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Conservation agriculture and gendered livelihoods in Northwestern Cambodia: decision-making, space and access

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Abstract Smallholder farmers in Rattanakmondol District, Battambang Province, Cambodia face challenges related to soil erosion, declining yields, climate change, and unsustainable tillage-based farming practices in their efforts to increase food production within maize-based systems. In 2010, research for development programs began introducing agricultural production systems based on conservation agriculture (CA) to smallholder farmers located in four communities within Rattanakmondol District as a pathway for addressing these issues. Understanding gendered practices and perspectives is integral to adapting CA technologies to the needs of local communities. This research identifies how gender differences regarding farmers' access to assets, practices, and engagement in intra-household negotiations could constrain or facilitate the dissemination of CA. Our mixed-methods approach includes focus group discussions, semi-structured interviews, famer field visits, and a household survey. Gender differences in access to key productive assets may affect men's and women's individual ability to adapt CA. Farmers perceive the practices and technologies of CA as labor-saving, with the potential to reduce men's and women's labor burden in land-preparation activities. However, when considered in relation to the full array of productive and reproductive livelihood activities, CA can disproportionately affect men's and women's labor. Decisions about agricultural livelihoods were not always made jointly, with socio-cultural norms and responsibilities structuring an individual's ability to participate in intra-household negotiations. While gender differences in power relations affect intra-household decision-making, men and women household members collectively negotiate the transition to CA-based production systems.

Keywords Gender · Livelihoods · Conservation agriculture · Decision-making · Cambodia

Abbreviations

CA	Conservation agriculture
CIRAD	Centre de Coopération International en Recherche pour le Développement
DMC	Direct-seeding mulch based cropping systems
FGD	Focus group discussion
FPE	Feminist political ecology
KHR	Cambodian Riel
KR	Khmer Rouge
MAFF	Ministry of Agriculture Forestry and Fishers
MFI	Micro-finance institution
OIRED	Office of International Research, Education and Development
PADAC	Projet d'Appui à la Diversification Agricole du Cambodge
SANREM IL	Sustainable Agriculture and Natural Resource Management Innovation Lab

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USAID	United States Agency for International Development
WEAI	Women's Empowerment in Agriculture Index

Introduction

In Northwestern Cambodia, agricultural livelihoods and agrarian landscapes have been transformed in recent decades due in part to deforestation, internal migration, global market demands, mechanization, war, and land commodification. The expansion of profitable smallholder commercial maize and cassava production established a viable pathway for improving farming livelihoods; however, continued tillage-intensive mono-cropping on ecologically sensitive upland reserves coupled with the effects of climate change and volatile market conditions threaten the sustainability of food production and the economic viability of smallholder agricultural livelihoods. Within Cambodia and the broader Mekong sub-region, international organizations and funders have increasingly promoted conservation agriculture (CA) as an approach to counteract environmental degradation and increase profitability for smallholder farmers (Pansak et al. 2008; Affholder et al. 2010; Lestrelin et al. 2012). These initiatives require an understanding of how gender[1] relations influence program interventions and how program activities can influence gender relations. For example, during the initial years of practicing CA, weed pressure may significantly increase (Knowler and Bradshaw 2007). In CA systems where weed management is based on manual weeding, women's burden can increase to unsustainable levels (Giller et al. 2009; Nyanga et al. 2012). Conversely, when herbicides are used, drudgery associated with manual weeding is reduced. Changes within farming systems and rural agrarian livelihoods must be understood in relation to the impacts on men's and women's access to assets, roles and responsibilities, and decision-making (Doss 2001; Beuchelt and Badstue 2013).

Soil management practices and technologies utilized in CA are based on three interrelated principles: (1) soil cover with organic crop residues; (2) minimal or no tillage; and (3) diverse crop rotations, sequences, and/or associations (Kassam et al. 2009). The established literature has demonstrated the potential agronomic benefits of CA, including enhanced soil carbon and organic matter resulting in improved soil productivity, greater resilience to climate variability, increased and stabilized yields, reduced soil erosion, and weed germination (Wall 2007; Hobbs et al. 2008; Kassam et al. 2009; Lal 2009; Derpsch et al. 2010; Thierfelder and Wall 2010). Along with these benefits, CA is also perceived as a pathway for smallholder farmers to increase profitability, decrease labor burdens, reduce production costs, and enhance household food security (Derpsch et al. 2010).

Despite the potential benefits of CA, smallholder farmers' ability to invest in CA-based production systems remains constrained by site-specific socio-economic and agronomic conditions (Erenstein 2003; Giller et al. 2009; Erenstein et al. 2012). An expanding literature has documented factors that influence smallholder farmers' ability to invest in CA: access to agrochemicals and specialized no-till machinery, weak land tenure security, limited support from extension services, and farmers' focus on short-term economic returns (Giller et al. 2009; Affholder et al. 2010). Assessing the feasibility of CA-based production systems requires "a better understanding of why, where and for whom CA works best" (Corbeels et al. 2014, p. 156). This includes assessing both men's and women's engagement in agricultural livelihoods and how the transition to CA can differently affect men and women within the farming household, as well as documenting how men and women household members collectively negotiate livelihood transitions (Erenstein 2003; Milder et al. 200; Beuchelt and Badstue 2013; Harman Parks et al. 2015).

This paper presents the results of the gender component of a larger study in Rattanakmondol District, Battambang Province, Cambodia conducted under the direction of a research for development program, SANREM IL.[2] In Rattankamondl, SANREM IL extended earlier work implemented by the Projet d'Appui à la Diversification Agricole du Cambodge (PADAC), the Cambodian Ministry of Forestry and Fisheries (MAFF), and the Centre de Coopération International en Recherche pour le Développement (CIRAD) that began in 2008 in Kampong Cham Province. From 2010 to 2015, SANREM IL, including US Universities, CIRAD, PADAC, and MAFF, used the DATE[3] approach, a multi-scale and multi-stakeholder participatory perspective, (Séguy et al. 1998; Husson et al. 2015) to adapt CA production systems derived from direct seeding mulch-based cropping (DMC) systems (Séguy et al. 1998; Affholder et al. 2010; Boulakia et al. 2012; Lestrelin et al. 2012) to the agro-ecological and socio-economic landscapes of Rattanakmondol. Different

[1] Gender refers to the dynamic socially constructed roles, rights, and responsibilities of men and women and the relations between them that are dependent upon age, social status, class, race, ethnicity, and culture (Doss 2001).

[2] SANREM IL was funded by the United States Agency for International Development (USAID) under cooperative agreement No. EPP-A-00-0400013-00.

[3] See Husson et al. (2015) for a detailed description of the DATE approach.

CA production systems were tested and evaluated under semi-controlled conditions; with potential CA cropping systems recommended to volunteer farmers within a pilot extension network. Within this network, farmers received technical assistance and interest-free credit from SANREM IL as an incentive for implementing the proposed CA production system. Additionally, SANREM IL collected technical and economic data on the performance of the recommended CA production system. Within this approach, we argue the utility of assessing the adaptability of CA to rural livelihoods through a gender lens and in this context and ask the following: (1) Do men and women have different access to assets, practices, and capabilities in intra-household negotiations that could impact their ability to adapt CA? and (2) Will the adaptation of CA differently affect men's and women's livelihoods?

At the intersection of livelihood, feminist political ecology, and conservation agriculture

This research uses a livelihoods approach and draws upon feminist political ecology (FPE) to frame the investigation of how gender structures smallholders' efforts to enhance their sustainability through CA in Northwestern Cambodia. Livelihoods are the means through which individuals, households, and communities earn a living, including the tangible and intangible assets/resources (human, natural, social, and physical) and practices used to pursue livelihood strategies and generate outcomes (Chambers and Conway 1991; Ellis 2000; Flora 2001; Valdivia and Gilles 2001). Rural livelihoods are embedded in dynamic power relations defined by gender, class, ethnicity, culture, and other subjectivities; these structure access and decision-making over resources and define and farmers' everyday life activities.

Gendered access to and control of natural resources and assets extends beyond the household and is linked to men's and women's knowledge derived from different roles, priorities, and practices (Rocheleau et al. 1996; Udry 1996; Basset 2002; Nightingale 2006). At the intersection of FPE and livelihoods literature we raise new questions exploring the patterns and process of gendered decision-making and how broader societal norms and beliefs limit and promote men's and women's individual options in the collective decision to adapt CA.

Access to resources is gendered (Rocheleau et al. 1996; Flora 2001) and studies on CA that account for gender have revealed differences in regards to land, capital, extension services, agrochemicals, and trainings (Erenstein et al. 2012; Beuchelt and Badstue 2013; Harman Parks et al. 2015). Men's and women's everyday responsibilities in agriculture are key to understanding these (Nightingale 2006), but they need further exploration. By investigating the linkages between assets and practices we provide insights that can assist in developing CA production systems sustainable for smallholder farmers in Rattanakmondol and elsewhere.

An extensive literature has considered the substantial impact new agricultural technologies and practices can have on existing gendered labor patterns and workloads, demonstrating the need to critically evaluate if technologies will diminish men's and women's drudgery or exacerbate existing labor demands to unsustainable levels (Doss 2001). The relevance of gender analysis of labor and time demands to CA has been demonstrated within different geographic, socio-cultural, and agroecological contexts (Milder et al. 2011; Nyanga et al. 2012; Halbrendt et al. 2014). While current examples focus on identifying the feasibility of proposed CA practices through quantifying and comparing men's and women's labor allocation in conventional and CA production systems, we consider the potential redistribution of labor patterns in agricultural production within the broader array of household livelihood activities and obligations.

A number of studies have examined the factors that can impact men's and women's power within the household (Basset 2002; Quisumbing 2003; Doss 2013). Men's and women's different access to resources, roles, and knowledge shape these power relations (Rocheleau et al. 1996; Flora 2001; Harman Parks et al. 2015) and gender differences in livelihood goals. Conceptualizing the household as a place where individuals act within their own self-interest does not adequately capture the complex power relations therein (Doss and Meinzen-Dick 2015). Households are locations of cooperation and conflict, but existing research using unitary and bargaining models of household decision-making does not fully conceptualize how individuals work collectively to produce livelihood strategies and outcomes (Doss 2013: IFAD 2014). We look at how household members collectively negotiate decisions, including the decision to adapt CA, by considering the beliefs and perceptions of the array of options available to individual household members. We aim to contribute to the expanding literature on household decision-making that investigates factors affecting household members' abilities to participate in collective negotiations.

Research methods

SANREM IL worked with smallholder farmers in four villages in Rattanakmondol District, central Battambang province: Boribo; Pichangva; Sengha; and Aukmum. We selected Pichangva (Fig. 1) based on its safety and accessibility, and the number of farmers implementing CA

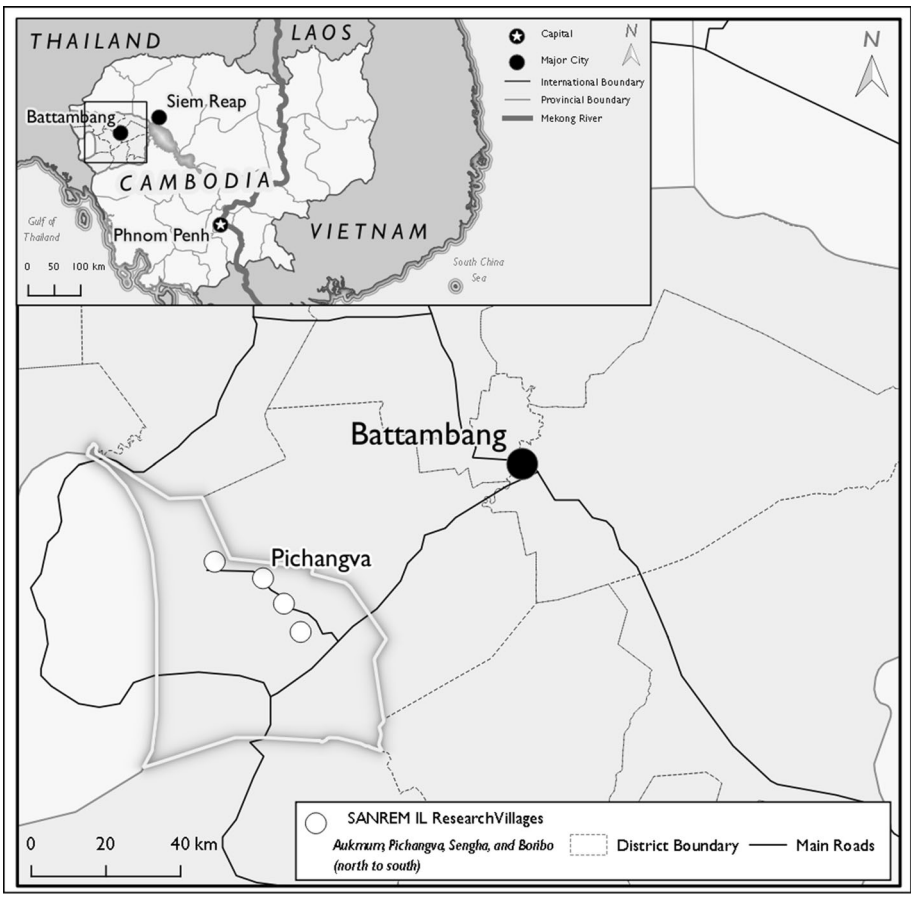

Fig. 1 Study area. (*Inset*) Indicates the province of Battambang (*outlined in grey*) within Cambodia. (*main map*) Rattankmondol district where SANREM IL operated is outlined. The research site, Pichangva, is one of the four villages were SANREM IL operated

(>15). Pichangva (Latitude: 12°58′2.48″N and Longitude: 102°52′50.92″E) lies in the upland piedmont area of the Cardamons Mountains, on rolling plains ranging between 20 and 70 m above sea level, surrounded by isolated hills with higher elevations.

Rattanakmondol and the area surrounding Pichangva have long been recognized for their agricultural potential, with cotton, peanut, and sugar cane production cultivated prior to the turmoil of the 70s. Pichangva's total population is 772, with 164 households (National Institute of Statistics 2011) consisting of former Khmer Rouge (KR) soldiers and rice farmers from northern Battambang province who migrated there because of the potential for lucrative cash crop production on upland areas with high drainage capacities. Farmers refer to these upland areas as *chamcar* and define chamcar as "a field where you can grow things other than rice" (Ricard 2010, p. 32).

Maize and cassava production comprises 75 % of the available 145 ha of arable land in Pichangva (Ricard 2010), primarily clay mollisols and vertisols (Belfield et al. 2013). Upland cash crop production is the principal income source for smallholder farmers in the area, though lowland rice production is also present, typically on small plots for household consumption. Off-farm economic opportunities are limited, and include small groceries, repair garages, and charcoal production. Farm sizes in Pichangva range between 1 and 13.5 ha (avg. 5 ha) for chamcar and between 1 and 12 ha (avg. 1.5 ha) for lowland rice. The increasing availability of two-wheeled hand tractors and four-wheeled tractors has led to the replacement of draught animals for land preparation activities. Despite the mechanization of agriculture, cattle remain an important source of living capital, with their sale used to fund investments in agricultural technology and household improvements. Intensive mechanized monocropping in the last decade has resulted in degradation of soil productive capital and declining yields, which threatens the viability of agricultural livelihoods in Pichangva (Ricard 2010).

Alternative production systems based on CA could increase the long-term sustainability of smallholder agricultural livelihoods. SANREM IL tested various CA systems within the study area and recommended farmers adopt a CA production system based on an association of maize and pigeon pea (*Cajanus cajan*). Under this system, maize is directly seeded into the residue from the previous crop of pigeon pea using imported small and large no-till sowing machines adapted for use with two-

wheeled hand tractors and/or medium-sized tractors. Prior to sowing, plots are prepared based on the surface state of the plot and the level of cover crop development, but typically the pigeon pea cover crop is rolled and glyphosate and 2,4-D (dichlorophenoxyacetic acid) are applied prior to sowing. As in conventional tillage-based production, hybrid seed varieties are used, with maize sown between late June and early July. Pigeon pea is intercropped with maize and manually sown 14–24 days after sowing maize.

Mixed methods were employed to collect data about farmers' access to productive resources that might influence their decision to invest in CA, practices, and input in intra-household decision-making related to agricultural production, conventional and CA.

Research began with a preliminary visit in January 2013 to test the survey, conduct FGDs, recruit research assistants from Battambang University, and establish relations with the local research team. This initial visit also included training project research and extension staff on participatory methods and gender analysis. Extended fieldwork, including household exercises and participant observation, was conducted over 6 weeks in June and July 2013. Methods included focus group discussions (FGDs), participant observation, and household visits including semi-structured interviews and a survey based on an adaptation of selected components from USAID's Women's Empowerment in Agriculture Index (WEAI) (Alkire et al. 2013). During the household visits, respondents were asked to consider their individual access, practices, and decision-making unless otherwise instructed to comment on the farming household as a unit. FGDs were held in two villages, Pichangva and Boribo, with a total of fifteen people (seven men and eight women) in single-sex groups to generate spaces that encouraged men and women to express their opinions and perceptions. Both FGDs and household visits were conducted in Khmer with discussions and responses translated into English. Participant observation activities were principally conducted during visits to twelve farmers' fields with the owners' consent, during which we observed men's and women's roles and interactions in conventional tillage-intensive production and CA.

FGDs consisted of four activities: (1) a timeline of changes in agricultural livelihoods, principally chamcar cultivation and soil conditions, and their impacts on men and women; (2) a socio-economic activity profile documenting men's and women's responsibilities; (3) semi-structured discussion of gendered access and control over productive assets and resources; and 4) participatory mapping to gauge knowledge of soils in the community. The socio-economic profile recorded gendered responsibilities related to productive and reproductive activities within the household and in the community.[4] Respondents were selected using purposeful sampling (Bernard 2006) based on their participation in previous CA program activities. Results from the FGDs were used in developing the questions for the semi-structured portion of the household visits as well as adapting the WEAI to the socio-cultural and household dynamics within the study area.

Household visits consisted of two components: 1) semi-structured interviews (including a participatory mapping exercise exploring where farmers exchanged CA information)[5] and (2) a household survey. We randomly selected 26 households to visit, interviewing the self-identified male and female decision-makers. Households were proportionally selected from the 49 households in Pichangva that had participated in project activities according to three categories: (1) farmers currently implementing CA; (2) farmers that tried but discontinued CA; and (3) farmers interested but not implementing. We excluded households no longer living in the village and absentee landowners not directly engaged in agricultural production. The final household sample included 23 dual-adult households[6] (husband and wife—none were polygamous households). The remaining three were female-headed, one headed by a widow and two by women who had recently separated from their husbands. In all but two of the 23 dual-headed households we were able to interview both the self-identified primary male and female decision-maker. In total during the household visits, we interviewed 47 participants (22 men and 25 women).

Participants ranged from 23 to 74 years of age, men 23–74 (avg. 47) and women 25–62 (avg. 44). There was no substantial difference in levels of education between men and women, with the majority of both having only completed some primary school education; however, more women than men had also attended secondary school. Respondents under 45 years of age generally had completed higher levels of education. These differences are rooted in the conflict and instability that characterized the late twentieth century, which limited access to formal education opportunities. The semi-structured portion of the visit revolved around farmers' motivation for implementing or wanting to implement CA, their beliefs surrounding the benefits and costs of CA, perceptions of CA's impact on labor allocation, and their beliefs regarding men's and women's roles and responsibilities in household decision-making. This offered insights into how

[4] Productive activities can include household subsistence agriculture, cash crop production, wage/salary employment, and small business. Reproductive activities refer to domestic activities and childcare. Community activities refer to roles in maintaining social relations and networks (Momsen 2010; Beuchelt and Badstue 2013).

[5] Future publication.

[6] We classified households in terms of whether there are both male & female adults, only female adults, or only male adults present (Alkire et al. 2013).

gendered decision-making dynamics impact men's and women's ability to pursue goals and outcomes related to agricultural livelihoods.

The household survey was based upon selected components from the WEAI, which we adapted to assess input into decisions over agricultural livelihood activities (including cash-crop production, subsistence production, and other activities); access, decision-making, and control[7] over productive assets (land, agricultural machinery, credit); decision-making over income and expenditures; and membership in agricultural and/or social groups. Our survey quantified respondents' self-reported input into decisions related to agricultural production activities, activities within the farming household, and the adaptation of CA. Additional qualitative data was collected for each survey module, giving an increased understanding of the cultural context of household dynamics, including the socio-cultural beliefs that shape men's and women's individual decision-making ability.

In the household survey we examined intra-household negotiations with multiple indicators. We used two questions to gauge men's and women's input in decision-making: (1) "Who normally makes the decision?" (Fig. 2) and (2) "To what extent do you feel you participate in decisions?" (Fig. 3). Possible responses to the first question included individuals beyond the household. Response options for the second were: small extent, medium extent, high extent, and no decision made. Farmers' responses during the semi-structured discussion enhanced the results from the household survey, revealing how men and women draw upon their available knowledge and power to collectively negotiate the decision to adapt CA.

Data from the household survey was analyzed in Microsoft Excel and basic descriptive statistics were calculated for men's and women's access and control over land, machinery, and credit and participation in intra-household decision-making. Results are presented as percentages or counts. To complement the descriptive statistics a two-tailed N-1 two-proportion test (Campbell 2007) was used to test for significant differences between men's and women's responses. A 5 % significance level was used to determine if results were statistically different. Qualitative data analysis was a continuous process initiated during data collection including daily reflective journal entries and detailed weekly reports from which key themes emerged that were explored further during household visits. Content analysis using computer-assisted qualitative analysis software (ATLAS.ti) was used to identify linkages between gendered livelihoods and CA. Qualitative results were disaggregated by gender to compare men's and women's responses, and categorized to identify gender-based constraints and opportunities relevant to the dissemination of CA. Recognizing that dissonance between results could assist in a more comprehensive analysis identifying connections between gender, power, livelihoods, and CA (Nightingale 2003), we used triangulation to compare qualitative and quantitative results and identify areas of overlap.

[7] Access is where individuals, households, or groups are able use assets and resources to generate benefits; control is the power relations (formal and informal) that affect the mechanisms used to access resources (Ribot and Peluso 2003).

Results

Gender differences in access to key productive assets may affect men's and women's individual ability to adapt CA. Agricultural production activities in Rattanakmondol are gendered with men principally involved in activities related to the field and women engaged within the sphere of the household. Farmers perceive the practices and technologies of CA as labor-saving, with the potential to reduce men's and women's labor burden in land-preparation activities. When considered in relation to the full array of productive and reproductive livelihood activities, CA disproportionately affects men's and women's labor. We identified gender patterns related to participation in decision-making for productive and reproductive livelihood activities. Respondents indicated that decisions about livelihoods were not always made jointly, with socio-cultural norms and responsibilities structuring an individual's ability to participate in intra-household negotiations. While gender differences in power relations affect intra-household decision-making, men and women collectively negotiate the transition to CA-based production systems.

Access to and control over credit, land and machinery

Credit

Farmers within our sample increasingly relied on credit to purchase seed, fertilizers, herbicides, and other agricultural inputs. One woman commented: "The price of seed, fertilizer, and herbicide is getting more expensive every year but the maize yield is not stable and the maize price is not increasing…my family has to take out loans to cover the rising costs" (July 3, 2013). Formal and informal sources of credit are available to smallholders, each with their own risks and benefits. According to the farmers, there are five main sources of credit available: (1) moneylenders; (2) micro-finance institutions (MFIs); (3) savings groups sponsored by international NGOs; (4) family members; and

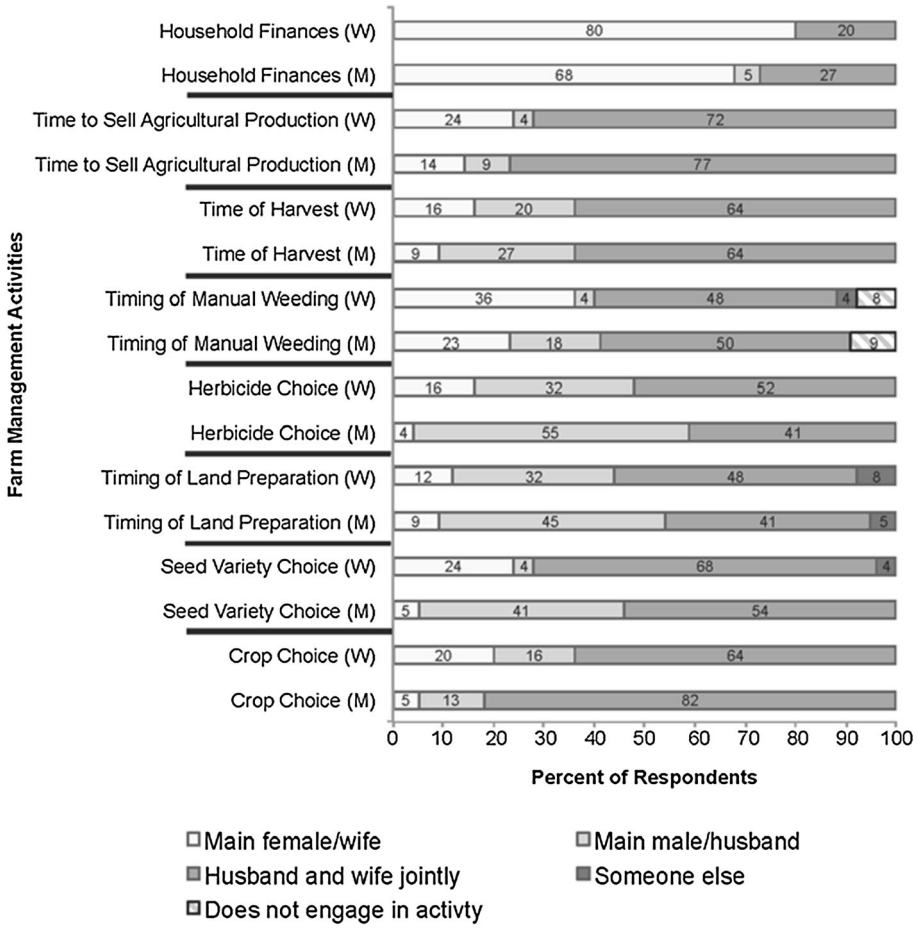

Fig. 2 Men's and women's responses: "*Who normally makes the decision…*?". Percentages (%) rounded to the nearest whole number. * Indicates where differences are significant $\alpha = .05$. [n = 47, men—22, women—25]

(5) middlemen. Prior to the availability of MFIs, farmers relied mostly on loans from moneylenders in a neighboring village or the provincial capital. Interest rates for this source of credit ranged from 5 to 20 % per month. MFIs became more widely available in 2005 and offered a cheaper source of credit with interest rates averaging 3 % per month for up to 250 USD. For both of these credit sources, farmers have to use their land as collateral, which represents a substantial risk. One woman said: "Farmers with less land and less capital have to take out more loans to cover their costs, but they often cannot pay back their loans and have to move to find new land and opportunities" (June 12, 2013).

Farmers indicated that MFIs and local moneylenders are important sources of credit for purchasing agricultural inputs. They highlighted the need for more flexible, affordable, and smaller-scale sources of credit. Savings groups sponsored by international NGOs working in the area offered a more flexible form of credit that can assist farmers with daily household expenditures. One woman noted the benefit of being a member of a savings group: "For the savings group I only have to contribute 10,000 KHR (2.50 USD) once a year… I can get money when I need it and the interest rate is low (1–3 %/month) and you pay back the total with interest at the end of the year" (June 20, 2013). In our sample, 52 % of women reported membership in at least one savings group. In comparison, only 36 % of men reported being a member while 32 % indicated they were not aware of any in the community. Men and women reported difficulties in acquiring loans from such groups, including an inability to receive a loan when they wanted and a lack of trust in the group's management of the savings. Loans from family members offered another flexible source of credit and do not require land as collateral, but are dependent upon the situation of the household and are not as prevalent as loans from MFIs.

Farmers identified additional factors that constrain men's and women's access to credit. One is the perception that borrowing money or taking out a loan is associated with downward financial security and loss of independence. Farmers typically take credit from a local middleman for the maize seed. They purchase the production from farmers and then sell to a larger processor. One women said: "When you take out a loan from a middleman to purchase the seed you have to sell your production back to that middleman even if you could have gotten a better price

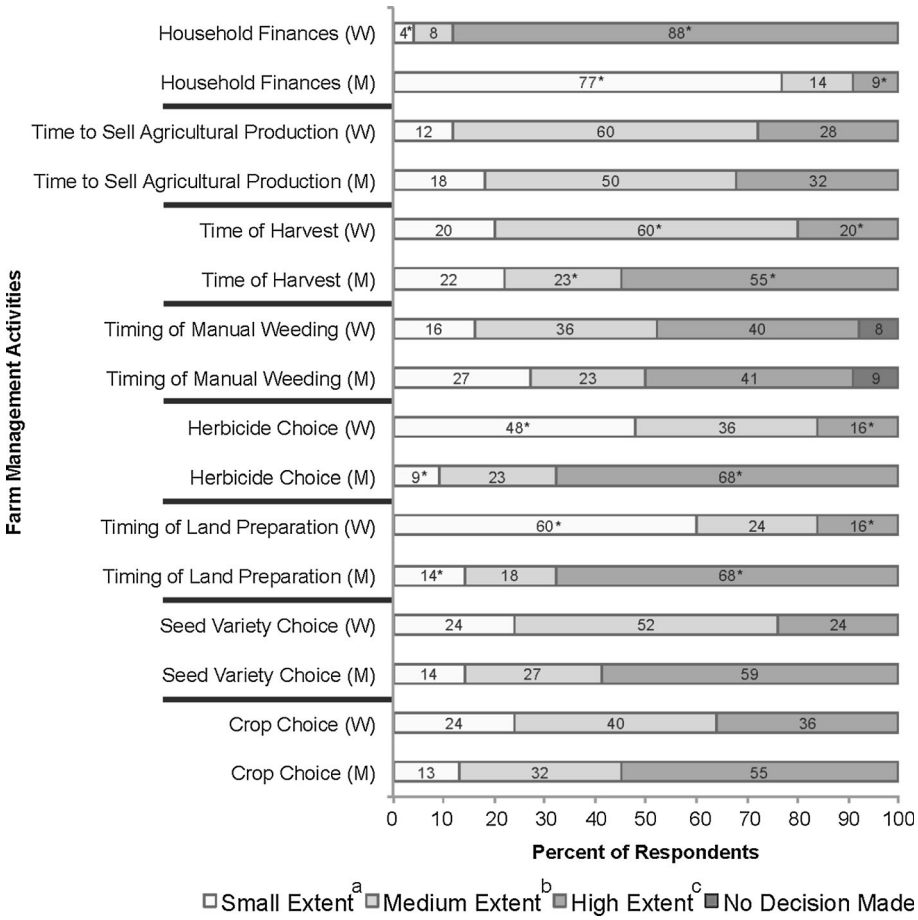

Fig. 3 Men's and women's responses: "To what extent do you feel you participate in decisions…?". Percentages (%) rounded to the nearest whole number. *Asterisk* indicates where differences are significant $\alpha = .05$. [n = 47, men—22, women—25]. [a]Small Extent—respondent is not asked for their opinion or respondent can give their opinion but that opinion is not considered in the final decision. [b]Medium Extent—Respondent is able to participate in the decision and everyone in the decision has to come to an agreement. [c]High Extent—Respondent can make the decision even if other members of the household disagree

elsewhere…sometimes the price is not enough to fully cover the loan" (July 5, 2013).

Recognizing constraints farmers face in accessing credit, SANREM IL initiated an internal subsidy and interest-free credit program to assist with the transition from tillage-intensive production systems.[8] The program credit is an important incentive for farmers starting to experiment with CA, as noted by 73 % of men and 84 % of women. With the interest-free credit and the sowing and herbicide application services offered by SANREM IL, farmers perceive CA as a possible alternative to conventional tillage-intensive agriculture. One man stated: "With CA there is no need to worry about the seed, fertilizer, or herbicide because SANREM IL credit covers all the costs" (July 4, 2013). SANREM IL is no longer offering the interest-free credit and men and women farmers reported that its discontinuation could affect farmers' decision to implement CA. The lack of free credit may not be an issue for wealthier farmers who have larger amounts of chamcar, but for those with less financial capital, the absence of the credit program could be a substantial constraint. One woman said: "More farmers would be interested in working with SANREM IL and experimenting with CA if SANREM IL still offered the free credit … I am not sure if farmers will be interested in experimenting with CA if there is no credit incentive" (June 5, 2013).

Farmers stated that both men and women have the ability to obtain loans and access credit from the sources noted above. Nonetheless, gender impacts men's and women's participation in decisions linked to credit, agricultural inputs, and managing household finances. Men and women in both FGDs and semi-structured interviews reported that women are primarily responsible for controlling the affairs of the home, including managing household finances. Survey results support this finding with 68 % of men and 80 % of women indicating that only women are involved in the following decisions about household finances (Fig. 2): budgeting household

[8] Farmers working with SANREM IL for more than 2 years are not eligible for the interest-free credit and the credit is only applied to 3 ha/farm). This program was available to farmers implementing CA from 2010 to 2012 and pre-financed the cost of agricultural inputs and services (sowing and spraying) on average amounting to 313 USD/ha. Farmers that produced more than 4.5 T/ha had to reimburse the full amount of the credit; for farmers with lower yields their reimbursement was based on their yield with the amount of 35 USD/ha deducted from every 250 kg/ha for a maximum subsidy of 175 USD for yields less than 3.5 T/ha.

expenses, paying back loans, and allocating the income from crop production.

Men reported they have greater control over the type of seeds and herbicides used (Figs. 2, 3), and that their daily responsibilities in the field gave them more knowledge about the types of fertilizers and herbicides needed. One man commented: "I am the one who goes to the upland plots and applies the herbicide so I know which type we should use or if we need to use a different variety" (June 5, 2013). Women reported they had less input in decisions about the type of chemical inputs (Fig. 3), suggesting that there is little interaction between men's and women's spheres of influence in these areas; however, results from the semi-structured interviews indicated that power-laden negotiations occur and link the field to the household in multiple ways. Men and women noted how women's decisions about household finances (in)directly affect decisions about the choice of farm inputs. One woman reported: "One time my husband asked me if he could purchase ten bags of fertilizer and I said no because our family did not have the money so we needed to purchase eight bags instead" (June 11, 2013). Men reported while they may decide what type of fertilizer or herbicide to use they needed their spouse's permission to make the purchase. They recognized their wives were aware of the different types of fertilizers and herbicides that were available in the local markets. This decision-making dynamic relates directly to household decisions about loans. Men may know what inputs are needed in chamcar and rice cultivation and when to take out a loan, but women respondents track how much money needs to be paid back and ensure that the debt is cleared.

Land

Land tenure security may affect a farmer's decision to invest in CA and access to land in Pichangva is complicated by historical and extant issues at the local and national level. There are several ways to obtain land: (1) redistribution from former KR generals as part of the reintegration of the KR beginning in 1996; (2) purchase from former KR soldiers and others; (3) inheritance from either the husband's or wife's parents; (4) renting land; and (5) "managing" land. The latter is an informal arrangement where a farmer agrees to clear the forest then cultivate the chamcar plots for an absentee landowner, normally a family member or a wealthier person from Battambang City. In this case, the landowner controls the entirety of the agricultural production including the income. Often in this situation the owner provides the manager with enough rice for domestic consumption. In other cases, the land manager may have decision-making power over some plots and is able to retain the income generated from the production. However, the manager is often responsible for managing larger tracts of maize or fruit tree production for the landowner. In our sample, smallholder farmers employed several of the above mechanisms to acquire land. Land ownership remains complicated as smallholder farmers may have an official land certificate or only letters of possessory right or "soft titles".[9] Most respondents—82 % of men and 68 % women—reported that land is a jointly-owned asset between a husband and wife, with both names listed on the letter of possessory right or land title (Table 1).

Joint ownership is mandated under the 2001 Land Law, defining ownership rights so they are shared equally between a husband and wife and land is confirmed as marital property (Mehrvar et al. 2008). The law is designed specifically to assist women secure tenure and control over land. Farmers reported that local officials require couples to jointly register their land. One woman reported: "When you have a land title like we do for our rice plot and you are married the title has to be registered in the wife's and the husband's name…my husband and I both had to travel to the primary school and apply our fingerprints to the title" (July 10, 2013).

While many farmers reported it was common practice for agricultural land to be jointly titled, several respondents currently implementing CA indicated only one person in the household owns the land (Table 1). Additionally, the majority of men and women farmers interested in CA implementation indicated that someone else owned the land. While suggesting tenure security could impact the decision to invest in CA, our sample of household interested in CA may be biased since the majority do not own the land they cultivate.

While joint land ownership was commonplace within our sample, how land was acquired can affect men's and women's level of access and control of land management decisions. One man reported: "My family has 2.5 ha of lowland rice and 3 ha of chamcar that I acquired from the government before I was married, listed in mine and my wife's name, but that land belongs to me…we have another 1 ha of lowland rice and 1 ha of chamcar that was an inheritance from my wife's parents, listed in mine and wife's name, but that land belongs to my wife" (June 21, 2013). As a result, men and women may not have equal control over the land and their access may be dependent on someone else in the household. Women participants indicated that even when women inherit land they often do not have full control over it. One woman reported: "I received some land from my parents as an inheritance…the land is

[9] These are typically issued by village, commune, or district chiefs and recognize land ownership but are not formally registered at the national level.

Table 1 Men's and women's reported land ownership by sampling category

Reported owner	Main male/husband		Main female/wife		Husband and wife jointly		Someone else	
Respondent	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)
Farmers currently implementing CA	17	13	8	7	75	80	0	0
Farmers that have tried but discontinued CA	0	0	0	14	100	86	0	0
Farmers interested but not implementing	0	0	0	0	33	50	67	50

Percentages (%) rounded to the nearest whole number

Farmers currently implementing CA: n = 27, men—13, women—14

Farmers that have tried but discontinued CA: n = 13, men—6, women—7

Farmers interested but not implementing: n = 7, men—3, women—4

* Where differences are significant $\alpha = .05$

in both mine and my husband's name, but I do not decide how that land is managed" (June 21, 2013).

Results from the survey and semi-structured discussions suggest that joint ownership is common in Pichangva, and that there are gender differences in decision-making regarding agricultural land (Table 1). Farmers believe that annual cash crop production is the viable pathway for improving the financial situation of the household. As such, most farmers are not interested in selling or renting agricultural land (Table 2). Several farmers were incredulous when we asked about selling agricultural land. One woman responded: "Why would I want to sell land when I want to buy land and expand production? When you rent out your chamcar land you can only earn a little income, you do not earn as much money as if you were to cultivate the land yourself" (June 13, 2013). Women participants indicated in the past it was common for wealthier upland farmers to allow less fortunate farmers clear the forest from uncultivated chamcar and manage the cash crop production for a period of time.

Farmers pursue opportunities to acquire more land. Most men and women respondents commented that both the husband and wife in the household need to be involved in the negotiations about new land (Table 2). Some men jokingly indicated that they could decide by themselves to purchase new land, but this might lead to divorce. Men and women participants also said that both have to be aware of several factors before purchasing new land: the potential productivity and price of the land, the household's financial situation, and the availability of labor for land clearance.

Agricultural machinery

Beginning in 2001, farmers in Pichangva started investing heavily in agricultural machinery, primarily two-wheeled hand tractors. This allowed farmers to increase the area of land under cultivation, save money by not paying an intermediary for plowing, and help ensure that the maize seed could be sown at the right time so that maize plants could withstand the monsoon rains in September and October. An additional benefit of hand tractor ownership is that it can be rented to assist others with plowing. Within our sample, all households indicated that they had regular access to a two-wheeled tractor, with 21 reporting that they owned a two-wheeled tractor, two renting, and one borrowing.

Table 2 Men's and women's responses: "Who normally makes decisions about agricultural land?"

Respondent	Main male/husband		Main female/wife		Husband and wife jointly		Someone else		No decision made	
	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)
Purchasing/renting agricultural land	9	4	9	20	41	48	14	4	27	24
Renting out agricultural land	0	0	4	4	0	4	0	8	86	84
Selling agricultural land	0	4	0	4	9	12	9	8	82	72

Percentages (%) rounded to the nearest whole number. [n = 47, men—22, women—25]

* Where differences are significant $\alpha = .05$

In Pichangva, conventional tillage-intensive agricultural practices rely upon two-wheeled tractors or four-wheeled tractors for multiple plowings per crop cycle. In Rattanakmondol SANREM IL purchased and used specialized no-till equipment imported from Brazil to sow the maize seed directly into the maize or cover crop residue. Farmers indicated the specialized no-till equipment reduces their production costs associated with land preparation and helps prevent soil erosion. The imported specialized no-till equipment used in CA was reported as too expensive of an investment for individual farmers, with costs ranging from 3500 USD for the smaller Fitarelli two-line planter to 14,000 USD for a Vence Tudo three or four-line no-till planter. The cost and availability of spare parts coupled with high service costs also made the equipment costly for farmer cooperatives or small groups of individual farmers to manage. Farmers were concerned that the equipment may not be managed effectively. The small number of available planters is also a constraint. SANREM IL personnel reported that for the 2013 maize growing season from May to January the two Vence Tudo no-till planters would need to sow maize for 165 ha on 80 plots in four villages within a two-week period. During the household visits and FGDs, participants emphasized that the time when the maize seed is sown is integral to the success of the crop. One man from the household visits discussed how the lack of planters could be a constraint: "Last year (2012) I wanted to start working with the project, but I could not wait for the planter to come sow the maize seed" (June 6, 2013).

The majority of men and women reported that two-wheeled tractors are considered a jointly-owned asset. In the household visits respondents reported that owning a two-wheeled tractor is a sign of a successful farmer. One man indicated that: "… a farmer feels proud when they have their own two-wheeled tractor because they don't have to depend on other farmers for help so you can sow the corn faster and on time" (June 17, 2013). The use of the hand-tractor is linked to men's land preparation responsibilities in rice and annual cash crop production. As such, two-wheeled tractors are an important status symbol, particularly for men.

These beliefs about agricultural machinery and men's and women's responsibilities in land preparation are linked to men's and women's role in decisions about agricultural machinery (Table 3). The purchase of a two-wheeled hand tractor (Approx. 2000 USD) represents a substantial investment for the household. Two-wheeled tractors and other equipment are typically purchased with the profits from the previous season. A majority of women (64 %) and many men (41 %) indicated that a husband and wife jointly decide to purchase or rent a two-wheeled tractor (Table 3). One woman stated: "Purchasing a two-wheel tractor is a major expense for the household so it is important that everyone has their input heard and everyone in the household agrees" (June 12, 2013).

Conversely, 50 % of men and 20 % of women said that only men are involved in decisions about purchasing or renting a two-wheeled tractor. Men stated that they are the ones who provide the labor for land preparation so they know that a two-wheeled tractor could make the plowing go faster and reduce their labor burden. Women respondents said that men might directly benefit from the investment in agricultural machinery, but they also raised concerns integral to the negotiations. One woman said: "A household has to think about how much money they have before they make a large purchase like a hand tractor…I am the one who manages the money for the household so I know if we can invest in the benefits of a hand tractor or not" (June 20, 2013). Farmers indicated that there is a similar decision-making dynamic for negotiations about the rental of larger four-wheeled tractors to assist with land preparation.

Gendered practices, roles and responsibilities

Results from the FGDs, household visits, and field observations showed that both men and women participate in agricultural activities in Pichangva, with primarily men responsible for tillage activities (plowing, discing, and furrowing) and herbicide application. Respondents claimed men had greater physical strength to handle the "heavy" agricultural machinery, carry the 16–20 L backpack sprayer, and clear the forest for new fields. In the FGDs women respondents named several activities in which they participate but may not have decision-making power over: sowing, fertilizer application, and harvesting. Male famers perceived these activities as "lighter" work better suited for women. Many women in the household visits said women are primarily responsible for manual weeding.

Despite women's participation in agricultural activities, their contribution is often overlooked. One man reported: "I am responsible for all of the activities involved in maize production and my wife just helps with the manual weeding…my wife, like other women, just works around the house" (June 12, 2013). In the men's FGDs, participants stated that only men apply herbicide. Women FGD participants indicated that men and women are both involved in herbicide application, as women and children assist by diluting the herbicide in water. Men reported that women had a minimal role in determining the type of herbicide to be used. One man reported: "I see what herbicide types other farmers use and then I tell my wife to go to the market to purchase it" (July 3, 2013). Women respondents confirmed this; however, several women noted how they could affect the choice of herbicide through their management of household finances.

Table 3 Men's and women's responses: "Who normally makes decisions about agricultural machinery?"

Respondent	Main male/husband		Main female/wife		Husband and wife jointly		Someone else		No decision made	
	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)	Men (%)	Women (%)
Two-wheeled tractor	50*	20*	4	0	41	64	0	4	5	12
Four-wheeled tractor	18	12	9	20	50	36	0	0	23	32
CA no-till equipment	4	8	9	8	50	48	0	0	36	36

Percentages (%) rounded to the nearest whole number. [n = 47, men—22, women—25]

* Where differences are significant $\alpha = .05$

Men recognized women for their household domestic activities including washing, cooking, cleaning, and childcare. According to men's responses during the household visits, men assist with daily activities that support the household; however, this contradicted the answers presented in the FGDs, where men collectively indicated that they are often too busy with their work with the chamcar or rice production to assist with domestic activities. Women in the FGDs and household visits said that typically men only participate in domestic activities by chopping firewood for cooking or using two-wheeled tractors to transport water for the household. Male and female respondents in the FGDs and household visits indicated that other support activities associated with the household were primarily women's responsibility, including: managing household vegetable gardens and fruit trees; raising small livestock (chickens, geese, and ducks); marketing and selling the maize and rice production; and managing household finances. While men are primarily responsible for activities in the field, women's roles in the "domestic sphere" are integral to the farming system.

The gendered division of labor and access to assets within the farming household is reflected in intra-household negotiations. Men's and women's responses in the semi-structured interviews indicated that women have greater control over activities associated with the home while both reported that it is important for the husband and wife to be involved in field-related decisions. One woman told us: "I talk with my husband about the maize production…when you get married you have to talk with your spouse about all of the aspects of agricultural production and a husband and wife have to agree about every decision" (June 27, 2013). While participants reported that men and women are both involved in decisions about agricultural management, we further examined the decision-making dynamic by asking to what extent they participated (Fig. 3). Generally, men indicated higher levels of participation in decisions regarding field activities such as timing of land preparation and crop choice, while women respondents indicated lower levels of participation.

Men and women may both be involved in certain decisions about agricultural production, but there are gender-based differences in the extent of their participation (Fig. 3). In land preparation, 68 % of men indicated that they participate to a high extent and may make decisions even if other members of the household disagree; only 16 % of women said the same. The majority of women (60 %) (Fig. 3) indicated they could not give their opinion or their opinions did not affect the outcome of decisions related to land preparation. Men and women noted that this decision-making dynamic is due to men's greater responsibilities in agricultural activities.

Men and women respondents indicated that gender differences in roles and responsibilities influence participation in decision-making; however, respondents stressed that women's roles and responsibilities in the house could impact the field, and men's responsibilities in the field could impact household decisions. For example, a wife's marketing strategy and management of household finances are linked to decisions about the maize harvest and land preparation. One woman reported: "Farmers in Pichangva often try to sow their maize sooner so they can harvest sooner to pay back their credit…in my household I am the one who negotiates with the middleman so I track the changes in the maize price and know when we need sow and harvest the maize so we can get the best price" (June 13, 2013).

During the semi-structured discussion, the majority of men (77 %) and women (80 %) indicated that the specialized no-till equipment used in CA could reduce the amount of time men and women must allocate to land preparation. One woman reported: "Implementing CA makes the work easy…when you are implementing CA you just have to hire the services of the planter and the machine does all of the work…applies the fertilizer and sows the maize seed" (June 13, 2013).

In conventional production farmers typically have to plow their land twice before seed is sown: the first time a four-wheeled tractor is used and the second time a two-wheeled hand tractor is used. During sowing, a two-wheeled tractor is used to trace lines while two additional

household members, usually women, follow behind on foot and apply the fertilizer and seed manually. In comparison, with CA the multiple plowings before sowing are unnecessary and the no-till machinery sows the seed directly. Men respondents said that CA decreases the amount of time they allocate to land preparation; women respondents also reported their responsibilities were reduced as fertilizer application and seed sowing is mechanized in CA. One male farmer commented on these perceived benefits: "When we plowed, my whole family had to help during land preparation but with CA my wife and children no longer have to sow the maize seed or touch the fertilizer" (June 19, 2013).

In discussing the labor-saving benefits of CA, both men and women respondents reported how they are able to use the "extra time" they saved. It is important to note that within our sample most farmers only implemented CA on a portion of their total land holdings and used conventional tillage-intensive practices on the majority of their land. With this caveat, we asked farmers in the household visits how they allocate their "extra time." The majority of men (72 %) and women (78 %) respondents indicated that with CA they are able to allocate more time to additional agricultural production activities, including household rice cultivation, tillage-based cash crop production, vegetable garden management, and fruit tree production. Several women also indicated that they allocate their "extra" time towards domestic activities within the house. Respondents discussed how socio-cultural norms and beliefs affected how men and women were expected to and did reallocate their "extra" time. Both men and women noted that the introduction of CA practices did not redefine men's and women's socially expected roles and responsibilities in the field or the household. One woman reported: "Even with CA my husband is still too busy to assist me with any of the household tasks" (June 10, 2013).

Discussion

The principal goal of this research was to investigate gender-based constraints and opportunities associated with the dissemination of CA. Farmer's perceive that women have greater responsibility over household management while men have greater control over agricultural production. We found that men and women collectively negotiate the transition to CA. Additionally, the introduction of CA has the potential to positively impact the gender division of labor but does little to redefine existing gendered livelihood practices. This case study from Rattanakmondol illustrates the need for CA research-for-development programs to identify the linkages between assets, capabilities, and practices, and understand how these livelihood components are gendered and could constrain or promote the collective decision to adapt conservation agriculture.

Land tenure security is recognized as an important factor needed to implement sustainable land management (Jones 2002); both men's and women's insecure access to land may decrease interest in implementing CA (Knowler and Bradshaw 2007; Giller et al. 2009; Beuchelt and Badstue 2013). Farmers noted the complexities surrounding land tenure security in the region but appeared to trust the village chief's recognition of farmers' letters of possessory right. Doubts surrounding tenure security could increase farmers' reluctance to experiment with CA as they could lose their long-term investment in their soil if the land was reallocated to other farmers or an international agri-business company. Short-term land management arrangements including renting or "managing" could be a constraint as the short-term benefits of CA are minimal and farmers could be limited in their control over land management decisions, including the decision to utilize CA. Farmers renting or managing a plot could be less interested in applying CA management practices as they may be more interested in immediate profits than increasing soil production potential. Beuchelt and Badstue (2013) note that farmers might experiment with CA and other new agricultural technologies on rented plots and implement on their own land if they see benefits.

We identified how gender intersects with other factors to determine smallholder farmers' options and investment in the long-term benefits of CA. We found that the majority of households consider land to be a jointly-owned asset with men and women involved in investment and production decisions about land usage and management. Even when land is reported as jointly owned, women are often not listed on formal and informal ownership documents and do not have full control over the land (Bomuhangi et al. 2011). Joint ownership can help ensure that women have access and control over the land. Women's secure access to land is especially critical in cases of divorce, separation, abandonment, or death of the husband. Despite apparent gains in tenure security and the dissemination of CA, land security remains an issue that needs to be addressed to promote the dissemination of CA and gender equity in Pichangva and across Cambodia.

Negotiations and dynamics within the household can affect the dissemination of agricultural technologies and management practices, including CA (Udry 1996; Doss 2001, 2013). Gendered decision-making dynamics are rooted in socio-cultural perceptions that men control different yet complementary spheres within the farming household, as has been identified elsewhere in Cambodia (Brickell 2011). While the farming household is not a homogenous unit, men's and women's roles in decision-making within the

home and field are not independent. Rather, men and women both participate in decisions though power differences impact their levels of participation.

The complexity inherent in intra-household negotiations and men's and women's control over assets, spaces, and activities makes it difficult to conceptualize how these factors will affect farmers' decision to implement CA (Doss 2013). While men's and women's decision-making are perceived as independent, their decisions are interrelated in multiple ways. The decision to experiment with CA could be perceived solely as a field management decision under the purview of men, however we saw that women's roles as household financial managers involve them in decisions directly linked to CA. Women's roles, responsibilities, and concerns affect household decision-making that is part of agricultural production and as such need to be considered by CA projects.

Gender is key to who does what in home and field, and understanding the potential effects of CA on rural livelihoods (Beuchelt and Badstue 2013). CA can reduce men's and women's labor burden, yet the introduction of specialized no-till equipment does little to change accepted sociocultural beliefs governing gendered livelihood practices. In rural areas, including Pichangva, women often have a triple workload and are responsible for reproductive, productive, and community activities. These multiple responsibilities are often overlooked in development interventions, including CA programs. Our results align with similar research documenting inequities in men's and women's ability to access benefits from changes in labor requirements brought about by CA and mechanization (Farnworth et al. 2015). In a region where agriculture is increasingly mechanized and available agricultural labor is dwindling, the perceived and actual impact of CA on gendered labor patterns is crucial to sustainable agricultural livelihoods.

CA has gendered impacts based on men's and women's different responsibilities in weed management. In Pichangva, perennial weeds are an increasing issue, leading to a growing reliance on herbicides. Herbicides and cover crops can compensate for increased weed pressure and reduce women's labor burden related to manual weeding. If components such as herbicide application or cover crops (both of which suppress weeds) are only partially implemented, and considering that women are primarily responsible for weeding, women's multiple responsibilities and limited amount of time to spend in the field could impede the success of CA.

Farmers voiced concerns about limited off-farm income-generating opportunities and the rising cost of chemical inputs needed in conventional tillage-intensive agriculture and CA. Collateral requirements coupled with social norms and perceptions limit farmers' access to credit. Women could be disproportionally affected by these constraints due to their responsibilities managing household finances and ensuring that loans are repaid. As we have seen, they have considerable impact on decisions and may resist CA. Examples from the literature highlight that without access to credit and other financial capital, CA and other sustainable natural resource management practices are unlikely to be accepted (Jones 2002). Smallholder farmers in Pichangva facing declining crop yields, increasing soil erosion, and the rising costs of chemical inputs are hesitant to risk their land to cover the cost of inputs needed in CA due to uncertainty surrounding its results.

Conclusions

We postulated that gender differences in access to assets, practices, and participation in intra-household negotiations would affect smallholder farmers' ability to integrate CA, and that CA development interventions would impact gendered livelihood practices. While our results reveal that the gendered dimensions of CA are complex and context-specific, we identified three themes—access, decision-making, and space—that should be considered when evaluating the interaction between gender and CA.

We demonstrate how gender plays a role in men's and women's ability to access and control key assets (credit, land, and machinery) that can effect CA integration within smallholder agricultural livelihoods. In particular, access to land, with all the associated complexities between gender, decision-making, CA, and farm management, requires further research in Southeast Asia and other contexts. This research will comprehend the implications of joint or sole decision-making and ownership on smallholders' willingness to integrate CA and other associated technologies.

We used multiple indicators and both qualitative and quantitative data to document the gendered power relations that impact men's and women's influence in intra-household decision-making. We show that it is critical to interview both men and women (and ask questions in different ways) as they often have different perspectives, priorities, and interests regarding CA implementation, household livelihood activities, and their intersection.

Likewise, we identified that decision-making power is linked to men's and women's perceived different roles and responsibilities within different spaces and spheres within the rural farming household; however, our results indicate the complex interactions and negotiations that link those spaces and responsibilities as men and women collectively determine the appropriateness of CA as well as broader agricultural livelihood decisions. To be effective, development programs promoting CA must recognize the multiple spaces of the farming household and challenge the

assumption that CA and other agricultural activities are solely a field management decision controlled by men. While this study is site-specific, the methods and findings may encourage similar research to investigate how gendered spaces and responsibilities affect household members collectively negotiate the integration of CA. Additionally, understanding how gender intersects with other variables affecting power (age, income, ethnicity, etc.) would strengthen the understanding of the constraints and opportunities associated with CA.

Farmers interviewed believed that CA practices can reduce smallholders' labor burdens; however, we found they have varying effects on men and women. Additional empirical data is needed to document how CA impacts redistribution of labor in the broader spectrum of household and community activities.

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