations at the household level and increased women's control over household resources (Bishop-Sambrook & Wonani, 2008).

Pathway 5: Improved Household Nutrition and Educational Achievement

Doss (2006) finds the share of assets held by women (used as a proxy for women's bargaining power) to be positively associated with rural household expenditure on food and education in a study in Ghana, suggesting that changing the bargaining power of women would influence household expenditure patterns. However, Aromolaran's (2010) analysis of households in southwestern Nigeria contradicts this finding, concluding that redistributing household income from men to women is not positively associated with per capita calorie intake or the quality of food calorie sources. The final pathway hypothesizes that increasing women's control over agricultural income would change the allocation of household expenditures to improve household nutritional and educational outcomes. In turn, these positive outcomes may lead to longer-term economic benefits, in particular reduced health costs and increased labor productivity. This pathway rests on the assumptions that:

a. Women have less control over agricultural income than men, favoring men's spending choices, which on average involve less food and education,
b. More spending on food and education (particularly for children) improves nutritional and educational outcomes, and
c. The marginal returns to household nutritional and educational outcomes for spending decisions made by women would be greater than for spending decisions made by men, *ceteris paribus (see Figure 11)*.

Figure 11. Evidence Base Supporting Pathway 5



We identified 11 studies analyzing the relationship between women's control over income or share of household assets (an indicator of household bargaining power and a contributor to decision-making authority) and household food and education expenditures in low-and middle-income countries. (Table 5.1). Studies conducted in Bangladesh (Quisumbing & de la Briere, 2000), Cote d'Ivoire (Duflo & Udry, 2004; Hoddinott & Haddad, 1995), Ghana (Donkoh & Amikuzuno, 2011), Jamaica (Handa, 1996), and Tanzania (Seebens, 2009) report that women spend more income on the care of children, as measured by spending on food and education. These studies report that having a female head of household is associated with a significant increase in the budget share on food (Handa, 1996), the budget share on education (Seebens, 2009), and the likelihood of positive annual educational expenditure (Donkoh & Amikuzuno, 2011), and that increases in wives' income or share of household income is associated with increased spending or food (Duflo & Udry, 2004) and budget share on food (Hoddinott & Haddad, 1995).

Quisumbing & de la Briere (2000) find that additional assets held by women at marriage are associated with an increased budget share for education in Bangladesh. Doss (2006) similarly finds that in Ghana, an increase in the share of assets held by women is associated with increased household food expenditure. She also finds an association with increased education spending, but this association is only significant for rural women. Four other studies also suggest that gender differences in household expenditure do not hold in all contexts. Quisumbing & Maluccio (2003) find that increases in wives' shares of income are associated with positive increases in the budget share on food in Ethiopia and on education in South Africa, but not in Bangladesh or Indonesia. One study in Malaysia suggests that male-headed households in developed rural areas are associated with a higher likelihood of positive budget shares for education, but also finds no significant difference between gender of household head for other measures of spending on children's education and food (Kenayathulla, 2016). Kennedy & Peters (1992) also find no difference in food expenditure patterns by gender of household head in Kenya and Malawi, when controlling for household income. Yabut-Bernardino (2011) finds that in the Phillipines, female-headed households are associated with increased education spending only for the middle and upper deciles of the income distribution, with no significant difference by gender of the household head in lower income deciles.

Beyond the examination of food and education expenditures, two studies (Handa, 1996; Quisumbing & de la Briere, 2000) report that female-headed households are associated with lower levels of health spending. The authors suggest, however, that this relationship may be explained by lower spending on curative care and higher spending on preventive care by female-headed households.

A large body of evidence connects household spending on food and education with improved nutrition and education outcomes for children. Several studies from low- and middle-income countries report that increases in total food expenditures per capita and per adult are associated with statistically significant increases in children's height-for-age, weight-for-age, and weight-for height (Devi & Geervani, 1994; Duflo, 2000; Johnson & Rogers, 1993; Masiye et al., 2010; Schnepf, 1992), though Devi & Geervani (1994) find that only the effect on the first two measures is significant in India and Alderman & Mundial (1990) find not significant association with height-for-age in Ghana. Chawla's (2001) study of Nicaraguan households finds that increased per capita expenditures on food are associated with small but significant decreases in height- and weight-for-age, though the authors conclude that these results may be due to measurement error in food expenditure reporting. Large-scale correlational studies conducted in Bangladesh and Brazil also find strong positive correlations between household food expenditure and calorie and protein intake (Thomas, 1990), dietary diversity and (Thorne-Lyman et al., 2010), and children not being underweight (Torlesse, Kiess, & Bloem, 2003). With respect to education, we find evidence that household spending on children's education is associated with increased school enrollment in Mexico (Davis et al., 2002) and Senegal (Maertens & Verhofstadt, 2013), decerased school dropouts in Cambodia (Kosal & KinKesa, 2015), and decreased disparity between boys and girls test scores in Uganda (Ogawa & Wokadalo, 2013).

We identified six studies reporting on gender differences in the association between household food and education spending and nutrition and education outcomes (Table 5.2). Johnson & Rogers (1993) find that in the Dominican Republic, increases in height-for-age and weight-for-age are associated with the household proportion of income earned by women. Thomas (1990) reports that in Brazil, non-wage income received by women has a four to seven times larger effects on child calorie and protein intake than non-wage income received by men. Duflo (2000) finds that in South Africa households in which a grandmother receives an old-age pension are linked to an increase in weight-for-height for girls, but that the effects only hold for maternal, not paternal grandmothers, suggesting some effect through mothers. Davis et al. (2002) find that in Mexico, cash grants that increase household expenditure on education are associated with significant increases in school enrollment for female transfer recipients, but the impact on enrolment is not significantly different from zero for male transfer recipients. Maertens & Verhofstadt (2013) report that in Senegal a 10% increase in female off-farm wage income increases the likelihood of primary school enrolment by 1.5 percentage points.

We find further evidence that women's greater control over household decision-making and resources, in particular income, is associated with improved child nutrition and education outcomes (Amugsi et al., 2016;

Bhagowalia et al., 2012; Malapit & Quisumbing, 2015; Rajendran et al., 2014; Smith et al., 2003; Sraboni et al., 2014; Yoong, Rabinovich, & Diepeveen, 2012), though these do not specify that this is accomplished through increased household spending on food and education. Further evidence from Kenya, Malawi, and South Africa suggests that female-headed households, despite having lower income levels on average, are associated with better child nutritional and anthropometric statuses compared to male-headed households (Duflo, 2000; Kennedy & Peters, 1992).

A wealth of evidence suggests that improved child nutrition is likely to produce economic benefits such as reduced health costs over a child's lifetime (African Union Commission, 2014; Darnton-Hill et al., 2005; The World Bank, 2006). A 2014 report by the African Union Commission and others finds that treatment of undernutrition is a recurring expense for health systems in low-income countries, costing between 1-11% of countries' total public health budgets (African Union Commission et al., 2014) These increased health costs can also translate into reduced economic growth, with a World Bank (2006) estimate suggesting economic loss to malnutrition could amount to 2-3% of gross domestic product. Equally, improving child nutrition leads to positive effects on labor productivity (Aguayo et al., 2003; Deolalikar, 1988; Haddad & Bouis, 1991; Hoddinott et al., 2008; Van Den Boom, 1996; The World Bank, 2006; Weinberger, 2003). Hoddinott et al., (2008) estimated some of these positive effects by examining Guatemalan young adults who had been enrolled in a village-based nutrition intervention. Those who enrolled benefitted from a 46% increase in average wages. However, a prospective cohort study examining the relationship between nutrition in childhood and labor productivity in adulthood finds positive associations in Brazil and India, but not in Guatemala (Victora et al., 2008). Poor nutrition can also lead to negative effects on productivity. For example, a study of households engaged in rural labor in India finds that wages are 5-17% lower on average due to micronutrient deficiency (Weinberger, 2003).

Increasing children's educational achievement also has demonstrable effects on health costs and labor productivity over children's lifetimes. Increased child educational attainment can also lead to improved labor productivity, as evidenced by both small-scale studies in Uganda and Cote d'Ivoire (Appleton & Balihuta, 1996; Appleton, Hoddinott & Knight, 1996) and large-scale meta-analyses (Lockheed, Jamison, & Lau, 1980; Phillips, 1994). The more recent of these meta-analyses, incorporating studies from both high- and low-income countries, estimates a 10.5% increase in production for four years of schooling. A number of large-scale studies examine the private returns from investment in education. For example, Psacharopoulos & Patrinos (2002) estimate a 24.6% private return for both primary and secondary school completion in Sub-Saharan Africa, although a replication of the study finds a much lower mean rate of return at approximately 9% (Banerjee & Duflo, 2005). Similarly, analysis of the International Income Distribution Database that includes nationally representative samples across 131 countries from 1970-2011 finds a 10.4% average rate of private return to another year of schooling, with average returns highest in Sub-Saharan Africa at 12.8% (Montenegro & Patrinos, 2013). Other studies find additional years of schooling are positively associated with local off-farm work and migration participation (Abdulai & Delgado, 1999; Qiao et al., 2015). A study of female education effects in Uganda finds that each year of education received by girls is associated with a 6.7% reduction in the likelihood of contracting HIV, thereby reducing health costs (De Walque, 2004).

We did not identify any studies reporting on the longer-term economic benefits of improved child nutrition and education outcomes from women's decisions to spend more household income on food and education, but the above general supporting evidence for the link from improved child nutrition and education to increased labor productivity and reduced health costs is summarized in Table 5.3.

Table 5.1. Summary of Evidence of Male/Female Differences Related to Pathway 5: Improved Household Nutrition and Educational Achievement							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Hoddinott & Haddad, 1995	Cote d'Ivoire - National	1,503 households (nationally representative)	1986/87 Cote d'Ivoire Living Standards Survey	**Quasi-experimental**: Instrumental variables regression analysis (instruments: difference in educational attainment between household head and spouse, proportion of household land holdings operated by adult women) at the household-level; household demographic, socioeconomic and geographic controls included	Wives' share of income in the household	Budget share on food	**Supportive**: A 1% increase in wives' share of income in the household is associated with a five percentage point increase in the budget share on food
Duflo & Udry, 2004*	Cote d'Ivoire - National	1,500 farming households	1985-88 Cote d'Ivoire Living Standards Measurement Survey	**Quasi-experimental**: Instrumental variables regression analysis (instrument: rainfall shocks) at the household-level; household socioeconomic controls included	Output of yams (proxy for female income)	Food expenditure	**Supportive**: A 10% increase in predicted female income from a shock that increases the output of crops predominantly cultivated by women is associated with a 4% increase in expenditure on food compared to a 0.3% decrease for men
Quisumbing & de la Briere, 2000*	Bangladesh - Local (Saturia, Jessore, and Mymensingh districts)	826 monogamous households	1996 survey conducted from 47 villages in three rural sites in Bangladesh	**Quasi-experimental**: Instrumental variables regression analysis using panel data (instruments: husband's and wife's education, age, age squared, birth order, number of siblings, number of living brothers, husband's and wife's families' landholdings, indicators of the educational attainment of their parents) at the household-level; household demographic, socioeconomic, geographic, and survey round controls included	Share of assets held by women at marriage	Budget share on children's education	**Supportive**: An additional asset at marriage owned by the wife is associated with an increase in the budget share on children's education of 33.9 percent

Handa, 1996	Jamaica - National	1,983 (of 3,500 households) (nationally representative)	1989 Jamaican Survey of Living Conditions based on the World Bank LSMS	**Non-experimental**: Regression analysis (OLS) at the household-level; household demographic and socioeconomic controls included	Gender of head of household	Budget share on food	**Supportive**: Presence of a female head is associated with an increase in the budget share on food by 1.5 percentage points
Seebens, 2009*	Tanzania - National (mainland regions of Tanzania)	18,783 households (nationally representative)	2000/01 Tanzanian Household Budget Survey	**Non-experimental**: Regression analysis (probit) at the household-level; household socioeconomic and demographic controls included	Expenditure per capita	Budget share on education	**Supportive**: A 1% increase in expenditure per capita for female-headed households is associated with a one percentage point increase in the budget share spent on education compared to no increase for men
Donkoh & Amikuzuno, 2011	Ghana - National	3,941 households (nationally representative)	2006/07 Ghana Living Standards Survey Round Five	**Non-experimental**: Regression analysis (logit) at the household-level; household demographic, socioeconomic and geographic controls included	Gender of head of household	Probability of a household incurring expenditure on formal education	**Supportive**: Having a male-headed household is associated with a 12 percentage point decrease in the likelihood of the household making any expenditure on education compared to having a female head of household.
Kenayathulla, 2016	Malaysia - National	8,599 households with at least one child between ages 5-19 (drawn from a sample of 14,084 households)	2004/05 Malaysian Household Expenditure Survey	**Non-experimental**: Regression analysis (OLS and probit) at the household-level; household demographic, socioeconomic and geographic controls included	Gender of head of household	Budget share on education	**Non-supportive**: Male-headed households in rural developed regions have a 0.96 percentage point increased likelihood of a positive budget share for education compared to female-headed households

Kennedy & Peters, 1992	Kenya, Malawi - Multi-national	Not specified	Not specified	**Descriptive**: Subgroup analysis of male- and female-headed households with similar income levels	Gender of head of household	Budget share on food	**Non-supportive**: Analysis of male- and female-headed households with similar income levels finds no statistically significant difference in food expenditure patterns between male- and female-headed households
Quisumbing & Maluccio, 2003	Bangladesh, Indonesia, Ethiopia, South Africa - Multi-national	839 households in Bangladesh, 128 households in Indonesia, 1,347 households in Ethiopia, 492 households in South Africa (random sample)	1996/7 survey conducted by authors in three sites in rural Bangladesh and two regions in Indonesia; 1996/7 Ethiopian Rural Household Survey ; 1996/7 South Africa KwaZulu-Natal Income Dynamics Study	**Quasi-experimental**: Instrumental variables regression analysis (instruments: Bangladesh - parent's land, number of living brothers, year of marriage; Indonesia - parent's land, educational attainment of parents and in-laws, birth year of husband and wife; Ethiopia - education of the parents of the husband and wife, value of bridal gifts transferred from the groom's to the bride's family and vice versa; South Africa - education of parents of husband and wife, indicators of whether parents alive at time of marriage, value of gifts transferred from the groom's to the bride's family and vice versa) at the household-level; household demographic and socioeconomic controls included	Share of assets held by women	Expenditures on children's education	**Mixed**: A 1% increase in wives' share of income is associated with a 2.1 percentage point increase in the budget share on food in Ethiopia and a 10.1 percentage point increase in the budget share on education South Africa. Estimates were not significant in other countries.
Yabut-Bernardino, 2011*	Philippines - National	38,484 households (nationally representati ve)	2006 Philippine Family Income and Expenditure Survey	**Quasi-experimental**: Instrumental variables regression analysis (instruments: school-age dependents and children less than 7 years old) at the household-level; household socioeconomic, demographic, and geographic controls included	Gender of head of household	Total education expenditures	**Mixed**: Female-headed households are associated with a PHP2109 increase in total education expenditures. However, these findings only hold for the middle and upper deciles (5 to 10) of the income distribution, with no difference observed between male- and female-headed households in lower income deciles

Doss, 2006	Ghana - National	1,372 households (nationally representative)	1991/92 and 1998/99 Ghana Living Standards Surveys	**Non-experimental**: Regression analysis (logit) at the household-level; household demographic, socioeconomic and geographic controls included	Share of assets held by women	Expenditure on food and on education	**Mixed**: A one percentage point increase in the share of assets held by women is associated with a 796 cedis increased monthly expenditure on food. Increases in the share of assets for rural women were also statistically significantly associated with increased education spending, but these relationships did not hold for urban women.

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Table 5.2. Summary of Evidence of Direct Outcomes Related to Pathway 5: Improved Household Nutrition and Educational Achievement							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Yoong, Rabinovich, & Diepeveen, 2012*	Latin America, South Asia - Multicountry	15 studies	1990-2010 literature review	Review: Systematic review/narrative synthesis using 3 tiered search string across multiple databases	Receipt of transfer or income	Health, Labor, Nutrition, Expenditure, Investment, Education, Assets, Enterprise performance	Supportive: Targeting cash transfers towards women through conditional cash transfer programs and pensions appears to improve child nutrition and health but does not guarantee positive non-nutrition outcomes
Davis et al., 2002	Mexico - National	12,625 low-income households of 24,000 households selected from 505 PROGRESA communities (random sample)	1997 ENCASEH survey and 1998 ENCEL survey	Quasi-experimental: Instrumental variables regression (instrument: theoretical cash payment to household) at the household level; individual and household demographic, socioeconomic, and geographic controls included	Receipt of cash transfer for education spending	School enrolment	Supportive: Cash grants that increase household expenditure on education are associated with significant increases in school enrollment for female transfer recipients, but the impact on enrolment is not significantly different from zero for male transfer recipients
Maertens and Verhofstadt, 2013	Senegal - Regional (Niayes region)	451 households in 36 villages in 4 rural communities (stratified random sample)	2007 survey conducted by authors	Quasi-experimental: Instrumental variables regression analysis (instruments = distance to nearest horticultural export company in km, total village population, share of households in village with females working in export agro-industry, female membership of an organization in the year 2000) at the household level; individual and household-level socioeconomic, demographic, and geographic controls included	Female off-farm wage income, share of female wage income in total income	Primary school enrolment	Supportive: 10% increase in female off-farm wage income and in the share of female wage income in total income increases the likelihood of primary school enrolment by 1.5 and 5.8 percentage points, respectively
Johnson & Rogers, 1993	Dominican Republic - National	706 families with children under age 6 from 1,440 surveyed families (nationally representative sample)	1986-1987 Tufts University School of Nutrition Food Consumption Survey	Non-experimental: Regression analysis (OLS) at the household level; household demographic, socioeconomic and geographic controls included	Household proportion of income earned by women	Height-for-age, weight-for-age	Supportive: The household proportion of income earned by women and nutritional outcomes is associated with small increases in height-for-age and weight-for-age

Thomas, 1990	Brazil - Regional (Northeast and Southeast regions and major cities)	25,000 urban households (of 55,000 households from a random national sample)	1974-1975 Estudo Nacional da Despesa Familiar survey	**Non-experimental**: Regression analysis (OLS) at the household level, household socioeconomic and demographic controls included	Non-wage income received by mothers	Children's total calorie intake; children's total protein intake	**Supportive:** Non-wage income received by mothers has a four to seven times larger effect on child health, as measured by total calorie and protein intake, compared to non-wage income received by fathers
Rajendran et al., 2014	Tanzania - Regional (Babati, Kongwa, Kieto)	300 farm households (multi-stage random sample)	2013 survey conducted by authors	**Non-experimental**: Regression analysis (OLS) at household level; controls for socioeconomic and individual characteristics	Women's control over household income	Dietary diversity	**Supportive**: Dietary diversity is increased when women have control over household income
Amugsi et al., 2016	Ghana - National	2262 women aged 15-49 years and who have complete dietary data	2008 Ghana Demographic and Health Survey	**Non-experimental**: Regression analysis (logit) at household and individual level; demographic, socioeconomic, and urban/rural controls included	Women decision-making autonomy	Women's dietary diversity	**Supportive**: Women who have a say in making household purchases are more likely to achieve higher dietary diversity compared to those who do not participate in decision-making
Bhagowalia et al., 2012*	Bangladesh - National	5,247 households with children	2007 Bangladesh Demographic and Health Survey	**Non-experimental**: Regression analysis (logit, Principal Components Analysis) at individual level, demographic, socioeconomic, and geographic controls included	Women's empowerment	Prevalence of stunting and minimum diet diversity scores	**Supportive**: Greater female empowerment and maternal endowments are associated with better long-term nutritional status of children; significant association of female participation in decision making and minimum diet diversity score (1.00 odds ratio)
Malapit & Quisumbing, 2015	Ghana - Regional (Northern Ghana)	4410 households (1783 for analysis)	2012, Feed the Future population-based survey	**Non-experimental**: Regression analysis(OLS) at household level; demographic controls included	Women's empowerment	Nutritional outcomes (dietary diversity score and BMI)	**Supportive**: Women's empowerment is associated with diet quality rather than nutrition status (0.454 coefficient at 90% significance); credit decisions participation by women improves their dietary diversity
Sraboni et al., 2014	Bangladesh - National	5503 households	2011-2012 Bangladesh Integrated Household Survey	**Non-experimental**: Regression analysis (OLS, SLS, instrumental variables re: women's empowerment and measures of household food security) at household level; demographic and socioeconomic controls included	Control over use of income	Household per-adult equivalent calorie availability and dietary diversity	**Supportive**: Female empowerment score is significantly associated with per capita calorie availability and household dietary diversity (235.364 (OLS), 898.858 (SLS) and 0.493 (OLS), 1.938 (SLS), respectively); Female ownership of assets is significantly associated with per capita calorie availability and household dietary diversity (33.263 (OLS), 146.085 (SLS) and 0.104 (OLS), 0.178 (SLS), respectively)
Smith et al., 2003*	36 developing countries in South Asia, Sub-Saharan Africa, and Latin America and the Caribbean - Multicoutnry	117,242 children under three years of age	1990-1998 Demographic and Health Surveys (36 different surveys)	**Non-experimental**: Regression analysis (OLS, logit) at household and individual level; demographic and socioeconomic controls included	Women's empowerment	Child nutritional status	**Supportive**: Women's decision-making power and societal gender equality are significantly associated with child weight-for-age; In South Asia and SSA, women's' decision-making power is significantly negatively related to child stunting, wasting, and underweight (the higher the decision making power, the lower the chance)

Duflo, 2000*	South Africa - National	9,000 households (nationally representative sample)	1993 National Survey of South Africa	**Non-experimental**: Regression analysis (OLS) at the household level; household demographic, socioeconomic and geographic controls included	Female head of household receives old-age pension	Children's anthropometric status	**Mixed**: Households in which a woman receives an old-age pension have a 0.48 increase in weight for height z-score for girls (but not boys) compared to male recipients and households that receive no old-age pension, although these effects only hold for maternal, not paternal, grandmothers

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Table 5.3. Summary of Evidence of Economic Benefits Related to Pathway 5: Improved Household Nutrition and Educational Achievement							
Author, Year	Geographic Area, Scale	Sample Size	Data Source	Methodology	Independent Variable(s)	Dependent Variable(s)	Findings
Phillips, 1994	Global - Multi-national	59 datasets from low-income countries (data from 1967-1985) from 30 studies	Literature review	**Review (Meta-analysis):** Meta-analysis with study-based controls	Educational attainment	Production	**Supportive:** Production increased on average by 10.5% for four years of schooling
Lockheed, Jamison, & Lau, 1980	Asia - Multi-national	37 datasets from 18 studies conducted primarily in Asia (data from 1967-1985)	Literature review	**Review (Meta-analysis):** Meta-analysis of findings conducted in low-income countries	Educational attainment	Agricultural production	**Supportive:** 4 years of schooling is associated with an average 8.7% increase in agricultural production
Aguayo et al., 2003	Sierra Leone - National	22 sources	Literature review	**Review**: Review of literature on nutrition and productivity based on PROFILES, a data-based approach to nutrition policy analysis	Anemia in women	Agricultural productivity	**Supportive:** Anaemia in women in Sierra Leone was forecasted to result in agricultural productivity losses among the female labor force exceeding $94.5 million till 2011; future productivity losses associated with intellectual impairment resulting from intrauterine iodine deficiency were estimated at $42.5 million in Sierra Leone
Banerjee & Duflo, 2005	Global - Multi-national	29 studies from 1958-1996	Replication of Pscharopoulos and Patrinos's (2002) review	**Review**: Review of literature on returns to education; replication of Pscharopoulos and Patrinos's (2002) review	Educational attainment	Private returns	**Supportive:** Mean rate of returns to private investment in education are 8.96%
The World Bank, 2006*	Global - Multi-national	36 sources	Literature review	**Review**: Review of literature of effects of child malnutrition	Child malnutrition	Health care costs	**Supportive:** GDP lost to malnutrition (no country specified) can be as high as 2 to 3 percent
Psacharopoulos & Patrinos, 2002*	Global - Multi-national	29 studies from 1958-1996	Literature review	Review: Review of literature on returns to education in developing countries	Educational attainment	Private returns	**Supportive:** 20%, 26.6%, and 24.6% private return to investment in education for primary school, 15.8%, 17.0%, 24.6% for secondary school across Asia, Latin America/Caribbean, and sub-Saharan Africa, respectively
Darnton-Hill et al., 2005	Pakistan, Vietnam - Multi-national	Not specified	Literature review	**Review**: Review of literature (no additional methods information)	Presence of micronutrients (vitamin A, iodine, iron, zinc) in diet	Output (measured as GDP or GNP)	**Supportive:** Protein-energy malnutrition, iron deficiency and iodine deficiency are responsible for 3-4% loss of GDP in Pakistan and 2-3% of GDP in Vietnam in any given year

Hoddinott et al., 2008	Guatemala - National	1,424 young adults enrolled in a 4-village nutrition study (2 villages assigned nutritious supplement and 2 villages assigned less nutritious supplement), chosen from 300 selected rural communities	1969-77 Institute of Nutrition of Central America and Panama study	**Experimental:** Regression analysis (OLS) at the individual level; individual, household, and community demographic and socioeconomic controls included	Nutrition intervention as a child	Hourly wages	**Supportive:** Exposure to the nutritious supplement before (but not after) age 3 is associated with a 46% increase in hourly wages
Deolalikar, 1988	India - Regional (rural southern districts)	240 households in six typical villages in 3 different agroclimatic zones in South India	1975- panel data from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Village -Level Studies (VLS) data	**Quasi-experimental:** Instrumental variables regression (instruments: food prices, household assets) at the household level; household demographic and socioeconomic controls included	Weight-for-height	Labor productivity	**Supportive:** A 1kg/cm increase in weight-for-height is associated with a 1.9 elasticity for farm output
de Walque, 2004*	Uganda - Local (15 villages each year in southern Uganda)	6,312 HIV-tested individuals in 15 villages surveyed annually from 1989-2000	1989-2000 General Population Cohort Longitudinal Survey	**Quasi-experimental:** Panel data with fixed effects regression analysis (logit) at the individual level; demographic controls included	Years of education for girls	Likelihood of contracting HIV	**Supportive:** Each year of education for girls is associated with a 6.7% decrease in likelihood of contracting HIV
Qiao et al., 2015	China - Regional	2,832 households in rural China (nationally representative)	2005 and 2008 Center for Chinese Agricultural Policy of the Chinese Academy of Sciences Survey	**Quasi-experimental:** Panel data with fixed effects (OLS, probit) at the household-level; household and individual demographic, socioeconomic and geographic controls included	Years of education	Probability of local off-farm work participation and migration	**Supportive:** Each additional year of education for females positively associated with an increase in probability of local off-farm work participation by 0.94% and migration participation by 1.48%

Weinberger, 2003*	India - National	5,800 households engaged in rural labor (systematic sampling)	1993/4 Socio-Economic Survey of the National Sample Survey Organisation	**Quasi-experimental:** Instrumental variables regression (instruments: food prices, household size, religious affiliation, ecoregion) at the household level; individual and household demographic, socioeconomic, and season controls included	Micronutrient deficiency	Wages	**Supportive:** 50% increase in average iron intake is associated with an increase in average productivity of agricultural wage laborers of 5.1-17.2%
Haddad & Bouis, 1991	Philippines - Regional (Bukidnon province)	448 rural households	1990 survey (four times at four-month intervals) of rural households residing in Bukidon province conducted by authors	**Quasi-experimental:** Panel data with fixed effects regression analysis (OLS) at the household level; individual and household demographic, socioeconomic, and geographic controls included	Height (childhood stunting)	Wage rate	**Supportive:** 15cm height increase of a person of mean height is associated with a 13% increase in wage rate
Van Den Boom, Nube & Asenso-Okyere, 1996	Ghana - National	1,147 adults (nationally representative)	1987-92 Ghana Living Standards Survey	**Quasi-experimental:** Panel data with fixed effects regression analysis (OLS) at the individual-level; individual and household demographic, socioeconomic, and geographic controls included	Food consumption	Wage rate	**Supportive:** 1% increase in food consumption associated with 0.61% wage rate increase for men and 0.47% wage rate increase for women
Appleton, Hoddinott & Knight, 1996*	Cote d'Ivoire, Uganda - National	Not specified	Not specified	Non-experimental: Regression analysis (logit) at the individual level; individual and household demographic, socioeconomic, and geographic controls included	Educational attainment	Private returns	**Supportive:** The private rates of return to primary education in Cote d'Ivoire and Uganda are positive, but significantly lower than expected, at less than 5%
Appleton & Balihuta, 1996*	Uganda - National	4,877 households drawn from 10,000 households (nationally representative)	1992-93 Integrated Household Survey	**Non-experimental**: Regression analysis (OLS) at the individual level; individual demographic, socioeconomic, and geographic controls included	Primary school completion; secondary school completion	Crop production	**Supportive:** Primary school completion and secondary school completion are associated with a 13% and 18% increase in crop production, respectively.
African Union Commission et al., 2014*	Egypt, Ethiopia, Swaziland, Uganda - Multi-national	Not specified	1998-2010 Demographic and Health Surveys	**Non-experimental**: Cost-benefit analysis	Child undernutrition	Public budget allocated to health	**Supportive:** Child undernutrition produces health costs equivalent to 1-11% of the total public budget allocated to health; specifically: child undernutrition generated annual health costs estimated at $213 million or 0.11% of GDP in Egypt in 2009, $155 million or 0.54% of GDP in Ethiopia, $7 million or 0.2% of GDP in Swaziland and $254 million or 1.6% of GDP in Uganda

Abdulai & Delgado, 1999	Ghana - Regional (rural Northern Ghana)	228 households selected from 37 villages across 4 districts in Northern Ghana (stratified random sample)	1992-3 survey conducted by authors	**Non-experimental**: Regression analysis (probit) at the household-level; household demographic, socioeconomic and geographic controls included	Years of education	Wage rate; non-farm labor participation	**Supportive:** A one-year increase in schooling increases the wage rate of women by 6.9% and that of men by 4.9%. With each additional year of schooling, probability of women's participation in nonfarm labor increased by 0.51%, versus 0.30% for men
Montenegro & Patrinos, 2013*	Global - Multi-national	545 harmonized household surveys from 131 economies	2005-11 (includes data from 1970-2011) World Bank World Development Report Dataset	**Non-experimental**: Survey of findings using data from standardized household surveys	Educational attainment	Average rate of return	**Supportive:** s10.4% average rate of private return to another year of schooling (returns are highest in sub-Saharan Africa at 12.8% and relatively lower in South Asia at 7.0%; women also receive higher returns to education than men)
Victora et al., 2008	Brazil (Pelotas), Guatemala (four villages), India (New Delhi), the Philippines (Cebu), South Africa (Soweto) - Multi-national ()	5,914 in Brazil, 2,392 in Guatemala, 8,181 in India, 3,080 in the Philippines, and 3,273 in South Africa	Panel surveys conducted by the authors	**Quasi-experimental:** Prospective cohort studies (Brazil, India, Philippines, and South Africa) and community trial (Guatemala) at the individual-level	Nutrition in childhood (weight-for-age and height-for-age)	Labor productivity in adulthood	**Mixed**: 1 z-score increase in height-for-age (weight-for-age) is associated with an 8% (9%) increase in income in Brazil and 27% (29%) increase in India, but no statistically significant increase in Guatemala; no other countries' results provided

Asterisks denote sources not published in peer-reviewed journals. Studies are sorted first by supportive, non-supportive, mixed findings, then by methodology (field experiment, experimental, quasi-experimental, non-experimental, review, descriptive).

Returns to Women's Empowerment in Agriculture: Estimates and Data Limitations

Drawing from the Women's Empowerment in Agriculture Index, we considered three measures of women's empowerment in agriculture: decision-making power around agricultural productive resources, around agricultural management and production, and around agricultural income. This report reviewed the extant literature supporting five causal pathways that theorize how interventions leading to improvements in these measures of women's empowerment in agriculture might lead to economic benefits along two avenues: 1) equalizing access to productive resources (including access to and control over land, labor, and other inputs) between men and women to increase productivity, and 2) leveraging male/female differences in decision-making that might lead to improved household outcomes. We found evidence (primarily peer-reviewed) from a variety of contexts evaluating the assumed links in these causal pathways, though the evidence of direct links from women's empowerment to economic benefits is limited.

The **first pathway** hypothesizes that increasing women's control over agriculturally productive resources (including both access to and control over agricultural inputs and technologies) would contribute to more efficient allocation of inputs and technology across household plots, leading to longer-term benefits from increased agricultural productivity. Overall, the literature strongly suggests that women farmers have less access to productive resources than male farmers, and that this difference in access to inputs drives part of the productivity differential between male and female farmers (Aguilar et al., 2015; Horrell & Krishnan, 2007; Kilic, Palacio-Lopez, & Goldstein, 2015; Palacios-Lopez, 2015; Tiruneh et al., 2001). We do not find much evidence of interventions to increase women's access to or control over productive resources, though the available evidence indicates that interventions targeting women with inputs and/or extension support increased input use by women (Table 1.2).

The evidence on productivity gains from increasing women's access to inputs is not conclusive. Two studies find that an intervention to increase input use increased women's productivity more than men's (Davis et al., 2012; Vasilaky & Leonard, 2015), but one found no difference in productivity gains (Karamba & Winters, 2015). Six studies find that agricultural resources are inefficiently allocated at the household level (Aguilar et al., 2015; Andrews, Golan, & Lay, 2014; Chavas, Petrie, & Roth, 2005; Saito et al., 2014; Udry, 1996; Udry et al., 1995) and therefore argue that increasing women's control over agricultural resources will increase productivity, but do not demonstrate this empirically. Finally, while five studies find that women have equal or greater productivity than men when controlling for input use (Alene et al., 2008; Gilbert, Sakala, & Benson, 2002; Moock, 1976; Nwaru et al., 2011; Quisumbing, 1996), six other studies find evidence that a gender productivity gap remains even after controlling for the gender gap in input access (Aguilar et al., 2015; Kilic et al., 2015; Kinkingninhoun-Mêdagbé et al., 2010; Oseni et al., 2015; Peterman et al., 2001; Slavchevska, 2015). These studies suggest that that even if women were given the same level of inputs as men, there would still be significant differences in productivity between men and women, and that productivity gains may vary by context. As a result, though empowering women by increasing their access to and control over agricultural productive resources may create economic benefits from increased productivity, these productivity gains may not be sufficient to close the gender productivity gap.

The **second pathway** hypothesizes that increasing women's decision-making authority over their own labor time and mobility would increase women's participation in markets, including off-farm labor markets, which would contribute to increased household labor productivity. While we recognize that not all women would choose to participate more in off-farm labor markets if given full control over their own time and labor, this pathway assumes that women face more constraints to participating in the formal off-farm labor market, and that some constraints are related to lack of control over decisions on their own time and labor.

Overall, we find consistent empirical support for the claim that women participate less in off-farm labor markets (Babatunde et al., 2010; Clay et al., 1997; Haggblade et al., 2010; Jost et al., 2016; Lanjouw, 2001; Lanjouw & Shariff, 2004; Matshe et al., 2004), and that where they do participate it is most commonly in areas with lower returns, such as self-employment and small cottage industries (Haggblade et al., 2010; Lanjouw, 2001). Three studies find that women in female-headed households are more likely to participate in off-farm work as compared male-headed households (Ackah, 2013; Beyene et al., 2008; Shehu & Abubakar, 2015), suggesting that different circumstances in female-headed households may be associated with increased women's participation in off-farm labor. The evidence also links improvements in women's education, access to credit, and income transfers - factors that may improve women's household bargaining power and control over decision-making (Anderson, Reynolds, & Gugerty, 2017; Doss, 2013; Jejeebhoy et al., 2001) - to an increased probability of non-farm employment (Abdulai & Delgado, 1999; Beyene et al. 2008; Doss, 2013; Fafchamps & Quisumbing, 1999; Owusu et al.,2011; Qiao et al., 2015; Swaminathan, Du Bois, & Findeis, 2010), though we note that not all women will choose to increase their off-farm labor participation if given more control over their own labor. Gladwin et al. (2000) observe that rural women are not a homogenous group and may have different ability to respond to income-generating opportunities. They argue that younger women with young children and more demands on their labor may be less able to respond to opportunities than older women with grown children and more available labor, but that women in female-headed households may be better able to adopt income-generating activities than women in male-headed households despite having less adult labor available.Most of the evidence from low- and middle-income countries suggests that while incomes are higher for non-farm employment compared to farm-employment, women earn lower wages than men (Lanjouw, 1999; Lanjouw & Shariff, 2004; Nerman, 2015; Owusu, Abdulai, & Abdul-Rahman, 2011; Yang, 1997) – potentially due to their concentration in less productive employment (Haggblade et al., 2010; Lanjouw, 2001) or to differences in education compared to men (Abdulai & Delgado, 1999; Qiao et al., 2015). As a result, it is not clear that interventions that increase women's control over their own time and labor by improving their education and access to credit, for example, will consistently lead to economic benefits from increased labor productivity for women.

The evidence suggests that participating in off-farm labor can increase labor productivity and economic benefits, hence to the extent that women would choose to participate more given the authority to do so, we would expect their own labor productivity to rise, conditional on context and the availability of off-farm labor opportunities. That said, although women's lower rates of participation in off-farm labor markets are assumed to be at least in part attributable to their lack of decision-making authority over their own labor and mobility, we did not search for evidence linking this to limited mobility. Further, it is more difficult to understand how overall household labor productivity would change without knowing whether a woman's non-farm labor hours were in addition to, or instead of, previous off-farm, domestic, or leisure hours, and how household labor was re-allocated in response to her non-farm work.

The **third pathway** hypothesizes that increasing women's relative decision-making authority related to agricultural management and production will affect decisions of what crops to plant, increasing household dietary diversity and improving nutritional outcomes, thereby leading to reduced health costs and increased labor productivity. The pathway assumes that women, on average, grow a more diverse and nutritious set of crops than men do. Studies from a variety of contexts report that female farmers plant a greater diversity of crops on their plots than male farmers (e.g., Akhter et al., 2010; Benin, Smale, & Pender, 2006; Dillon, McGee, & Oseni, 2015; Peterman et al., 2011). This difference may be driven by household decisions on allocating certain crops to plots managed by women, as the literature indicates that women are the primary managers of home gardens across a range of contexts, and that these plots typically include a greater diversity of crops, including more nutritious vegetables and legumes (Akhter et al., 2010; Amri & Kimaro, 2010; Chambers et al., 2007; Ibnouf, 2009; Schadegan et al., 2013). Four studies looking at crop diversity by gender of the head of household, however, suggest that differences in planting decisions are not solely based on allocation of certain crops to women (Benin, Smale, & Pender, 2006; Dillon, Mcgee, & Oseni, 2015; Peterman et al., 2011; Saenz & Thompson, 2017).

The link from household crop diversity to improved dietary and nutrition has been demonstrated empirically across a range of contexts (e.g., Ekesa, Walingo, & Abukutsa-Onyango, 2008; Jones et al., 2014; Kumar, Harris, & Rawat, 2015), and five published studies highlight the role of women in promoting this association (Dillon, Mcgee, & Oseni, 2015; Jones et al., 2014; Oliver, 2016; Pandey et al., 2016; Shively & Sununtnasuk, 2015). We find no specific evidence of the longer-term economic benefits of women's more diverse planting decisions, but a large body of evidence indicates economic benefits from improved nutrition through increased labor productivity (e.g., Aguayo et al., 2003; Behrman, 1993; COHA Report, 2013; Croppenstedt & Muller 2000; Deolalikar, 1988; Haddad & Bouis, 1991; The World Bank, 2006) and decreased health costs (e.g., COHA Report, 2013; Darnton-Hill et al., 2005; Pelletier et al., 1995). As a result, to the extent that vegetable and legume crops or home garden crops contribute to household nutrition outcomes and that women choose to plant more of these crops than men, the evidence suggests that increasing women's decision-making authority related to agricultural management and production might lead to economic benefits. It is not clear, however, how women's planting decisions might change if given greater access to productive resources and control over agricultural management. Whether or not households are net buyers or sellers of products and have market access also likely matters.

The **fourth pathway** hypothesizes that increasing women's decision-making authority over farm management would result in improved on-farm soil management practices including higher rates of intercropping, leading to improved soil quality, and ultimately higher land productivity. There is some evidence suggesting that women choose to intercrop more frequently than men, both as plot managers (EPAR, 2013; Mishra et al., 2009), as joint plot managers (EPAR 2013; Ndiritu, Kassie, & Shiferaw, 2014), and as heads of household (Khan et al., 2008), though another body of literature suggests this pattern does not necessarily hold across different contexts (Bezner-Kerr et al., 2007; Buyinza & Wambede, 2008; Chijikwa, 2013). The literature strongly supports the claim that intercropping can improve soil quality and can reduce soil erosion for a variety of intercropping systems (e.g., Blanchart et al., 2006; Dzung & Preston, 2007; Garland et al., 2016; Li et al., 2015; Odunze et al., 2008; Verma et al., 2014; Wu et al., 2016). While none of the evidence specifically reports on effects of women's intercropping on soil quality, there is no objective reason to believe the outcomes of intercropping would be different by gender.

Similarly, the link between soil quality and agricultural productivity is also relatively well-established in the field of soil sciences (e.g., Byiringiro & Reardon, 1996; Lal, 2009; Liu et al., 2015; Naylor, 1996), so for contexts in which women intercrop more than men, increasing women's control over agricultural management decisions might produce economic benefits. As a result, although the evidence on whether women choose to intercrop more often than men is mixed, for contexts in which women intercrop more than men the evidence suggests that increasing women's control over agricultural management decisions might produce positive economic benefits associated with greater agricultural productivity.

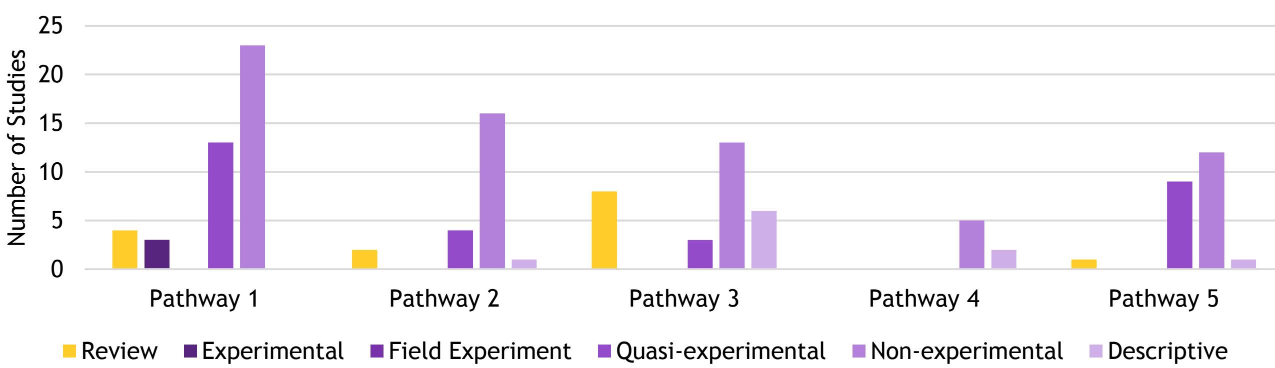
The **fifth pathway** hypothesizes that increasing women's control over agricultural income would change the allocation of household expenditures to improve household nutritional and educational outcomes. The majority of the evidence on gender resource allocation preferences supports the assumption that women spend a greater proportion of household income than men on expenses benefiting children, in particular food and education (Donkoh & Amikuzuno, 2011; Duflo & Udry, 2004; Handa, 1996; Hoddinott & Haddad, 1995; Quisumbing & de la Briere, 2000; Seebens, 2009), although five studies (Doss, 2006; Kenayathulla, 2016; Kennedy & Peters, 1992; Quisumbing & Maluccio, 2003; Yabut-Bernardino, 2011) suggest that the differences in expenditure between male- and female-headed households do not hold in all circumstances, such as when controlling for household income.

A large body of evidence suggests that increased food expenditure and increased educational expenditure are associated with improved nutrition and increased achievement for children, respectively, and several studies suggest a specific effect of women's control over household income and spending in supporting these outcomes (Amugsi et al., 2016; Bhagowalia et al., 2012; Davis et al., 2002; Duflo, 2000; Johnson & Rogers, 1993; Kennedy & Peters, 1992; Maertens & Verhofstadt, 2013; Malapit et al., 2015; Rajendran et al., 2014; Smith et al., 2003; Sraboni et al., 2014; Thomas, 1990; Yoong, Rabinovich, & Diepeveen, 2012). While we did not find any evidence specifically testing the longer-term benefits of women's control over household income or spending, a large body of evidence indicates a relationship between positive nutritional and educational outcomes for children and measurable economic benefits, such as decreased health costs and increased labor productivity (Table 5.3). As a result, if differential gender spending preferences exist in a given socio-economic and country context, there may be significant economic benefits from interventions that increase women's decision-making power around agricultural income.

The results of this review suggest many potential pathways for economic returns through women's empowerment in agriculture; however, we also note some inconsistencies in published methods and findings, and several key data gaps.

1. Published estimates of economic returns to empowering women in agriculture are still relatively rare, are mostly non-experimental, and are often limited in terms of data quality. Ultimately, due to the heterogeneity of study types, interventions, and indicators it is difficult to provide empirical evidence in support of all links within a specified causal pathway (Figure 12). Direct evidence for some of these pathways – from women's empowerment to economic benefits - is limited, though we find supporting evidence when separately considering a) the associations between male/female differences and direct outcomes and b) the associations between those direct outcomes and long-term benefits without considering a gender element.

   Figure 12. Methods Applied in Gender-Specific Published Evidence across All Pathways



   A review of the literature suggests some - but not conclusive - support for portions of all five theorized causal pathways. The literature also provides some dissenting evidence surrounding women's constraints and preferences, most notably that results can be context specific.

2. Published estimates provide some indication that, in many contexts, economic returns to women's empowerment might be substantial – however differences in measurement and reporting impede readily comparing benefits across contexts. Several of the studies we reviewed include estimates of the potential returns to outcomes relating to the theorized pathways from women's empowerment. These estimates are aggregated and summarized in Table 6. In most cases, however, studies do not calculate benefits of women's empowerment specifically, but rather provide a range of estimates of economic benefits from the

outcomes in the pathways we evaluated. This is particularly true for pathways 3, 4, and 5 which consider the benefits of leveraging differences in decisions between men and women.

Table 6. **Estimates of Economic Benefits of Empowering Women in Agriculture**

Path-way	Author, Year	Geographic Area, Scale	Methodology	Independent Variable(s)	Findings
1	Vasilaky, & Leonard, 2013*	Uganda - Regional (villages in North and North-East Uganda)	**Experimental:** RCT; difference-in-differences analysis ; regression analysis (probit) at plot level; intervention participation controls included	SNI (Social network based ag training)	Average 98 kg/acre increase in yield for female farmers and 74 kg/acre increase across all intervention participants
1	Aguilar et al., 2015	Ethiopia - National	**Quasi-experimental:** Oaxaca-Blinder mean decomposition; fixed effects model for crop products and different levels of geographical aggregation; Regression analysis OLS) at plot level; demographic, socioeconomic, input controls included	Access to productive resources	23.4% gender differential in agricultural productivity, in favor of male land managers; 10.1 percentage points explained by differences in access to resources, and land and land manager characteristics; 13.4 percentage points explained by unequal returns to productive components; There is higher inequality in the middle of the productivity distribution; At lower levels of productivity, returns to factors of production are similar to men and women, and the gender gap in productivity is mainly due to lower access to resources for women.
1	Davis et al., 2012	Kenya, Tanzania, Uganda - Multicountry	**Quasi-experimental:** Longitudinal impact evaluation; a double difference with matching estimators (propensity score matching for participants and non-participants based on characteristics affecting program participation and outcomes and covariate matching) at household level; demographic and socioeconomic controls included	Farmer field school participation (where participants learn about new breeds, inputs, complex crop or livestock management such as integrated pest management).	Per capita agricultural income of female-headed FFS households increased by 187%, while per capita agricultural income of male-headed FFS households did not change significantly
1	Elias et al., 2013	Ethiopia - Local (3 kebeles of Gozamin woreda)	**Quasi-experimental:** Regression analysis (OLS), Heckman Treatment Effect Model (HTEM) and Propensity Score Matching (PSM) address selection-bias due to self-selection of farmers into the program and endogenous program placement; demographic; at household and plot level, input and topographic controls included	Participation in agricultural extension	Male-headed households have 5% higher farm productivity than female headed households after participation in ag. extension service
1	Alene et al., 2008	Kenya - Regional (Nyanza and Western Provinces, 32 villages in 8 major maize growing districts)	**Non-experimental**: Regression analysis (Seemingly unrelated regression method (SUR)) at plot and individual level; demographic and geographic controls included	Land use, extension access	Men and women have equal economic efficiency, controlling for inputs; The elasticity of maize production with respect to land is 0.43 for women and 0.35 for men farmers, this implies that a 10% increase in land use would raise maize production by 4.3% for women and 3.5% for men farmers, holding other inputs constant; Regular contact with extension raised maize supply by 18% for men and 21% for women farmers
1	Andrews, Golan, & Lay, 2014	Uganda - National	**Non-experimental**: Regression analysis (OLS, household and parcel fixed effects) at plot level; demographic, socioeconomic, urban/rural controls included	Labor (male/female)	Inefficient intra-household allocation of male and female labor on male and female controlled plots suggest that total household output could be increased by 19% by reallocating male labor to female controlled plots, and by 9% through the vice-versa

1	Chavas, Petrie, & Roth, 2005	Gambia - Local (3 peri-urban villages near the capital city of Banjul)	**Non-experimental**: Regression analysis (Tobit) at household level; demographic, access to markets, and tenure controls included	Gender of household head	Allocative inefficiency is high for farm households; for an average household, the cost of allocative inefficiency amounts to 43% of household income; male headed household status is a significant barrier to allocative efficiency (-0.493 coefficient); intra-household allocation of labor and land rights contributes to significant allocative inefficiencies in male-headed households
1	Moock, 1976	Kenya - Local (Vihiga division)	**Non-experimental**: Regression analysis (OLS) at farm level; demographic, ag. input controls included	Gender of individual farm manager	Women maize farmers are more technically efficient than male maize farmers, obtaining about 7% more output at the mean levels of input use
1	Nwaru, Okoye, & Ndukwu, 2011	Nigeria - Regional (Imo State)	**Non-experimental**: Regression analysis (Cobb-Douglas stochastic frontier production function) at household level; demographic, socioeconomic, access to credit controls included	Gender of individual	Farm size and gender were negatively signed indicating that female farmers were more allocatively efficient than their male counterparts; sweet potato farmers in Imo State are predominantly women who are not fully allocatively, technically and economically efficient
1	Quisumbing, 1994*	Africa, Asia, L. America - Multicountry	**Review**: Literature Review (methodology not described)	Gender of individual	Most reviewed studies find female farmers equally technically efficient (no significant difference) as male farmers in terms of yield, once individual characteristics and input levels are controlled for
1	Quisumbing, 1996	Kenya, Burkina Faso, Nigeria, Korea, Thailand - Multicountry	**Review (Meta-analysis):** (pooled regressions) at individual and plot levels; Controls for individual characteristics and inputs	Gender of individual and plot manager	Female farmers are equally technically efficient in terms of yields as male farmers, once individual characteristics and input levels are controlled for.
1	Karamba & Winters, 2001	Malawi - National	**Quasi-experimental:** Regression analysis (OLS, probit, propensity scores for FISP participation) at plot level; demographic, geographic, climate, socioeconomic, and input controls included	Participation in Fertilizer Input Subsidy Program (FISP)	FISP participation increases agricultural productivity for both male and female farmers by 17%
1	Kinkingninhoun-Mêdagbé et al., 2010	Benin - Local (Koussin- Le´le´ irrigation scheme in central Benin)	**Non-experimental**: Regression analysis (Production Frontier Model) at plot level; ag. input controls included	Land use	Men have higher productivity than women per unit of land, seeds, fertilizer and labor; avg yield of men is 4.95 tonnes/ha and that of women is 3.89 tonnes/ha; the larger MP for men is mainly due to the effect of larger land holding size and increasing marginal returns to land, women too experience increasing marginal returns to land with same factors; those with larger land holdings will have higher marginal returns and higher productivity
1	Oseni et al., 2015	Nigeria - National	**Non-experimental**: Regression analysis (RIF decomposition, Oaxaca-Blinder mean decomposition) at plot level; demographic, socioeconomic, input controls included	Access to inputs	In the Northern region, women produce 28% less than men, even after controlling for observed factors of production; in Oaxaca-Binder decomposition results, the structural effect is larger than the endowment effect at the mean; if women were given the same level of inputs as men, there would still be significant differences in productivity between men and women; In the Southern region, the endowment effect is more important, access to resources explains most of the 24% of unconditional gender gap in productivity; If women were given the same level of inputs as men, the gap would be statistically insignificant

1	Slavchevska, 2015	Tanzania - National	**Quasi-experimental:** Regression analysis (plot, household, and village fixed effects) at household and village level; demographic , inputs, time controls included	Gender of labor	Unequal returns to factors of production, including male family labor and other unobservable factors (perhaps land quality) widen the gender differential in productivity; Within the same household, plots managed by a sole woman are 21% less productive than those managed by a sole man, controlling for manager and plot characteristics, inputs and primary crops; At all levels of productivity, sole female farmers obtain lower returns from the factors they apply on their plots
1	Kilic, Palacios-Lopez, & Goldstein, 2015	Malawi - National (768 enumeration areas)	**Non-experimental**: Regression analysis (recentered influence function (RIF) regression, Naïve regression) at plot level; Controls for factors of production	Input use	Female-managed plots are on average 25% less productive than male managed plots with 82% of is gap explained by differences in observable covariates such as the endowment effect and 18% explained by gender differences in returns to adult male labor and inorganic fertilizer input and child dependency ratio
1	Peterman et al., 2011	Nigeria, Uganda - Multicountry (8 districts in Uganda and program areas of 12 states in Nigeria)	**Non-experimental**: Regression analysis (probit, Cragg's two-tiered unconditional tobit model, Honore ¤'s fixed-effects tobit estimator) at household level and plot level; demographic and input controls included	FHH; Crop ownership female	When household-level unobservables and other inputs are controlled for, female-owned plots have the lowest productivity in Uganda
2	Owusu, Abdulai, & Abdul-Rahman , 2011	Ghana - Regional (10 rural communities in Savelugu-Nanton district)	**Quasi-experimental:** Regression analysis (probit, propensity score matching) at individual level; PSM to control for self-selection that normally arises when participation in non-farm work is not randomly assigned and self-selection into participation occurs; demographic, socioeconomic, geographic, and access to credit controls included	Non-farm employment participation	Males' participation in non-farm employment results in an increase in household income by about ¢3,467,900 (US$367), while females' participation tend to increase household income by about ¢2,658,600 (US$281)
2	Qiao et al., 2015	China - National	**Quasi-experimental:** Regression analysis (probit) at household level using panel data; demographic, socioeconomic, time, and controls included	Education	Education for females is positively associated with an increase in income from local off-farm work participation by 0.87% and income from migration by 3.90%;
2	Yang, 1997	China - Regional (Sichuan province)	**Quasi-experimental:** Instrumental variable analysis (instrument = number of household members in the labor force), correlation analysis; demographic controls included	Farm labor supply/schooling	The labor marginal productivity in farming is below the sample mean wage rate (4.65 yuan) for non-farm work; positive relationship between education and off-farm wage rates; women earn less than men for off-farm employment (-0.298 coefficient)
2	Abdulai & Delgado, 1999	Ghana - Regional (27 villages in 4 districts in Northern Ghana)	**Non-experimental**: Regression analysis (probit) at individual level; demographic, socioeconomic, and geographic controls included	Education	"A one-year increase in schooling was found to increase the wage rate of women by 6.9% and that of men by 4.9%" (p. 128); "the own-wage elasticities for males and females are, respectively, 0.32 and 0.66, suggesting that females are more responsive to changes in the marginal returns to their labor than are males" (p. 126-127); "The estimated male wage effect on female labor supply was negative and significant. A 10% increase in the wage rate of husbands is associated with a 2.1% reduction in the number of days worked by wives" (p. 127)

2	Lanjouw, 1999	Ecuador - National	**Non-experimental**: Regression analysis (OLS, probit) at individual level; demographic, socioeconomic, and geographic controls included	Industry of employment in non-agricultural wage labor	Moving from traditional sector employment to most non-agricultural sectors analyzed is associated with a rise in average incomes (true for all industries except mining and extraction); low-labor-productivity activities that act as residual source of employment are common among women; women and other groups who are not able to enter ag. wage employment can gain means to economic security through nonag. income (probit coefficient of .642 for all nonag. employment, 0.852 in low-productivity jobs, -0.248 in high-productivity jobs for probability of employment as primary occupation)
2	Nerman , 2015	Tanzania - National	**Non-experimental**: Regression analysis (OLS) at household level; demographic and access to credit controls included	Activity combination of Household (Ag+Non-Ag Wage Work)	Being engaged in ag. wage work is correlated with a lower marginal return in own farming; the average and median marginal returns in agriculture are less than 40% of their wage labor counterparts; men tend to have moderately higher wages than women, the different estimates are roughly 10–20% higher for men
2	Ruben & Van den berg , 2001	Honduras - National	**Non-experimental**: Regression analysis (tobit, logit) at household level; demographic, geographic, and access to credit controls included	Farm and non-farm work	The share of non-farm income in total income increases from 14 to 31% as household income rises, higher income strata receive substantially more income from livestock production, non-farm wages, and self-employment compared to lower income strata; Poor households rely strongly on cropping income (52%) and farm wage employment income (28%); Non-farm wages are between twice as high (in the West) and half as high (in the South) as farm wages; Hourly returns on self-employment are 2.6–3 times higher than farm wages, with the Southern region having a 50% higher rate than the Western region; Women have coefficients of 2.005 for nonfarm wage employment and 1.854 for self-employment participation
2	Lanjouw & Shariff , 2004	India - National	**Non-experimental**: Regression analysis (multinomial logit, OLS and censored least absolute deviation (CLAD) model) at individual level; demographic, socioeconomic, and geographic controls included	Average wage rate for sowing and harvesting; average yield	"The analysis of non-farm employment probabilities and earnings suggests that the poor are not particularly well placed to benefit from the expansion of this sector. Low education levels, wealth and social status, all appear to restrict access of the poor to the relatively more attractive non-farm occupations." (p.4445); women have negative coefficients for farming and other occupations, non-farm casual wage, non-farm own enterprise and non-farm regular employment across all regions studied with larger magnitude negative coefficients for non-farm variables
3	No estimates of economic benefits identified that are specific to this pathway (leveraging women's decisions to cultivate more diverse and nutritious crops)				
4	No estimates of economic benefits identified that are specific to this pathway (leveraging women's decisions to intercrop more frequently)				
5	No estimates of economic benefits identified that are specific to this pathway (leveraging women's decisions to allocate more household income to children's food and education)				

Selected estimates of these benefits drawn from the existing literature, summarized in Table 7, suggest that investments in women's empowerment in agriculture through the five pathways we have described could be significant in contexts where the assumed male/female differences hold, though it is not clear how these differences might be affected if women were given greater control over agricultural productive resources, management, and income.

For example, several studies estimate the benefits of increasing women's use of productive resources to close the agricultural productivity gap between men and women (Pathway 1). Published aggregate estimates of the gender gap in agricultural productivity point to potential gross gains of $100 million in Malawi, $105 million in Tanzania, and $67 million in Uganda per year (UN Women, 2015), while estimates from Burkina Faso and Uganda suggest aggregate household output could be increased by 10-19% by reallocating factors of production (including labor) used between plots controlled by men and women in the same household (Andrews et al., 2014; Udry et al., 1995). Others have suggested closing the gender gap in agricultural productivity could lead to a 0.72 percent reduction in the incidence of undernourishment, with an additional 80,000 people being sufficiently nourished every year in Tanzania (UN Women, 2015).

A broad base of evidence reports on benefits from improved nutrition through improved labor productivity and reduced health costs. A 2014 report by the African Union Commission and others finds that treatment of undernutrition is a recurring expense for health systems in low-income countries, costing between 1-11% of countries' total public health budgets (African Union Commission et al., 2014). These increased health costs can also translate into reduced economic growth, with a World Bank (2006) estimate suggesting economic loss to malnutrition could amount to 2-3% of gross domestic product and individual productivity losses due to malnutrition globally are estimated at more than 10% of lifetime earnings. Hoddinott et al., (2008) report that Guatemalan young adults who had been enrolled in a village-based nutrition intervention benefitted from a 46% increase in average wages. To the extent that women's decisions to plant more diverse and nutritious crops and to allocate more household income to food, empowering women in agriculture could therefore have significant benefits through improved nutrition.

Table I. Selected estimates from the existing literature of economic benefits of pathway outcomes, indicating potential returns to women's empowerment in agriculture.					
Pathway	Source	Geographic Area, Scale	Methodology	Independent Variable	Valuation Estimate
1. Increased Women's Use of Productive Resources: Provide new agricultural resources to women or reallocate household resources to eliminate the yield gap between men and women	UN Women. (2015). *The Cost of the Gender Gap in Agricultural Productivity in Malawi, Tanzania, and Uganda.*	Malawi, Tanzania, Uganda - National	**Non-experimental:** Cost-benefit analysis	Agricultural productivity (measured as gross value of output per unit of land)	Estimates of the gender gap in agricultural productivity point to potential gross gains of $100 million in Malawi, $105 million in Tanzania, and $67 million in Uganda per year.
	Andrews et al. (2014). Inefficiency of Male and Female Labor Supply in Agricultural Households: Evidence from Uganda.	Uganda - National	**Quasi-experimental:** Regression analysis (OLS, household and parcel fixed effects) at plot level; demographic, socioeconomic, urban/rural controls included	Gender of plot manager	Total household output could be increased by 19% by reallocating male labor to female controlled plots
	Udry et al. (1995). Gender differentials in farm productivity: implications for household efficiency and agricultural policy.	Burkina Faso - Regional (6 villages in 3 agroclimatic zones)	**Quasi-experimental**: Regression analysis (OLS, fixed effect Tobit estimates, Cobb-Douglas) at household level; fixed effects are household-year-crop and household-year; labor, inputs, plot size, topography, and soil type controls included	Gender of plot manager	A loss of 10-15% of household output is due to inefficient factor allocation within a household, and the authors argue that a higher household output could be achieved through the reallocation of variable factors from plots controlled by men to plots controlled by women
2. Increased Women's Participation in Labor Markets: Eliminate the mobility gap between men and women to increase women's labor productivity	Doss, Bockius-Suwyn, & D'Souza (2012). Women's economic empowerment in agriculture: Supporting women farmers.	India - Regional (Uttar Pradesh)	**Review**: Review of 34 projects targeting target small-scale farmers or agricultural processors identified by experts in the field with knowledge of field-based interventions targeting rural women agriculturalists	Income-generating interventions for women	Participating in the Sunhara Wal-Mart Project which included interventions such as starting financial practices within groups and linking groups with large buyers, quadrupled beneficiary women's income to $4/day.

3. Improved Household Nutrition: Leverage women's preference for nutritious crops to improve household labor productivity and reduce health expenditures	African Union Commission et al. (2014). The Cost of Hunger in Africa: Social and Economic Impact of Child Undernutrition in Egypt, Ethiopia, Swaziland and Uganda	Egypt, Ethiopia, Swaziland, Uganda - Multi-national	**Non-experimental:** Cost-benefit analysis	Child undernutrition	Eliminating child undernutrition can reduce health costs by up to 11% of the total public budget allocated to health
	UN Women. (2015). *The Cost of the Gender Gap in Agricultural Productivity in Malawi, Tanzania, and Uganda.*	Tanzania - National	Not stated	Agricultural productivity (measured as gross value of output per unit of land)	Closing the gender gap in agricultural productivity could reduce undernourishment in Tanzania by 0.72%
	Horton & Hoddinott (2014). *Benefits and costs of the food and nutrition targets for the post-2015 Development Agenda.*	Global - Multi-country	**Non-experimental:** Cost-benefit analysis	Nutrition intervention treatment	Interventions reducing stunting by 59.4% have a benefit-cost ratio from 3.5 (Democratic Republic of the Congo) to 42.7 (Indonesia)
4. Improved Household Soil Quality: Leverage women's preference for intercropping to increase household land productivity	Kassie et al. (2008). Estimating returns to soil conservation adoption in the northern Ethiopian highlands.	Ethiopia - Regional (Tigray and Amhara)	**Quasi-experimental:** propensity score matching and regression analysis (OLS) at the household-level; household and plot-level controls included	Soil conservation (use of stone bunds)	Soil conservation has been linked to crop productivity gains of 18% to over 100% in smallholder contexts
	Crusciol et al. (2015). An innovative crop-forage intercrop system: early cycle soybean cultivars and palisadegrass.	Brazil - Local (Botucatu)	**Field Experiment**: Analysis of variance comparing treatment means; blocks and block interactions considered random effects; soil variable controls included	Maize intercropped with palisadegrass	Higher soil fertility resulting from maize-palisadegrass intercropping increased subsequent soybean yield by 14%, white oat yield by 24%, and maize yield by 12.7% over plots that had been previously treated with maize monocrop

	Lal (2009). Soil carbon sequestration impacts on global climate change and food security.	Global – Multi-country	<u>**Review:**</u> Review of literature on soil degradation and its effects on agricultural productivity and food security, summarized current state of the food security literature and connected that to environmental effects (namely soil degradation) that will intensify as a result of climate change	Soil degradation	Carbon sequestration via sustainable farming practices could offset 5-15% of global fossil-fuel emissions
5. Improved Household Nutrition and Educational Achievement: Leverage women's preferences for spending income on food and education to increase household labor productivity and reduce health expenditure	Montenegro & Patrinos (2013). Returns to schooling around the world: Background paper for the World Development Report 2013.	Global - Multi-country	<u>**Non-experimental:**</u> Survey of findings using data from standardized household surveys	Educational attainment	The average rate of private return to another year of schooling is 12.8% in Sub-Saharan Africa
	Van Den Boom, Nubé, & Asenso-Okyere (1996). Nutrition, labour productivity and labour supply of men and women in Ghana.	Ghana - National	<u>**Quasi-experimental:**</u> Panel data with fixed effects regression analysis (OLS) at the individual-level; individual and household demographic, socioeconomic, and geographic controls included	Food consumption	In Ghana, a 1% increase in food consumption is associated with 0.61% wage rate increase for men and 0.47% wage rate increase for women

3. <u>Key variables necessary for extrapolating study findings to broader estimates of the benefits of economic empowerment – including basic variables such as land area managed by women – are not readily available</u>. We found few readily available data sources on key variables such as women's land ownership, women's land management, input use, or labor necessary to calculate the household-level and aggregate net benefits of interventions increasing women's access to and use of inputs such as fertilizer, labor, or even land at the margin. Analysis of the marginal productivity returns to changes in women's access to agricultural productive resources (including land, labor, and fertilizer and other inputs) using LSMS-ISA or other datasets could provide more refined estimates of the potential benefits to investments to women's empowerment in agriculture (see a sample analysis establishing the trends in women's behavior and decision-making in an analysis of the 2012-2013 Tanzania LSMS-ISA in Appendix B).

5. <u>Data on the costs of interventions addressing (eliminating or leveraging) the male-female differences in the five pathways are limited</u>, making calculations of potential returns per dollar of investment difficult. While estimates of the marginal benefits of interventions along these pathways are also limited, further research could help establish a range of potential benefits in different contexts.

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Appendix A. Literature Search Methodology

Pathway 1: Increased Women's Use of Productive Resources

Pathway Category	Location	Search String	Total Results	Reviewed Results	Relevant non-duplicate Results
Gender differences: Women's plots receive fewer inputs and have lower agricultural productivity	Google Scholar	(women OR female OR gender) AND (inputs OR land OR credit OR labor OR fertilizer) AND (agriculture OR farm*)	18,800	First 60	17
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Google Scholar	increas* AND women* AND control AND (farm* or agriculture) AND (fertilizer or insecticide or credit or land or tool* or labor)	162	162	2
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Scopus	(women* or gender or female) AND (control or autonom*) AND (farm* or agriculture) AND (fertilizer or insecticide or credit or land or tool* or labor) AND (resource* or input*)	274	120	2
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Scopus	increas* AND use AND control AND (women or gender or female) AND (fertilizer or land or labor or tool* or credit)	17,500	First 40	2
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Google Scholar	increas* and (women or female or gender) and (input* or fertilizer or land or credit) and (use or usage)	17,100	First 40	1
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Google Scholar	increas* and women and control and (input* or fertilizer or land or credit) and (use or usage) and plot*	8,940	First 60	1
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Google Scholar	(women OR female) AND (empower OR control OR decision* OR bargain* OR authority OR WEIA)) AND (farm* OR agri* OR crop OR livestock) AND (improv* OR increas* OR rais*) AND (input OR fertilizer OR credit OR land OR labor)	24,000	First 40	0
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Google Scholar	(women OR female) AND (empower OR control OR decision* OR bargain* OR authority OR WEIA)) AND (farm* OR agri* OR crop OR livestock) AND (improv* OR increas* OR rais*) AND (input OR fertilizer OR credit OR land OR labor) AND (experimen	17,400	First 120	0
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Google Scholar	(women or female or gender) AND (fertilizer or insectide or seed or land or labor) AND (use or usage) AND (household or plot)	1,050	First 80	7
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Google Scholar	(women or female or gender) AND (RCT or experiment*) AND (fertilizer or seed or labor or land or manure)	59	59	0

Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Scopus	(women OR female) AND (farm* OR agri* OR crop) AND (improv* OR increas* OR rais*) AND fertilizer AND subsidy)	8	8	0
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Google Scholar	(gender or women or female) AND (farm* OR agri*) AND subsidy AND fertilizer	18,300	First 80	0
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Scopus	((women OR female) AND (empower OR control OR decision* OR bargain*) AND (farm* OR agri* OR crop OR livestock) AND (improv* OR increas* OR rais*) AND (input OR fertilizer OR credit OR land OR labor))	504	First 40	0
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Google Scholar	((provision OR provide OR give*) AND (fertilizer OR seed OR land) AND (gender OR women OR female) AND (use OR usage) AND (farm* OR agricul*) and (experiment* or RCT)	2,920	First 80	0
Direct outcomes: Increasing women's control over productive resources leads to increased use of inputs on women's plots	Scopus	TITLE-ABS-KEY ((women OR female OR gender) AND (intra-household OR intrahousehold) AND allocation AND (farm OR crop OR plot OR agricultur*) AND (fertilizer OR seed OR land OR labor))	26	26	0
Economic benefit: Increased use of inputs associated with increased agricultural productivity	Google Scholar	(women OR female OR gender) AND (fertilizer OR seed OR credit OR land) AND (farm* OR agric*) AND (agriculture AND productivity) AND (increas* OR improv*) AND (experiment OR RCT or data)	25,400	First 50	2
Economic benefit: Increased use of inputs associated with increased agricultural productivity	Google Scholar	((increas* OR rais* OR improv*) AND (use OR usage) AND (fertilizer OR seed OR manure OR pesticide) AND productivity AND (female OR gender OR women))	34,300	First 50	0
Economic benefit: Increased use of inputs associated with increased agricultural productivity	Scopus	((increas* OR rais* OR improv*) AND (fertilizer OR seed OR manure OR pesticide) AND productivity AND (female OR gender OR women))	170	First 80	1
Economic benefit: Increased use of inputs associated with increased agricultural productivity	Scopus	((data OR experiment OR rct) AND (increas* OR improv* OR rais*) AND economic AND productivity AND (farm OR crop OR agricultur*) AND (seed OR fertilizer OR manure OR pesticide)) AND PUBYEAR > 1999	340	First 20	3
Economic benefit: Increased use of inputs associated with increased agricultural productivity	Scopus	(productivity OR yield) AND (fertilizer OR seed OR land) AND (plot OR farm))	18,484	First 80	1

Pathway 2: Increased Women's Participation in Labor Markets

Pathway Category	Location	Search String	Total Results	Reviewed Results	Relevant non-duplicate Results
Gender differences: Women are less mobile than men	Google Scholar	(female or gender or women) and mobility and (agriculture or farm) and (off-farm* or non-farm*) and developing and countr*	2,580	First 60	1
Gender differences: Women are less mobile than men	Scopus	(female or gender or women) and (agriculture or farm*) and (mobility or off-farm or "labor market") and developing and countr*	106	106	3
Gender differences: Women are less mobile than men	Scopus	(female or women) and (non-farm or off-farm) and labor and men	45	45	1
Gender differences: Women are less mobile than men	Google Scholar	women and ("labor market" or "non-farm" or "off-farm") and agricultur*	2,630	First 80	3
Gender differences: Women are less mobile than men	Scopus	women OR female OR gender) AND participate AND ("labor market" OR "mobility") AND (agriculture OR farm*))	10	10	0
Gender differences: Women are less mobile than men	Google Scholar	"labor market participation" AND (women or gender or female) AND ("more mobile" or mobility) AND (farm* or agri*)	62	62	0
Gender differences: Women are less mobile than men	Google Scholar	increas* and "women's mobility" and (non-farm or off-farm) and labor	31	31	0
Gender differences: Women are less mobile than men	Google Scholar	("labor market participation" AND women AND (mobility or mobile)	2,110	First 40	0
Gender differences: Women are less mobile than men	Google Scholar	"labor market participation" AND women AND (farm* or agriculture)	3,730	First 80	0
Gender differences: Women are less mobile than men	Scopus	women AND off-farm AND participation	32	32	0
Gender differences: Women are less mobile than men	Scopus	(women OR female) AND (farm* OR agri* OR crop OR livestock) AND (mobil* OR work OR (labor AND market)) AND (experiment* OR caus* OR data)	2,117	First 80	0
Gender differences: Women are less mobile than men	Google Scholar	(women OR female) AND (farm* OR agri* OR crop OR livestock) AND (mobil* OR work OR (labor AND market)) AND (experiment* OR caus* OR data)	22,500	First 40	0
Gender differences: Women are less mobile than men	Google Scholar	(women or female) AND (mobil* or (labor and market)) AND (agriculture or farm*)	21,500	First 80	3
Gender differences: Women are less mobile than men	Google Scholar	(gender OR female OR women) AND (non-farm OR off-farm) AND (mobil* OR work OR (labor AND market) AND agriculture	16,700	First 20	0
Direct outcome: Increasing women's control over her own labor/mobility increases their labor market participation	Google Scholar	(women OR female) AND (empower OR control OR decision* OR bargain* OR authority) AND (farm* OR agri*) AND (improv* OR increas* OR rais* OR participat* OR engag*) AND (mobil* OR work OR (labor AND market)) AND (experiment* OR caus*)	6,150	First 40	3

Direct outcome: Increasing women's control over her own labor/mobility increases their labor market participation	Google Scholar	(women OR female) AND (control OR decision* OR bargain* OR authority) AND (farm* OR agri*) AND (mobil* OR work OR (labor AND market) AND (experiment* OR caus*)	22,600	First 60	2
Direct outcome: Increasing women's control over her own labor/mobility increases their labor market participation	Scopus	(women OR female) AND increas* AND (mobility OR (labor AND market)) AND (agric* AND farm*))	58	58	0
Direct outcome: Increasing women's control over her own labor/mobility increases their labor market participation	Scopus	((women OR female) AND (empower OR control OR decision* OR bargain* OR authority) AND (farm* OR rural) AND (mobil* OR work OR (labor AND market)) AND "off -farm"))	17	17	2
Direct outcome: Increasing women's control over her own labor/mobility increases their labor market participation	Google Scholar	(gender or women or female) and ("labor market") and mobility and agricultur*	88	First 40	0
Economic benefit: Increased off-farm (labor) market participation increases labor productivity	Scopus	((women OR female OR gender) AND labor AND market AND productivity AND (participat* OR employ* OR work*) AND (income OR consum*) AND (increas* OR improv* OR raise)) AND PUBYEAR > 2004	32	32	0
Economic benefit: Increased off-farm (labor) market participation increases labor productivity	Google Scholar	((women OR female OR gender) AND labor AND market AND productivity AND (participat* OR employ* OR work*) AND (income OR consum*) AND (increas* OR improv* OR raise))	18,100	First 90	0
Economic benefit: Increased off-farm (labor) market participation increases labor productivity	Google Scholar	(women OR female OR gender) AND (employment or wages or income) AND labor AND market AND productivity AND (participat* or employ* or work*) AND (income or consum*) AND (off-farm or non-farm) AND productivity	3,910	First 40	1
Economic benefit: Increased off-farm (labor) market participation increases labor productivity	Scopus	(women OR female OR gender) AND (employment or wages or income) AND labor AND market AND productivity AND (participat* or employ* or work*) AND (income or consum*) AND (off-farm or non-farm) AND productivity	3	3	0
Economic benefit: Increased off-farm (labor) market participation increases labor productivity	Scopus	TITLE-ABS-KEY ((women OR female OR gender) AND (off-farm OR non-farm) AND productivity AND (participat* OR employ* OR work*)) AND PUBYEAR > 1999	23	23	2
Economic benefit: Increased off-farm (labor) market participation increases labor productivity	Google Scholar	((women OR female OR gender) AND (off-farm OR non-farm) AND productivity AND (participat* OR employ* OR work*))	17,300	First 40	1
Economic benefit: Increased off-farm (labor) market participation increases labor productivity	Scopus	TITLE-ABS-KEY (labor market AND (employ* OR work OR participat*) AND labor productivity AND (off-farm OR non-farm)) AND PUBYEAR > 1999	35	35	1

Pathway 3: Improved Household Nutrition

Pathway Category	Location	Search String	Total Results	Reviewed Results	Relevant non-duplicate Results
Gender differences: Women plant a greater variety of crops than men	Scopus	(women* OR gender*) AND (role*) AND (smallholder OR farm* OR agric*) AND (develop* OR low-income OR poor) AND (divers* AND crop*)	30	30	8
Gender differences: Women plant a greater variety of crops than men	Google Scholar	(women* OR gender*) AND (role*) AND (smallholder OR farm* OR agric*) AND (develop* OR low-income OR poor) AND (divers* AND crop*)	35	35	1
Gender differences: Women plant a greater variety of crops than men	Google Scholar	(women* OR gender*) AND (role*) AND (smallholder OR farm* OR agric*) AND (develop* OR low-income OR poor) AND (divers* AND crop*)	15,900	First 40	0
Gender differences: Women plant a greater variety of crops than men	Google Scholar	(women* OR gender*) AND (role*) AND (homegarden* OR "home garden*" OR home-garden*)	5,340	First 40	5
Direct outcomes: Crop diversity leads to increased dietary diversity and nutrition	Scopus	("crop diversity" OR "plant diversity" OR "agricultur* diversity") AND ("dietary diversity" OR nutri*) AND (household* OR famil*)	66	First 40	8
Direct outcomes: Crop diversity leads to increased dietary diversity and nutrition	Google Scholar	("crop diversity" OR "plant diversity" OR "agricultur* diversity") AND ("dietary diversity" OR nutri*) AND (household* OR famil*)	2,090	First 40	5
Economic benefits: Increased dietary diversity and/or nutrition lead to lower health costs	Scopus	(malnutrition OR undernutrition OR "food security" OR "food insecurity") AND (child* OR famil* OR household) AND ("health cost*" OR "health expen*" OR "health spend*" OR "medical cost*" OR "medical expen*" OR "medical spend*")	54	First 40	4
Economic benefits: Increased dietary diversity and/or nutrition lead to lower health costs	Google Scholar	(malnutrition OR undernutrition OR "food security" OR "food insecurity") AND ("health cost" OR "health expen*" OR "health spend*" OR "medical cost*" OR "medical expen*" OR "medical spend*")	10,800	First 40	0
Economic benefits: Increased dietary diversity and/or nutrition lead to increased labor productivity	Scopus	(nutrition* OR "food security" OR "food insecurity") AND ("labor productivity" OR "labour productivity")	79	First 50	8
Economic benefits: Increased dietary diversity and/or nutrition lead to increased labor productivity	Google Scholar	(nutrition* OR "food security" OR "food insecurity") AND ("labor productivity" OR "labour productivity")	16,400	First 40	2

Pathway 4: Improved Household Soil Quality

Pathway Category	Location	Search String	Total Results	Reviewed Results	Relevant non-duplicate Results
Gender differences: Women intercrop more than men	Scopus	(women OR gender OR "female farmer*") AND (intercrop* OR "inter crop*")	28	28	3

Gender differences: Women intercrop more than men	Google Scholar	(women OR gender OR "female farmer*") AND (intercrop* OR "inter crop*")	4,490	First 40	0
Direct outcomes: Intercropping leads to higher soil quality	Scopus	(intercrop* OR inter-crop* OR "inter crop*") AND (improve* OR chang* OR associat* OR "leads to" OR link* OR affect*) AND ("soil quality" OR "soil fertility")	402	First 50	14
Direct outcomes: Intercropping leads to higher soil quality	Google Scholar	(intercrop* OR inter-crop* OR "inter crop*") AND (improve* OR chang* OR associat* OR "leads to" OR link* OR affect*) AND ("soil quality" OR "soil fertility")	16,600	First 50	0
Economic benefits: Improved soil quality leads to increased land productivity	Scopus	("soil quality" OR "soil fertility") AND (improve* OR "leads to" OR "associated with" OR increase*) AND ("crop yield") AND (productivity)	553	First 80	15
Economic benefits: Improved soil quality leads to increased land productivity	Google Scholar	("soil quality" OR "soil fertility") AND (improve* OR "leads to" OR "associated with" OR increase*) AND ("crop yield") AND (productivity)	17,000	First 40	3

Pathway 5: Improved Children's Nutrition and Educational Attainment

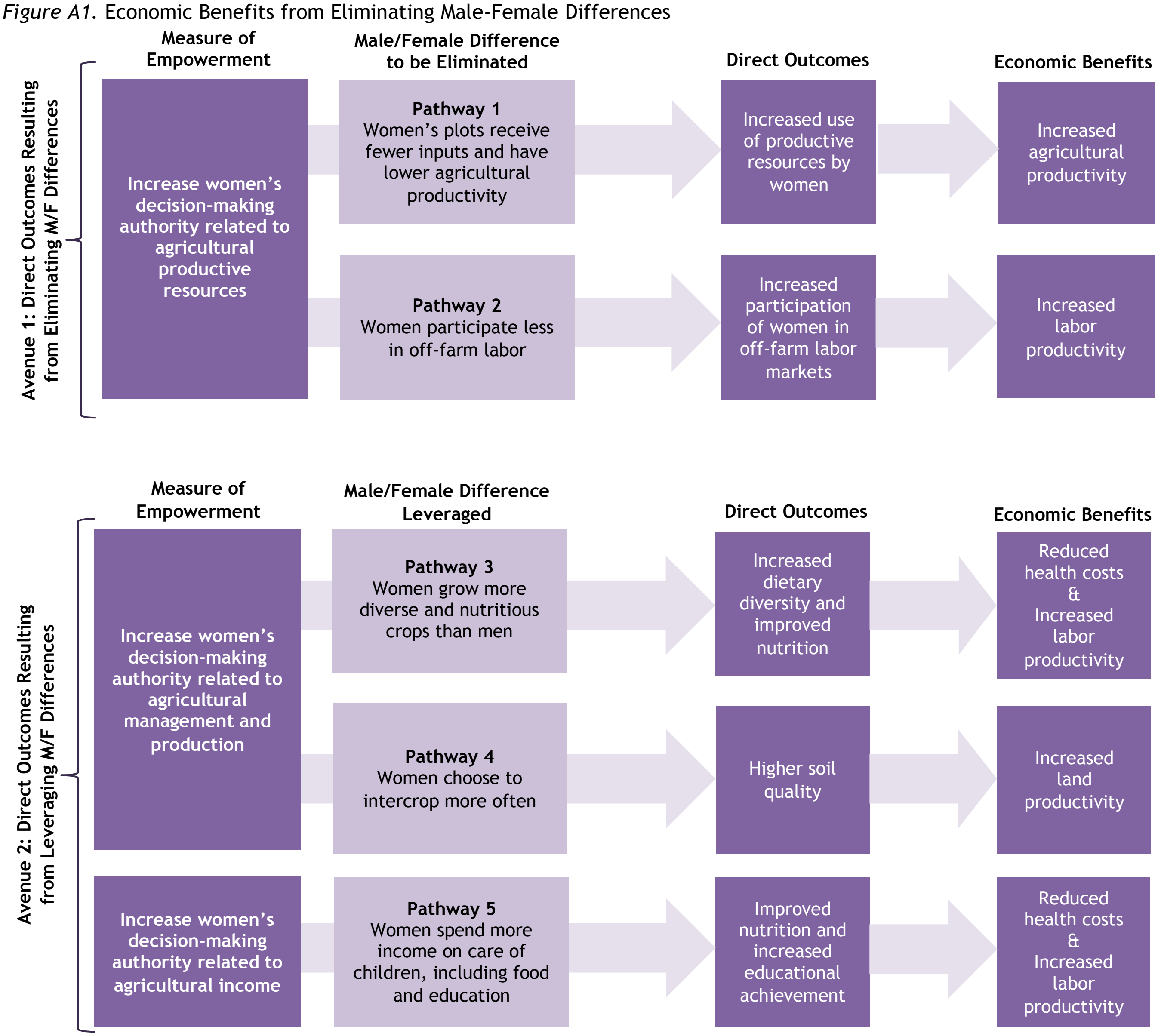
Pathway Category	Location	Search String	Total Results	Reviewed Results	Relevant non-duplicate Results
Gender differences: women spend more income on care of children, including food and education	Scopus	TITLE-ABS-KEY ((Wom?n* OR female) AND (intrahousehold OR household) AND (expenditure OR spend*) AND (allocat* OR diff* OR prefer*) AND child* AND (food* OR diet* OR educat* OR school*)) AND PUBYEAR > 2005	333	First 100	12
Direct outcomes: Increased spending on food leads to better nutrition	Scopus	TITLE-ABS-KEY (Household AND (expenditure OR spend* OR allocat*) AND (food OR diet*) AND (nutri* OR health* OR "food security" OR "food insecurity" OR hunger) AND (experiment* OR caus* OR regress* OR data)) AND PUBYEAR > 2005	614	First 100	6
Direct outcomes: Increased spending on food leads to better nutrition	Google Scholar	"food expenditure" AND nutrition	14,100	First 40	1
Direct outcomes: Increased spending on food leads to better nutrition	Google Scholar	"household food expenditure" AND food security	1,320	First 40	1
Direct outcomes: Increased spending on food leads to better nutrition	Google Scholar	"household food spending" AND health	312,000	First 40	0
Direct outcomes: Increased spending on education leads to increased children's educational achievement	Scopus	TITLE-ABS-KEY (increas* OR rais* OR high* OR greater OR large* OR improv*) AND (expenditure OR spend* OR allocat*) AND (educat* OR school*) AND (achieve* OR attain* OR graduat* OR drop* OR complet* OR qualif* OR score* OR learn*) AND (experiment* OR caus* OR regress*)) AND PUBYEAR > 2005	254	First 100	3

Direct outcomes: Increased spending on education leads to increased children's educational achievement	Google Scholar	"household education expenditure" AND achievement	204	First 40	1
Economic Benefits: Improved nutrition leads to reduced health costs and/or increased labor productivity (also see productive resources pathway searches)	Scopus	TITLE-ABS-KEY (malnutrition OR undernutrition OR "food security" OR "food insecurity") AND (child* OR famil* OR household) AND ("health costs" OR "medical costs" OR "health expenditure" OR "health spending" OR "health benefit" OR productivity OR output) AND PUBYEAR > 2005	124	First 100	6
Economic Benefits: Improved nutrition leads to reduced health costs and/or increased labor productivity (also see productive resources pathway searches)	Google Scholar	returns to nutrition AND (productivity OR health)	126,00	First 40	2
Economic Benefits: Increased educational achievement leads to reduced health costs and/or increased labor productivity	Scopus	TITLE-ABS-KEY (increas* OR rais* OR high* OR greater OR large* OR improv*) AND (expenditure OR spend* OR allocat*) AND (educat* OR school*) AND (achieve* OR attain* OR graduat* OR drop* OR complet* OR qualif* OR score* OR learn*) AND ("health costs" OR "medical costs" OR "health expenditure" OR "health spending" OR "health benefit" OR productivity OR output) AND PUBYEAR > 2005	410	First 100	4
Economic Benefits: Increased educational achievement leads to reduced health costs and/or increased labor productivity	Google Scholar	returns to education AND (productivity OR health)	625,000	First 40	6

Appendix B: Evidence from 2012-2013 Tanzania LSMS-ISA

The following statistical analysis serves as an illustrative case study from Tanzania to test several of the hypothesized relationships surrounding the potential impacts of women's empowerment in agriculture as reported in the literature. We examine relationships between gender, control over agricultural plot management, and various crop management choices and outcomes assumed in the women's empowerment in agriculture pathways outlined in the full report (Figure A1). The empirical results presented here represent findings from one context at one point in time, so they are not generalizable, but provide further evidence to help evaluate the hypotheses underlying different pathways from women's empowerment to economic impacts.

Figure A1. Economic Benefits from Eliminating Male-Female Differences



Methods

Our analysis uses 2012-2013 data on plot-level, individual-level, and household-level characteristics drawn from the Tanzania National Bureau of Statistics National Panel Survey (TNPS), conducted in conjunction with the World Bank's Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA). The survey provides detailed data on agricultural production, farm management, and individual and household demographics.[4]

The sample includes 3,090 households, of which 2,367 have a male head of household (HOH) and 723 have a female HOH. At the plot level, the sample includes 13,665 plots, including 10,575 plots in male-headed households and 3,090 plots in female-headed households. Plot management decisions are made solely by a man on 3,777 plots, jointly by a man and a woman on 6,730 plots, and solely by a woman on 3,158 plots.

We use the 2012-2013 data to provide additional evidence evaluating selected hypotheses for pathways 1-4, primarily testing assumed male/female differences. The survey design is less appropriate to evaluate the hypotheses identified in pathway 5 (nutrition outcomes) due to limitations in how household food and education expenditures are measured and difficulties in tying expenditures to nutrition and education outcomes within a single survey wave, so we did not use these data to further evaluate these hypotheses.

[4] The TNPS relies on a multi-stage stratified random sample where the primary sampling unit is the enumeration area (EA). The sample consists of eight administrative zones, each with a rural and an urban cluster, for a total of 16 sampling strata. EAs are based on the 2002 Census, and eight households per EA are randomly selected to participate in the survey. The survey data are representative at the national, urban/rural, and agro-ecological zone levels; however, sample size limitations preclude reliable statistics at the regional or district level. Households were interviewed in the 11 months following harvest about the prior growing season.

Table 1. Descriptive Statistics for Sample Households

	(1) All Households		(2) Female-Headed Households		(3) Male-Headed Households	
	Mean (SD)	**Min/Max**	**Mean (SD)**	**Min/Max**	**Mean (SD)**	**Min/Max**
Age of HOH	48.74 (16.16)	18 108	55.05 (15.50)	19 100	46.83 (15.88)	18 108
Education of HOH (years)	4.88 (3.62)	0 18	3.31 (3.44)	0 17	5.36 (3.53)	0 18
Household Size	5.65 (3.29)	1 54	4.71 (2.78)	1 21	5.94 (3.37)	1 54
Number of Children in Household (≤15 years old)	2.57 (2.22)	0 33	2.06 (1.89)	0 11	2.72 (2.29)	0 33
Household Annual Consumption (TSH)	859,991.4 (652,304.4)	43,480.59 6,423,195	852,832.7 (667,820.1)	107,222.5 5,468,869	862,156.5 (647,663.9)	43,480.59 6,423,195
Farm Size (ha)	2.87 (7.57)	0 180.96	2.04 (5.80)	0.008 107.37	3.12 (8.02)	0 180.96
Number of Plots	5.96 (4.37)	1 39	5.64 (4.04)	1 27	6.06 (4.46)	1 39
Household Used Any Fertilizer	0.28 (0.45)	0 1	0.23 (0.42)	0 1	0.30 (0.46)	0 1
Household Hired Any Labor	0.40 (0.49)	0 1	0.40 (0.49)	0 1	0.40 (0.49)	0 1
Distance to Nearest Road (km)	21.37 (23.83)	0 135.4	20.81 (23.53)	0 135.3	21.54 (23.93)	0 135.4
Distance to Nearest Market (km)	81.45 (54.34)	0.7 257.1	79.04 (52.83)	0.7 253.3	82.18 (54.78)	0.7 257.1
Observations	3,090		723		2,367	

The average HOH age for households in the sample is 49 years, with the mean age of female HOHs over eight years higher than male HOHs (Table 1). Female HOHs have on average less education, a smaller household size, and fewer children age 15 or younger in the household. Female-headed households on average have a farm that is 1.08 hectares smaller than male-headed households, which relates to the fewer number of plots in an average household with a female HOH. Per capita consumption across all households is similar as is the rate at which households hire labor. Overall, only 28% of households used organic and/or inorganic fertilizer, but this number falls to 23% of female-headed households and increases to 30% of male-headed households. Households with a female HOH are slightly closer to roads and markets. Owing to the substantial differences in characteristics between women in male-headed households and women in female-headed households, in the results below we consider these two subsets of women farmers separately.

We used these data to further evaluate six of the hypotheses in the theorized pathways for the economic benefits of women's empowerment. We tested for male/female differences in the number of crops cultivated, the number of vegetables and legumes cultivated, the likelihood of intercropping, and the likelihood of input use using the same analytical model. We also looked at male/female differences in participation in off-farm labor at the individual level. In addition, we analyzed the relationship between input use and maize yield. As the models and methods were specific to each analysis, we describe these methods together our findings as we report them below.

These analyses are not intended to test for causality in the relationships we are interested in, but rather to evaluate whether the associations revealed align with what would be expected based on the hypotheses in our causal pathways. The findings should therefore be interpreted as supplemental evidence from a particular context that relate to particular hypotheses, and not as generalizable conclusions about the validity of those hypotheses.

Pathway 1. Increased Women's Use of Productive Resources

Our literature review suggests that women have less access than men to a variety of agricultural inputs. In our analysis of the Tanzania 2012-2013 LSMS-ISA data, we find that both sex of the plot decision-maker and sex of the HOH appear to influence input use. In male-headed households, 34.4% of plots used inputs (fertilizer, herbicide, insecticide, pesticide, oxen, and/or farm implements), compared to 26.5% in female-headed households. Jointly-managed plots have the highest input use in male-headed households, at 36.5%, followed by plots managed solely by men (31.9%) and plots managed solely by women (25.9%). In female-headed households on the other hand, plots managed solely by women are the most likely to have used any inputs, with 27.8% of these plots using inputs.

We used logit regression models to test for male/female differences in the likelihood of input use at the plot level and the household level, controlling for the age and years of education of the HOH, household size, household consumption (logged), and the total farm size of the household (logged). For the plot level analyses, we controlled for plot size (logged) but no longer controlled for farm size (logged) because of the high correlation between plot size and farm size. Our analyses, which consider only whether any inputs were used and do not take into account the quantity, quality, or type of inputs, are summarized in Table 2.

Table 2. Correlates of Input Use: How Different Variables Impact Input Use

	(1) HH-Level: All Households	(2) Plot-Level: All Households	(3) Plot-Level: All Households	(4) Plot-Level: Female-Headed Households	(5) Plot-Level: Male-Headed Households
Woman solely responsible for plot decisions			0.025* (0.014)	0.138*** (0.034)	-0.089*** (0.031)
Woman and man jointly responsible for plot decisions			0.068*** (0.011)		0.073*** (0.011)
Man solely responsible for plot decisions			0.000 (.)		0.000 (.)
Man only or woman and man jointly responsible for plot decisions				0.000 (.)	
Sex of HOH (female = 1)	-0.029 (0.027)	-0.018 (0.012)			
Age of HOH	0.002** (0.001)	0.002*** (0.000)	0.002*** (0.000)	0.004*** (0.001)	0.002*** (0.000)
Education of HOH (years)	0.022*** (0.003)	0.025*** (0.002)	0.025*** (0.001)	0.025*** (0.003)	0.025*** (0.002)
Farm Size (log)	0.022** (0.009)				
Plot Size (log)		0.019*** (0.004)	0.020*** (0.004)	-0.012* (0.008)	0.027*** (0.004)
Household Size	0.021*** (0.004)	0.007*** (0.002)	0.007*** (0.002)	0.019*** (0.004)	0.004*** (0.002)
Household Consumption (log)	0.104*** (0.017)	0.109*** (0.008)	0.111*** (0.008)	0.127*** (0.015)	0.105*** (0.009)
N	3090	13665	13665	3090	10575

The dependent variable for the three plot-level regressions is whether or not the individual plot received any inputs - fertilizer, herbicide, insecticide, pesticide, oxen, and/or farm implements. At the household level, it is whether any plot cultivated by the household received any inputs.
The coefficients and standard deviations in the table are the marginal effects from the logit regression models.
For female-headed households, we combine plots managed solely by men and jointly by men and women because of the very small number of plots managed solely by men.
Standard errors in parentheses
* p<*0.1*, ** p<0.05, *** p<0.01

We find no significant association between the sex of the household head and input use at either the plot or household level (Columns (1) and (2)). At the plot level for all households overall, plots managed solely by women and plots managed jointly by men and women are significantly more likely to receive inputs compared to plots managed solely by men, contrary to the assumed difference (Column (3)).

In male-headed households, however, female-managed plots are significantly less likely to receive inputs while in female-headed households the opposite is true (Columns (4) and (5)). This result suggests that the sex of the head of the household may matter more for allocation of inputs to individual plots than the sex of the plot decision-maker. As a result, women in male-headed households (the vast majority of households in our sample) do appear to have less access to and control of inputs, as assumed in the theorized causal pathway.

Reducing male/female differences in the use of inputs may lead to increases in agricultural productivity, as the literature suggests that increasing access to and use of inputs is associated with increased yield. Several studies find that the productivity gap between men and women farmers diminishes significantly after controlling for access to inputs, though we identified two studies that report giving women access to inputs was not associated with increases in yield.

We ran several OLS regressions to test the association between input use and yield at the plot level using 2012-2013 LSMS-ISA data from Tanzania, looking at yields for maize, one of the most commonly grown crops in the sample, and for rice, an alternative cereal crop. We measured yield in tonnes per hectare at the plot level by dividing quantity harvested by area planted of the crop. We report findings from regressions on logged values of yield, though our results for the association between yield and input use were broadly similar when not logging yield. We ran separate regressions using a dummy for any input use (fertilizer, herbicide, insecticide, pesticide, oxen, and/or farm implements), and individual dummies for categories of input use – any fertilizer, any herbicide, insecticide, or pesticide, and any oxen or farm implements (e.g., cart or plough), to evaluate whether particular types of inputs are associated with yield.

In all of our models we controlled for the age and years of education of the HOH, household size, household consumption (logged), plot size (logged), sex of the plot decision-maker (woman only, joint, or man only), and the total number of both household and hired labor days used on the plot. We looked at all households and separately at male- and female-headed households, and also considered whether the effect of input use might vary with the sex of the plot decision-maker by including interaction terms in some of our models.

Looking first at the regressions on maize yield (Table 3), we find that plots managed solely by women have lower yields than plots managed solely by men, though this association is not significant in any of the models. Joint plot management, however, is significantly associated with higher yields overall and in male-headed households, compared to plots managed solely by men. The age of the HOH, having a female HOH, and plot size are significantly negatively associated with yield, while household consumption (except in female-headed households) is significantly positively associated with yield. As might be expected, pre-harvest losses are negatively associated with maize yield, though this association is not significant in female-headed households.

Table 3. Correlates of Maize Yield: How Different Variables Impact Maize Yield

	(1) All Households	(2) All Households	(3) All Households	(4) All Households	(5) Female-Headed Households	(6) Male-Headed Households
Woman solely responsible for plot decisions	-0.137 (0.112)		-0.123 (0.081)		-0.258 (0.178)	-0.131 (0.136)
Woman and man jointly responsible for plot decisions	0.222** (0.098)		0.147** (0.066)			0.154** (0.067)
Man solely responsible for plot decisions	0.000 (.)		0.000 (.)			0.000 (.)
Man only or woman and man jointly responsible for plot decisions					0.000 (.)	
Sex of HOH (female = 1)		-0.183*** (0.066)		-0.178*** (0.067)		
Age of HOH	-0.010*** (0.002)	-0.009*** (0.002)	-0.009*** (0.002)	-0.009*** (0.002)	-0.008** (0.004)	-0.010*** (0.002)
Education of HOH (years)	0.003 (0.009)	0.003 (0.009)	0.006 (0.009)	0.006 (0.009)	-0.022 (0.018)	0.014 (0.011)
Plot Size (log)	-0.475*** (0.025)	-0.469*** (0.024)	-0.481*** (0.025)	-0.474*** (0.025)	-0.511*** (0.053)	-0.473*** (0.029)
Household Size	0.020** (0.010)	0.021** (0.010)	0.016 (0.010)	0.017* (0.010)	0.038 (0.028)	0.013 (0.011)
Household Consumption (log)	0.140*** (0.049)	0.129*** (0.049)	0.140*** (0.048)	0.132*** (0.048)	0.135 (0.100)	0.138** (0.055)
Any Input Use on the Plot	0.431*** (0.112)	0.346*** (0.055)				
Any Input Use on the Plot * Woman solely responsible for plot decisions	0.017 (0.155)					
Any Input Use on the Plot * Woman and man jointly responsible for plot decisions	-0.173 (0.132)					
Total Days of Household Labor on the Plot	0.001*** (0.000)	0.001** (0.000)	0.001** (0.000)	0.001** (0.000)	0.001 (0.001)	0.001** (0.000)
Total Days of Hired Labor on the Plot	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.002*** (0.001)	0.007*** (0.002)	0.002** (0.001)
Any Fertilizer Use on the Plot			0.424*** (0.058)	0.433*** (0.058)	0.489*** (0.120)	0.386*** (0.066)
Any Herbicide, Insecticide, or Pesticide Use on the Plot			-0.062 (0.089)	-0.070 (0.089)	0.390** (0.153)	-0.155 (0.102)
Any Oxen or Farm Implements Use on the Plot			0.186*** (0.064)	0.177*** (0.064)	-0.165 (0.144)	0.268*** (0.070)
Any Pre-harvest Losses on the Plot			-0.198*** (0.060)	-0.189*** (0.060)	-0.063 (0.121)	-0.254*** (0.069)
Constant	0.312 (0.664)	0.525 (0.671)	0.393 (0.657)	0.543 (0.660)	0.673 (1.408)	0.376 (0.741)
N	1869	1869	1869	1869	429	1440
R-sq	0.268	0.262	0.289	0.284	0.321	0.293

The dependent variable for is logged maize yield measured as quantity harvested (in tonnes) divided by area planted (in hectares).
Standard errors in parentheses
* p<*0.1*, ** p<0.05, *** p<0.01

We find that both household labor days (except in female-headed households) and hired labor days are positively and significantly associated with maize yield. Use of any non-labor input (fertilizer, herbicide, insecticide, pesticide, oxen, and/or farm implements) also has a significant positive impact on yield (Columns (1) and (2)). This effect of input use does not vary significantly with the sex of the plot decision-maker, indicating that increased input use would be expected to increase yield regardless of who manages the plot.

Looking at specific inputs (Columns (3)-(6)), we find that any fertilizer use is significantly positively associated with maize yield, and that the size of the effect is greater in female- than in male-headed households. Across all households overall and in male-headed households, use of any herbicide, insecticide, or pesticide has a negative but not significant association with yield while use of any oxen or farm implements has a positive and significant association. We find the opposite in female-headed households, where herbicide, insecticide, or pesticide use has a positive and significant association with yield but use of any oxen or farm implement has a negative but not significant effect.

Turning to regressions on rice paddy yield (Table 4), we find that unlike for maize, the coefficient for female plot decision-making is not consistently negative as it is positive in female-headed households, though it is not significant in any model. In addition, having a female HOH is also no longer significantly associated with lower yield. The age of the HOH (except for female-headed households) and plot size remain significantly negatively associated with yield, but household size and pre-harvest losses no longer have a significant effect, indicating some differences between rice paddy and maize cultivation.

Table 4. Correlates of Rice Paddy Yield: How Different Variables Impact Rice Paddy Yield

	(1) All Households	(2) All Households	(3) All Households	(4) All Households	(5) Female-Headed Households	(6) Male-Headed Households
Woman solely responsible for plot decisions	-0.121 (0.166)		-0.030 (0.161)		0.279 (0.354)	-0.498 (0.322)
Woman and man jointly responsible for plot decisions	0.064 (0.145)		0.135 (0.127)			0.142 (0.130)
Man solely responsible for plot decisions	0.000 (.)		0.000 (.)			0.000 (.)
Man only or woman and man jointly responsible for plot decisions					0.000 (.)	
Sex of HOH (female = 1)		-0.141 (0.132)		-0.119 (0.133)		
Age of HOH	-0.014*** (0.004)	-0.015*** (0.004)	-0.013*** (0.004)	-0.013*** (0.004)	-0.007 (0.010)	-0.012*** (0.004)
Education of HOH (years)	0.019 (0.019)	0.018 (0.019)	0.019 (0.019)	0.018 (0.019)	0.068* (0.040)	0.005 (0.021)
Plot Size (log)	-0.570*** (0.048)	-0.573*** (0.048)	-0.598*** (0.049)	-0.604*** (0.049)	-0.615*** (0.125)	-0.609*** (0.056)
Household Size	0.019 (0.019)	0.020 (0.018)	-0.005 (0.019)	-0.004 (0.019)	0.041 (0.050)	-0.008 (0.020)
Household Consumption (log)	0.342*** (0.104)	0.344*** (0.104)	0.324*** (0.104)	0.325*** (0.104)	0.192 (0.171)	0.372*** (0.122)
Any Input Use on the Plot	0.456* (0.241)	0.421* (0.222)				
Any Input Use on the Plot * Woman solely responsible for plot decisions	0.248 (0.473)	0.250 (0.450)				
Any Input Use on the Plot * Woman and man jointly responsible for plot decisions	-0.078 (0.296)	-0.013 (0.259)				
Total Days of Household Labor on the Plot	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	0.001* (0.001)	0.001*** (0.000)
Total Days of Hired Labor on the Plot	0.002** (0.001)	0.002** (0.001)	0.002* (0.001)	0.002* (0.001)	0.009** (0.004)	0.001* (0.001)
Any Fertilizer Use on the Plot			0.438*** (0.155)	0.441*** (0.154)	0.365 (0.340)	0.409** (0.170)
Any Herbicide, Insecticide, or Pesticide Use on the Plot			0.423** (0.207)	0.419** (0.205)	0.988 (0.901)	0.375* (0.206)
Any Oxen or Farm Implements Use on the Plot			0.494*** (0.121)	0.478*** (0.120)	0.043 (0.238)	0.611*** (0.141)
Any Pre-harvest Losses on the Plot			-0.180 (0.112)	-0.169 (0.112)	-0.358 (0.249)	-0.150 (0.126)
Constant	-1.244 (1.414)	-1.202 (1.418)	-0.930 (1.432)	-0.815 (1.439)	0.086 (2.600)	-1.504 (1.669)
N	633	633	633	633	131	502
R-sq	0.331	0.331	0.366	0.364	0.442	0.374

The dependent variable for is logged rice paddy yield measured as quantity harvested (in tonnes) divided by area planted (in hectares).
Standard errors in parentheses
* p<*0.1*, ** p<0.05, *** p<0.01

We again find that both household and hired labor days are positively and significantly associated with yield. Use of any non-labor input (fertilizer, herbicide, insecticide, pesticide, oxen, and/or farm implements) also has a significant positive impact on rice paddy yield (Columns (1) and (2)), regardless of who manages the plot. All three sub-categories of input use (any fertilizer, any herbicide, insecticide, or pesticide, and any oxen or farm implements) are positively associated with rice paddy yield, but the association is not significant in female-headed households (Columns (3)-(6)). The only factors that appear to be significant in female-headed households are years of education of the HOH, plot size, and the number of days of household and hired labor on the plot.

While these models do not consider the quantity or quality of input use, these analyses of maize and paddy yield generally support the hypothesis that increased input use would be expected to lead to increased crop yields, though it appears that this may not be the case for rice paddy in female-headed households. We do not find evidence of greater yield gains from increasing input use on female-managed plots, suggesting that women's plots would not experience significantly greater increases in yield from using inputs than men's plots.

Robustness check: Maize

As a robustness check, we ran an additional set of maize yield regressions on female-controlled, male-controlled, and joint-controlled plots separately, in order to isolate the coefficient for the association between input use and yield in plots controlled by different genders. We find that the effect of inputs on maize yield is larger on male-controlled plots than female-controlled plots. This result supports the findings from other models with interaction terms, namely that there is no additional positive impact of input use on women's plots versus men's plots for maize.

Robustness check: Paddy Rice

Similarly to the maize yield regression models, we ran an additional set of rice paddy yield regressions that separated female-controlled, male-controlled, and joint-controlled plots as a robustness check. Unlike for maize, we find that the effect of input use on female-controlled plots is larger than for male-controlled plots when logged rice paddy yield serves as the dependent variable. These models indicate higher average returns to labor and inputs on female-controlled plots. Additionally, we find that having a female head of household is associated with an increase in yield among female-controlled plots, but a yield decline in male-controlled plots.

Pathway 2. Increased Women's Participation in Labor Markets

The literature indicates that women in farm households are less likely than men to participate in off-farm labor markets, though some evidence suggests that women in female-headed households are more likely to participate. Using 2012-2013 LSMS-ISA data, we find that in Tanzania, 53.8% of male household members aged 16 or older in surveyed households participate in work for pay outside the domestic farm, compared to just 22.5% of female household members aged 16 or older.

We ran three logit regressions at the level of individual household members using the same model to test the association between participation in off-farm wage labor and the sex of individual household members and the sex of the HOH (Table 5). The sample is the number of household members aged 16 and older. We controlled for the age and education of both the individual and the HOH, as well as for household farm size, consumption, and number of household members. The outcome variable was a dummy for whether an individual participated in any off-farm wage labor.

Table 5. Correlates of Individual Participation in Off-Farm Wage Labor: How Different Variables Impact Off-Farm Wage Labor Participation

	(1) All Households	(2) Female-Headed Households	(3) Male-Headed Households
Sex of HOH (female = 1)	0.105*** (0.000)		
Sex of Individual (female = 1)	-0.150*** (0.000)	-0.062*** (0.001)	-0.162*** (0.000)
Age of HOH	-0.003*** (0.000)	-0.003*** (0.000)	-0.003*** (0.000)
Age of Individual	-0.002*** (0.000)	-0.003*** (0.000)	-0.002*** (0.000)
Education of HOH (years)	0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
Education of Individual (years)	0.004*** (0.000)	0.001*** (0.000)	0.005*** (0.000)
Household Farm Size (log)	-0.034*** (0.000)	-0.013*** (0.000)	-0.039*** (0.000)
Household Size	-0.003*** (0.000)	-0.003*** (0.000)	-0.003*** (0.000)
Household Consumption (log)	-0.007*** (0.000)	0.000 (0.000)	-0.008*** (0.000)
N	7034	1424	5610

The dependent variable is a dummy taking a value of 1 if the individual participated in any off-farm wage labor. The coefficients and standard deviations in the table are the marginal effects from the logit regression models.
Standard errors in parentheses
* p<*0.1*, ** p<0.05, *** p<0.01

Women are significantly less likely than men to participate in off-farm wage labor, and this effect is twice as large in male-headed households compared to female-headed households. Older individuals are less likely to do off-farm wage labor, but more educated individuals are more likely. We find that characteristics of the HOH are also significantly associated with individual household members' participation in off-farm wage labor. Individuals are significantly more likely to participate in off-farm labor if their heads of household are women, younger, and more educated. This finding holds in both female- and male-headed households.

Individuals in households with larger farm sizes, with more household members, and with more household consumption are significantly less likely to participate in off-farm wage labor. This result suggests that larger farms may require individuals to stay and work on the farm, and that better-off households (measured by consumption) may have less need for individuals to earn off-farm wages. An exception is that household consumption is not significantly associated with off-farm labor participation of individuals in female-headed households.

These results support the assumption that women in farm households are less likely than men to participate in off-farm labor markets. However, our findings also indicate that female-headed households may be relatively more likely to have a household member participate in off-farm labor.

Pathway 3. Improved Household Nutrition

The literature we reviewed suggests that women may plant a greater variety of crops than men, and particularly that they may plant more vegetables and legumes, with potential benefits to household nutrition outcomes. Some of the evidence, however, indicates that women's greater crop diversity may hold only for smaller garden plots and not for other household plots.

We tested the relationship between both the number of total crops cultivated and the number of vegetables and legumes cultivated and the sex of plot decision-maker at the plot level, the sex of the HOH at the plot level, and the sex of the HOH at the household level. Our outcome indicators only count the number of different crops and do not consider the area planted of different crops, so should be considered a crude proxy for cropping diversity.

To evaluate whether there are differences by HOH sex, we conducted OLS regressions for all households while controlling for sex of the HOH or sex of the plot decision-makers in addition to separately analyzing male- and female-headed households only. In these regressions, we controlled for the age and years of education of the HOH, household size, and household consumption (logged). For the plot level analyses, we controlled for plot size (logged) but not farm size (logged) because of the high correlation between plot size and farm size. We control for the total farm size of the household (logged) in the household-level analyses.

Table 6. Correlates of Number of Crops Grown: How Different Variables Impact the Number of Crops Grown

	(1) HH-Level: All Households	(2) Plot-Level: All Households	(3) Plot-Level: All Households	(4) Plot-Level: Female-Headed Households	(5) Plot-Level: Male-Headed Households
Woman solely responsible for plot decisions			-0.486*** (0.103)	0.717*** (0.162)	-0.735*** (0.205)
Woman and man jointly responsible for plot decisions			-0.378*** (0.085)		-0.327*** (0.087)
Man solely responsible for plot decisions			0.000 (.)		0.000 (.)
Man only or woman and man jointly responsible for plot decisions				0.000 (.)	
Sex of HOH (female = 1)	-0.344** (0.153)	-0.305*** (0.087)			
Age of HOH	0.048*** (0.004)	0.050*** (0.002)	0.050*** (0.002)	0.041*** (0.005)	0.054*** (0.003)
Education of HOH (years)	0.120*** (0.022)	0.115*** (0.013)	0.119*** (0.013)	0.125*** (0.031)	0.106*** (0.014)
Farm Size (log)	0.348*** (0.053)				
Plot Size (log)		0.188*** (0.026)	0.181*** (0.026)	0.144*** (0.051)	0.188*** (0.030)
Household Size	0.025 (0.022)	0.010 (0.011)	0.014 (0.011)	0.019 (0.028)	0.007 (0.012)
Household Consumption (log)	0.097 (0.107)	0.337*** (0.060)	0.335*** (0.060)	0.301** (0.120)	0.358*** (0.070)
Constant	-1.786 (1.489)	-3.472*** (0.828)	-3.207*** (0.834)	-3.218* (1.666)	-3.649*** (0.972)
N	3090	13665	13665	3090	10575
R-sq	0.084	0.059	0.060	0.040	0.068

The dependent variable for the three plot-level regressions is the number of different crops grown per plot. At the household level, it is the number of unique crops grown by the household, across all plots.
For female-headed households, we combine plots managed solely by men and jointly by men and women because of the very small number of plots managed solely by men.
Standard errors in parentheses
* p<*0.1*, ** p<0.05, *** p<0.01

In all models, we find that age and education of the HOH are positively associated with the number of crops grown. Plot size and farm size are also both significantly associated with growing additional crops. At the household level, we find that having a female HOH is significantly associated with fewer unique crops grown by the household – about 0.34 fewer crops across all plots (Table 6, Column (1)). At the plot level, we find that having a woman solely responsible for plot management has a significant negative association with the number of crops grown on that plot, compared to having a man solely responsible for plot management (Column (3)). Joint male/female decision-making on a plot and having a female HOH are also significantly associated with fewer crops grown on the plot (Columns (2) and (3)). In all three cases, the difference is about one-third to one-half fewer crops per plot.

In male-headed households, plots managed solely by women have about 0.74 fewer crops per plot compared to plots managed solely by men. In female-headed households, however, plots managed solely by women have about 0.72 more crops per plot than plots managed jointly or solely by men. Therefore, the difference in number of crops grown on plots managed by men and women may be related to household-level decision-making on what to plant on which plots, rather than plot-level decision-making.

While this analysis does not support the assumption that women grow more different crops than men, we do find evidence that women grow more vegetable and legume crops (Table 7), which have a higher nutritional value. While we find that female-headed households appear to grow fewer crops overall in Tanzania, having a female HOH is not significantly associated with growing fewer vegetables and legumes at either the plot level (Column (2)) or the household level (Column (1)).

Looking at plot-level decision-making, we find that having a woman solely responsible for plot management has a positive and slightly significant association with the number of vegetables and legumes grown compared to having a man solely responsible, and has about the same positive effect of having joint male/female plot management (Column (3)). The same positive finding also holds when only looking at female- and male-headed households, and in male-headed households having a woman solely responsible for plot decisions has more than twice the positive effect on the number of vegetables and legumes grown as joint decision-making, compared to having a man solely responsible for plot decisions (Columns (4) and (5)).

Table 7. Correlates of Number of Vegetables and Legumes Grown: How Different Variables Impact the Number of Vegetables and Legumes Grown

	(1) HH-Level: All Households	(2) Plot-Level: All Households	(3) Plot-Level: All Households	(4) Plot-Level: Female-Headed Households	(5) Plot-Level: Male-Headed Households
Woman solely responsible for plot decisions			0.018* (0.010)	0.035* (0.020)	0.036* 0.021)
Woman and man jointly responsible for plot decisions			0.015* (0.008)		0.016** (0.008)
Man solely responsible for plot decisions			0.000 (.)		0.000 (.)
Man only or woman and man jointly responsible for plot decisions				0.000 (.)	
Sex of HOH (female = 1)	-0.077 (0.053)	-0.002 (0.009)			
Age of HOH	0.006*** (0.001)	-0.001** (0.000)	-0.001** (0.000)	-0.000 (0.001)	-0.001** (0.000)
Education of HOH (years)	0.012* (0.007)	-0.002 (0.001)	-0.002 (0.001)	-0.000 (0.002)	-0.002 (0.001)
Farm Size (log)	0.108*** (0.018)				
Plot Size (log)		0.004 (0.003)	0.005* (0.003)	-0.000 (0.005)	0.007** (0.003)

Household Size	0.006 (0.008)	0.001 (0.001)	0.001 (0.001)	-0.002 (0.003)	0.001 (0.001)
Household Consumption (log)	-0.000 (0.038)	0.005 (0.006)	0.005 (0.006)	-0.001 (0.013)	0.005 (0.007)
Constant	-0.138 (0.507)	0.062 (0.083)	0.044 (0.084)	0.128 (0.162)	0.034 (0.098)
N	3090	13665	13665	3090	10575
R-sq	0.031	0.001	0.001	0.001	0.002
The dependent variable for the three plot-level regressions is the number of different vegetables and legumes grown per plot. At the household level, it is the number of unique vegetable and legume crops grown by the household, across all plots. For female-headed households, we combine plots managed solely by men and jointly by men and women because of the very small number of plots managed solely by men. Standard errors in parentheses * p<*0.1*, ** p<0.05, *** p<0.01					

The literature indicates that different crops in Sub-Saharan Africa are often thought of as men's or women's crops, so we cannot confirm whether the association between gender and vegetable/legume cropping reflects women's preference for cultivating vegetables and legumes or household-level decisions on which crops to cultivate on which plots, allocating crops to plots managed by the "appropriate" sex. The results do suggest, however, that increasing women's control over agricultural management decisions, such as decisions of what to plant on different plots, might lead to increased cultivation of vegetables and legumes.

Pathway 4. Improved Household Soil Quality

We found evidence that women intercrop more frequently than men in several contexts, though two studies (Buyinza & Wambede, 2008; Chijikwa, 2013) found that women were less likely than men to adopt new intercropping practices. In Tanzania, we find that in 2012-2013, 80.2% of plots in female-headed households and 76.6% of plots in male-headed households were intercropped, indicating a high overall prevalence of intercropping but a slightly greater likelihood with a female HOH. In both female- and male-headed households, the highest proportion of intercropped plots was for plots managed by women only, at 81.2% and 78.2%, respectively.

We conducted logit regression analyses to test whether sex of the HOH or plot manager is significantly associated with intercropping at the plot and household levels, looking at all households and at male- and female-headed households separately (Table 8). We controlled for the age and years of education of the HOH, household size, and household consumption (logged). For the plot level analyses, we controlled for plot size (logged) but not farm size (logged) because of the high correlation between plot size and farm size. We did control for the total farm size of the household (logged) in household-level analyses.

Table 8. Correlates of Intercropping: How Different Variables Impact if Intercropping Takes Place

	(1) HH-Level: All Households	(2) Plot-Level: All Households	(3) Plot-Level: All Households	(4) Plot-Level: Female-Headed Households	(5) Plot-Level: Male-Headed Households
Woman solely responsible for plot decisions			0.020 (0.013)	0.051** (0.025)	0.028 (0.027)
Woman and man jointly responsible for plot decisions			0.002 (0.010)		0.005 (0.010)
Man solely responsible for plot decisions			0.000 (.)		0.000 (.)
Man only or woman and man jointly responsible for plot decisions				0.000 (.)	
Sex of HOH (female = 1)	0.001 (0.025)	0.008 (0.011)			
Age of HOH	0.003*** (0.001)	0.002*** (0.000)	0.002*** (0.000)	0.003*** (0.001)	0.001*** (0.000)
Education of HOH (years)	0.011*** (0.003)	0.007*** (0.001)	0.007*** (0.001)	0.005* (0.003)	0.008*** (0.002)
Farm Size (log)	0.015* (0.008)				
Plot Size (log)		-0.008** (0.003)	-0.007** (0.003)	-0.021*** (0.007)	-0.004 (0.004)
Household Size	-0.003 (0.004)	-0.006*** (0.001)	-0.006*** (0.001)	-0.011*** (0.003)	-0.005*** (0.002)
Household Consumption (log)	-0.016 (0.017)	-0.006 (0.008)	-0.006 (0.008)	0.013 (0.016)	-0.016* (0.009)
N	3090	13665	13665	3090	10575

The dependent variable for the three plot-level regressions is whether the individual plot was intercropped. At the household level, it is whether any plot cultivated by the household was intercropped.
The coefficients and standard deviations in the table are the marginal effects from the logit regression models.
For female-headed households, we combine plots managed solely by men and jointly by men and women because of the very small number of plots managed solely by men.
Standard errors in parentheses
* p<*0.1*, ** p<0.05, *** p<0.01

We find no significant association between the sex of the HOH and the likelihood of intercropping at either the plot or the household level (Columns (1) and (2)), likely due to the overall high levels of intercropping (77.4%). We also find no significant association between the sex of the plot manager and intercropping for all households at the plot level (Column (3)). Female-managed plots in female-headed households are significantly more likely to be intercropped than male- or jointly-managed plots, but the coefficient on female plot management is not significant in male-headed households. Overall, these results do not indicate that women are consistently more likely to intercrop on plots they manage than men, as assumed in the theorized causal pathway, though this may be the case in female-headed households.

Applications of LSMS for Gender Empowerment Benefits Analysis

Estimates based on data from the 2012-2013 LSMS-ISA survey suggest that women currently manage roughly 23.09% of crop plots in Tanzania, representing 15.77% of agricultural land. Another 50.89% of cropland area is managed jointly by women and men (the remaining 33.34% of total cropland is managed by men only). Slavchevska (2015) used LSMS-ISA data to estimate an 8 percent gender gap in land productivity (defined as the value of agricultural output per unit of cultivated area) in Tanzania. Given an 8% gender productivity gap affecting 15.77% of agricultural land in Tanzania, addressing the productivity gap alone could lead to a 1.2% increase in the value of national annual crop production – with the benefits concentrated among women.

Using the Tanzania 2012-13 LSMS-ISA and World Bank data about the proportion of cultivated land area in Tanzania, we conducted a preliminary analysis focused specifically on estimating the potential benefits to eliminating the gender gap in maize and paddy rice yield in Tanzania. We anticipate this research focus continuing beyond the scope of what is included in this report.

Within the 2012-13 Tanzanian sample, maize cultivation on female-controlled plots totaled 594 hectares (ha), compared to 1260 ha on male-controlled plots. In a similar pattern, female-controlled paddy rice area was also smaller, at 185 ha compared to 398 ha on male-controlled plots. For both crops, yield on female-controlled plots is lower than for male-controlled plots, with the difference much larger for paddy rice yield than for maize yield. We calculated average maize yield as 0.591 tonnes/ha and 0.598 tonnes/ha and average paddy rice yield as 0.764 tonnes/ha and 0.993 tonnes/ha on female-controlled and male-controlled plots, respectively. In the 2012-13 Tanzania sample, this results in a potential maize production increase of 4.16 tonnes and rice production increase of 42.37 tonnes if the gender-based yield gap for households in the sample was closed (i.e., if yields on female-controlled plots were the same as on male-controlled plots).

Extrapolating the relationships observed in the nationally-representative Tanzania sample to the national scale, we calculate that 17% of total cultivated land is planted with maize, while 4% is planted with paddy rice. In total, we estimate that in 2012-13, over 4.3 million tonnes of maize and over 1.5 million tonnes of paddy rice were produced in Tanzania. These estimates match FAO estimates for maize and rice production in 2012-13.

Using findings on the yield gaps for maize and paddy rice between female- and male-controlled plots, we estimate the potential effects of closing these gaps on total national production of these crops. The minimal difference in maize yields for female- and male-controlled plots means that closing this gap could result in a less than 1% increase in total national annual maize production. However, given the larger gender-based yield gap for paddy rice, closing this yield gap could result in a more than 4% increase in total annual paddy rice production. In both cases, the benefits from the increased production would be concentrated among women. These findings offer further support for gender- and crop-disaggregated data to both inform and evaluate agricultural investments and policies.