Scientific African 7 (2020) e00250

Contents lists available at ScienceDirect

Scientific African

journal homepage: www.elsevier.com/locate/sciaf

Gendered constraints for adopting climate-smart agriculture amongst smallholder Ethiopian women farmers

Meseret Tsige*, Gry Synnevåg, Jens B. Aune

Department of International Environment and Development Studies (Noragric), Norwegian University of Life Sciences, 1430 Ås, Norway

ARTICLE INFO

Article history:
Received 9 May 2019
Revised 25 November 2019
Accepted 26 November 2019

Editor: Dr. B. Gyampoh

Keywords:
Climate-smart agriculture
Climate change
Ethiopia
Gendered constraints
Women smallholders

ABSTRACT

Although Climate-smart agriculture (CSA) can offer economic and food security opportunities for women farmers, success in the uptake of these technologies is contested by gendered constraints. Previous studies that use the household head as a unit of analysis to explain adoption patterns do not adequately demonstrate the extent to which women smallholders are restricted by gendered constraints. This study uses 344 women and men survey respondents involved in conservation agriculture (CA) and small-scale irrigation schemes (SSIS) as data sources for examining the effect of gendered constraints for adopting climate-smart agriculture amongst women in three areas in Ethiopia. Qualitative and quantitative data collections were applied using survey, in-depth interviews and focus group discussions. Quantitative data were analyzed using descriptive statistics, Pearson's chi-square test and binary logistic regression using statistical software for the social sciences (SPSS) version 24. Thematic and narrative analysis methods were used to analyze qualitative data. The findings show that women smallholders uptake is affected by limited access to credit, extension, restricted membership in cooperatives and water user associations, lack of access or user rights to land, skill training, information, and restricted mobility. Agricultural development interventions should be implemented by accepting and considering individual farmer's entitlement to development. Expanding off-farm diversification and rural employment opportunities through changing the land tenure system, which is currently state-owned, are essential to enhance women smallholders' access to land and other agricultural inputs.

Introduction

Climate change conceivably creates food insecurity as rainfall and temperature variability reduces food production [38,53,66]. Sustainable use of agricultural technologies has been proposed to enhance the food security of smallholders under climate change [6,38]. Climate-smart agriculture (CSA) encompasses agricultural technologies that can increase production and income, increase farmers' resilience to climate change, and reduce greenhouse gas emissions [24]. Conservation

* Corresponding author.
E-mail address: meseret.abebe@nmbu.no (M. Tsige).

https://doi.org/10.1016/j.sciaf.2019.e00250

agriculture (CA) and small-scale irrigation schemes (SSIS) are two different forms of CSA[1] practices [41] used as contextual cases in this study. The fundamental principles of CA include minimum disturbance of the soil or zero tillage (ZT)[2], maintenance of soil cover with crop residues (mulching), and crop diversification using crop rotation or intercropping between cereals and legumes [22,26,61]. These CA principles are expected to address food insecurity through building soil quality and making agriculture less vulnerable to climate-change-induced challenges [35]. However, the uptake of CA depends largely on farmers' access to inputs, credit, machinery, and information [28,65]. SSIS is another approach to increase production and income which contribute to sustainable livelihoods in sub-Saharan Africa [12,30]. However, the success of SSIS is dependent on adequate agricultural inputs and policy support. Inadequate financial resources, lack of knowledge, and lack of operational policy support are reported as factors constraining the success of CSA technologies in eastern Africa [23,67].

In spite of the fact that the use of agricultural technologies has the potential to improve rural people's income, food security and livelihoods [8,15,43], not everyone has the capability to properly adopt CSA technologies for improved food security and income [11]. In particular, women smallholders in Ethiopia are affected by many contextual gendered constraints that are slowing down their adaptive capacity to agricultural technologies [5,16]. It is also likely that agricultural interventions produce gender-differentiated impacts, owing to unequal use rights to production inputs [40]. Seebens and Sauer [54], indicate that if women and men were to possess equitable control over production inputs in rural Ethiopian households, production would increase significantly.

Although legal laws allow use rights to agricultural land for smallholder women, customary laws accept men as the primary "owners", and land inheritance is guided by patriarchal principles in most parts of Ethiopia. Fafchamps and Quisumbing [21], identify intra-household inequality in accessing or using agricultural land in Ethiopia. Furthermore, male household heads normally own livestock in rural Ethiopian households [20], and this adversely affects women's decision-making ability on how to use oxen for irrigated agriculture. Inequality between men and women's access to credit, water, fertilizer, and market linkages have also been identified in other parts of sub-Saharan Africa [45].

CA is assumed to be a labor-saving approach [28]. This aspect of CA can appear attractive to Ethiopian women smallholders, as they are responsible for multiple productive, reproductive and community roles. However, success in saving labor depends on how inputs are used – for example, savings are less likely to occur if farmers do not use adequate herbicides and do manual weeding [65]. Weed infestation in CA tends to increase as a result of lack of herbicide use, and women are responsible for weeding [4,59]. Preparing a flat weed-free seedbed for sowing is a common practice in Ethiopia. The *Maresha* (a scratch plow) is pulled by a pair of oxen to plow agricultural land [60].

Farmers who have no oxen need to pay up to 50 % of their harvest to get their land plowed [7]. Women are culturally prohibited from plowing [39] and their control over cattle is restricted [20]; hence, women smallholders and those who do not own oxen could be the primary beneficiaries of ZT. However, the need for other costly inputs such as herbicides, pesticides, and fertilizers is challenging for women. The lack of crop residues for mulching is also a major constraint affecting the adoption of CA by African smallholders [28]. Furthermore, the use of crop residue for mulching reduces the availability of residues as a fire source. As a result, mulching can increase the labor burden on women as they are often responsible for collecting firewood in smallholder households [11].

Gendered institutional, information and knowledge-related constraints also contribute to women's limited uptake of agricultural technologies. CA management and the operation of irrigation equipment require adequate knowledge and skills training. However, women smallholders in Ethiopia have little access to extension and training as a result of gendered institutional biases [5,16,63,64]. Agricultural extension services are provided primarily to men [14], and female-headed households receive less extension advice than male-headed households [48]. Besides, even for men, the extension service does not pay attention to farmers' needs and technology preferences [16]. The fact that most extension agents are men is also likely to affect women's access to extension services [14], as married women in some cultures are prevented from communicating with men without the presence of their husbands. A review of studies by Quisumbing and Pandolfelli [47] indicate that gender norms prohibit women's membership in Water User Associations (WUAs)[3]. Abebaw and Haile [1], highlight that most members of cooperatives in Ethiopia are male household heads. Women's access to rural institutional services was found to be restricted in four regions of Ethiopia, in the form of a bias against women's access to fertilizers and improved seeds from institutions [48]. Rural financial institutions do not recognize women as active economic agents and credit is often provided only to male household heads [25]. Aregu et al. [5], found that limited access to credit is one of the gendered constraints that limit agricultural technology adoption in Ethiopia.

The lack of knowledge and inadequate information on agricultural technologies is a general constraint to technology adoption in Ethiopia [19]. Aregu et al. [5], indicate that cultural factors, and the restricted knowledge that women farmers possess about technologies are gendered constraints that limit agricultural technology uptake in Ethiopia. In particular, CA demands complex management skills [65], and depends on farmers' knowledge regarding the selection and proper use of herbicides and pesticides. Information about improved seeds requires membership in farmers' cooperatives [59]. However, women often lack connections outside their village and are seldom accepted as members of cooperatives. This restriction, in turn, affects women's ability to adopt CA and access improved seeds for SSIS.

[1] Climate-smart agriculture (CSA); Conservation agriculture (CA); small-scale irrigation schemes (SSIS).

[2] zero tillage (ZT).

[3] Water User Associations (WUAs).

Several studies have investigated the technical determinants of agricultural technology adoption at the household level in Ethiopia. However, the adopters of agricultural technologies are often perceived to be only men in male-headed households and women in female-headed households [18]. Unlike previous studies that focus on household heads, this study investigated what and how gendered constraints affect women smallholders in male-headed households. Although men and women smallholders are referred to as users of technologies, gendered constraints do not have similar effects on men and women farmers even within the same households. Hence, the main question addressed in this study is: what are the agricultural inputs, institutional-knowledge-and information-related gendered constraints that contest the proper uptake of women smallholders who are currently practicing CA and SSIS technologies? Investigating such gendered constraints is an attempt to contribute to the broader picture of CSA technology uptake among women smallholders in the global south. The article provides information to agricultural development planners, on how, and which gendered constraints limit women smallholders' uptake of agricultural technologies.

Materials and methods

Conceptualizing gendered constraints within the contested agronomy framework

"Contested agronomy" is a political agronomy framework that uses a critical analysis approach to assess claims of success in technology adoption, particularly in developing economies [56]. The framework focuses on analyzing success constraints in crop production, including socio-cultural constraints [56]. Constraints to agricultural technology uptake and success can be viewed in two ways: either as embedded within the innovation process (endogenous), or as prerequisite conditions (exogenous) [55]. From this categorization, gendered constraints are prerequisite exogenous contestations affecting women's uptake of agricultural technologies. "Gendered constraints" in this study are constraints that restrict women smallholders' involvement and success in using CSA technologies and are those largely emanated from the socially constructed masculinity and femininity thoughts of societies.

The adoption and success of agricultural technologies in most contexts in the developing world is exceedingly reliant not only on technical aspects but also on social, cultural, institutional and political factors [55]. However, these factors are often excluded from the analysis and discourse on the topic of "limited success" [27]. The lack of gendered access to agricultural inputs and associated labor-related issues are prime contestations of the use of agricultural technologies. Weeding is regarded as the Achilles' heel of CA because ZT may increase weed infestation if insufficient herbicide is used [4].

Various stakeholders view agricultural technology-related problems from different perspectives, e.g. water engineers from an infrastructure perspective; environmentalists from a conservation perspective; agronomists from a yield maximization and soil management perspective; and economists from optimal economic adaptation. As a result, the social dynamics of using agricultural technologies in African agriculture are often overlooked [57].

Notably, irrigation technologies seldom address gender inequality, as schemes are designed and implemented by water engineers who tend to focus on technical aspects [50]. Hussain and Hanjra [34], indicate that excluding the social aspects of irrigation adversely affects the success of SSIS. Agronomic development schemes and policies often claim "participation of the poor" without addressing inequalities within the development process [57]. As a result, simply involving women farmers and other marginalized groups in development schemes do not necessarily lead to the successful uptake of agricultural technologies. Even the use of irrigation schemes may bring negative impacts unless the equality impacts of the use of irrigation by women and the poor are identified and addressed [42].

Although women users in male-headed households in this study are referred to as "users" of CSA technologies, as they work alongside their husbands, their adaptive capacity, involvement, and decision-making on how to use these technologies are differently affected by gendered contestations. Analysis of context-based, socio-cultural constraints of agricultural technologies is essential to identify and enhance their adoption rate and success. Hence, this study investigates gendered constraints under the contested agronomy framework's quest to expose the multiple dynamics and context-specific, gendered socio-cultural, institutional and economic contestations (exogenous factors) that constrain agronomic success [55,57]. Context-specific gendered contestations were investigated with regard to agricultural input, institutional, knowledge and information-related gendered constraints. Investigating these constraints helps to identify and strategize pathways to address barriers to the use of CSA among women smallholders and encourage gender-equality in production growth in smallholder farming households.

Methods

Both qualitative and quantitative data are useful in investigating the gender-related dynamics in agriculture [10]. Hence, a concurrent mixed-method design that combines quantitative and qualitative data [58], has been applied. The quantitative data through the survey investigated the most significant gendered constraints affecting women users and it compared the situation in which women and men smallholders are differently affected by gendered constraints. In-depth interviews explored women smallholders' experiences regarding how they are affected by gendered constraints in their uptake of CSA technologies. Three (one by study area) Focus Group Discussions (FGDs)[4] were conducted to investigate the cultural constructs of gendered constraints. The qualitative and quantitative data basis were concurrently collected and analyzed.

Description of study sites

Study sites were part of a larger research project known as Research and Capacity Building in Climate-Smart Agriculture in the Horn of Africa, which is a project promoting CSA technologies through research and capacity building activities and this study was part of this research project. Men and women also practice CSA in study areas. The study was conducted at three study sites, namely in the Loca-Abaya, Halaba and Ziway *Woredas* (a *Woreda* is an administrative unit that incorporates not less than 30 of the smallest administrative units, known as *Kebeles*). The Loca-Abaya *Woreda* is located in the Southern Nations Nationalities and Peoples Regional State (SNNPR) in Ethiopia. Farmers practice CA for maize and haricot bean crops. The CA practice includes zero tillage, which is practiced after herbicide application, intercropping maize with haricot beans, and using maize residue for mulching. Despite some dropouts, 160 households practiced CA in eight *Kebeles.* Since 2005, few selected users have been supported by FAO, International Maize and Wheat Improvement Center (CIMMYT), Ethiopia's Agricultural Transformation Agency (ATA), Sustainable Intensification of Maize-Legume Farming Systems for Food Security in Eastern and Southern Africa (SIMILESA)[5], and other NGOs and the same is true in this study area [17,23]. Farmers who did not access support also practiced CA in the scaling-up process.

The second study site was Halaba, which is a *Woreda* in the SNNPR. The Halaba SSIS is an improved gravity-based scheme, with a constructed diversion weir and a regulating dam weir on the Bilate River. The scheme covers 200 hectares of agricultural land, discharges 2200 cubic meters of water per second during the rainy seasons, and services 275 households. Smallholders produce primarily potatoes and onions. Ziway – the third study site – is located in the Oromia regional state of Ethiopia. Farmers produce primarily onions, tomatoes, green beans, cabbage, pepper, and maize. Water is pumped from Lake Ziway using both group-owned, large water pumps and individually owned small pumps. The scheme covers 203 hectares and services 470 households. All agricultural practices in the study areas can be categorized as a CSA approach, which aims primarily to improve food security and livelihoods since rainfall is scanty in the study areas.

Sampling

Although men smallholder farmers may be constrained by the same or different challenges, previous studies show that gendered input, institutional, information and knowledge-related constraints affect Ethiopian rural women more than men [16,20]. As a result, we estimated a higher proportion for women and lesser for men smallholder farmers. We obtained the required sample size using $n = (Z_{\alpha/2}+Z_{\beta})^{2} * (p_1 (1-p_1) + p_2 (1-p_2)) / (p_1-p_2)^2$ with 80 % power, meaning there is eighty percent of the probability of rejecting the null hypothesis when the alternative is true. The calculation provides sample variation and the number of samples or required observations per variable was calculated using the G*Power 3.1.9.4 statistical software. Men and women smallholder farmers were selected using a stratified proportional random sampling method (women from male-headed and female-headed houses and men from male-headed households). Fifteen *Kebeles* were purposefully selected from the three *Woredas* as they are users of CSA. Farmers were selected from the technology users list in *Kebeles* with the help of development agents (DAs)[6]. Selected CA users are those who managed to adopt at least two of the CA practices for three consecutive years as two-five cropping seasons or three years of crop rotation often increase soil quality and yields in CA [61,62]. SSIS users are consistent users as they have irrigated land within schemes. Accordingly, 223 women users from male-headed households and 92 men users from the same households were selected. Proportional sample sizes were also used to randomly select 107 non-user women from male-headed households and nine from female-headed households from *Kebele* dwellers list. In total, 460 respondents participated in the survey. Of the 223 randomly selected women users in male-headed households, 23.3 percent were CA users, 36.3 percent were canal-based SSIS users, and 40.4 percent were pump-based SSIS users. Of the 92 men users, 32.6 percent were CA users, 32.6 percent were canal-based SSIS users, and 34.8 percent were pump-based SSIS users. Of the 29 women users in female-headed households, 27.6 percent were CA users, 31 percent were canal-based SSIS users, and 41.4 percent were pump-based SSIS users. The regression analysis involved only CA and SSIS women users from male-headed households and female-headed households, and men users. In total, 252 women users and 92 men users, from all study areas were incorporated as individual participants. Purposeful sample selection was conducted to select 28 women users and 18 DAs for in-depth interviews. Besides, 32 men and women participated in three mixed focus group discussions, one in each study area. Hence, the survey was used to collect quantitative data whereas in-depth interviews and focus group discussions were used to collect qualitative data. Surevy questionnaires and in-depth interviews were interviewer-administered. Data collection was done using Amharic after being translated from English. DAs helped not only in identifying randomized households but also as translators whenever required. The research data in this study was collected from September 2015 to September 2016. Data were collected after informed consent was obtained from all study participants, and the principle of anonymity was applied. All participants in this study were smallholders with less than 2 hectares of land.

[4] Focus Group Discussions (FGDs)

[5] Ethiopia's Agricultural Transformation Agency (ATA);International Maize and Wheat Improvement Center (CIMMYT); Sustainable Intensification of Maize-Legume Farming Systems for Food Security in Eastern and Southern Africa (SIMILESA); Southern Nations Nationalities and Peoples Regional State (SNNPR).

[6] Development agents (DAs); Statistical Packages for the Social Sciences (SPSS).

Data analysis

Analysis of the quantitative data was done using descriptive statistics, Pearson's chi-square test (X^2) and binary logistic regression analysis using Statistical Packages for the Social Sciences (SPSS) version 24. The logistic model was crafted to investigate which gendered constraint had a greater effect on women users in the process of adopting CSA technologies compared to men. The logit is an estimation method for equations with binary dependent variables, that avoids the unboundedness problem of the linear probability model by using the cumulative logistic distribution function [29]. Let X indicate predictor or independent variables $\{x_1, x_2, x_3, \ldots x_k\}$. Given X, the conditional probability of a success event occurring under a Bernoulli trial is given as:

$$p(Y = 1|x) = \pi \tag{1}$$

The logit of Y is predicted from X and *logit* refers to the probability of the occurrence of gendered constraints with a greater effect on women users compared to men users of the CSA technologies. Men and women are dichotomous dependent variables coded as women (1) men (0). Men and women users responded to questions such as; do you have access to credit? The self-reported responses of women and men were coded as Yes (1) or No (0) that produces dichotomous outcome variables. The analysis enabled the calculation of which gendered constraint or variable had a greater effect on women users versus men. The logistic regression model has a linear form under the logit transformation:

$$logit\ (p) = \text{natural log (odds)} = \text{In}\left(\frac{\pi}{1-\pi}\right) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k \tag{2}$$

Where, β_0= the intercept constant, $\beta_1 - \beta_k$= coefficient of each independent variable or X's. x_1= Age, x_2= Education status, x_3= Access to land, x_4= Off-farm income, x_5= Access to credit, x_6= Access to collateral, x_7= Access to extension, x_8= Membership in cooperatives and WUAs x_9= DAs identify your needs, x_{10}= Access to crop residue. Independent variables were selected based on context-based experiences and from available studies. All variables were checked for multicollinearity and the model was fitted using the goodness of fit method where the p-value is expected to be insignificant [33]. Since age and education possess a confounding effect in the model, the crude odds ratios were adjusted for other covariates.

The model coefficients (β_i) are estimated by the maximum likelihood (ML)[7] method. In the ML estimation method, the likelihood equations are an explicit non-linear function of unknown parameters [29]. ML finds parameters of the model that best describe the data to yield the highest likelihood of explaining the data [2]. ML is specifically used to maximize the likelihood of reproducing the data given the parameter estimates. The logit is the natural logarithm (In) of odds of Y, and the Odds Ratio (OR) refer to ratios of probabilities *(n)* of Y happening divided by the probabilities of Y not happening [44]. Specifically, the OR can be defined as the following ratio:

$$odds\ ratio = \frac{\pi}{1-\pi} \tag{3}$$

The covariates coded as 1 and 0 can be displayed in the 2 × 2 contingency table. Exponentiation of the additive logit model provides a multiplicative model for the odds ratio. The logistic regression model [32] is given by:

$$\pi = \frac{e^{X\beta}}{1+e^{X\beta}}. \tag{4}$$

Where $X\beta = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k$ can be transformed to give a new interpretation, e refers to the base of the system of natural logarithms. The additive logit model provides a multiplicative model for the OR. The OR in this study are estimators of the extent to which specific gendered constraints affect women users compared to men users, such that it was possible to identify and rank gendered constraints that affect women users of CSA compared to men users.

Qualitative data were analyzed using thematic analysis methods, using inductively generated themes after coding and categorizing concepts based on their dimensions [13]. A narrative analysis method was also applied using extracts from the direct responses of participants. Narrative analysis was done when responses were not adequate in explaining the participant's intention or the real context [52]. Variables related to access refers to individuals' ability to benefit from production inputs [51]. "Control" relates to having power over resources, while "ownership" indicates a legal claim and the rights to sell, use and give away resources. The term CSA represents both CA and SSIS in the analysis. Although men farmers were used as a control group, this does not necessarily indicate they are not challenged by constraints of the use of technologies.

The study explicitly applies the feminist research approach whereby women's experiences and their direct voices generate new knowledge that is valuable in addressing women's problems [31,49]. Furthermore, gender-based studies should not use the household head as the center of an investigation, as gendered constraints do not affect men and women in the same way within the same household. The rationale behind gender analysis and the collection of gender-disaggregated data in this study is to investigate which constraints have a greater effect on women users and how women and men are affected differently by gendered constraints in the process of adopting CSA technologies. Although women users of CA and SSIS are referred to as "users," as they work alongside their husbands, and so their involvement, adaptive capacity, and

[7] Maximum likelihood (ML).

Table 1
Descriptive statistics and association between individual farmers and gendered constraints.

Variables		WUMHHs	WUFHHs	MUs	WNUMHHs	WNUFHHs	P-value
Education Status	Never been in school	82.5	96.4	41.3	92.5	88.9	0.000***
	Elementary and above	17.5	3.4	58.7	8.5	11.1	
Age	19-40	76.2	31	46.7	74.8	44.4	0.000***
	41-73	23.8	69	53.3	25.2	56.6	
Access to land		69.5	100	98.9	56.1	100	0.000***
Off-farm income		16.6	17.2	14.1	13.1	100	0.643
Access to collateral		40.4	44.8	60.9	31.8	22.2	0.007***
Access to credit		63.7	55.2	82.6	24.3	77.8	0.000***
Control over irrigation water		99.1	51.7	97.8	100	88.9	0.040*
Access to crop residue		21.1	27.6	17.4	11.2	55.6	0.007**
Membership in cooperatives and WUAs		11.2	44.8	81.5	2.8	0	0.000***
Access to extension services		20.2	51.7	83.7	6.5	0	0.000***
Access to skill training		6.3	31.0	87	0.9	0	0.000***
Access to training on how technologies fit with experience		3.1	3.4	29.3	0.0	0	0.000***
Access to extension from women DAs		4.0	0	4.3	4.7	0	0.779
Mobility		18.4	41.4	91.3	17.8	44.4	0.000***
Access to CSA information via radio		29.6	17.2	48.9	18.8	11.1	0.000***
Knowledge on technologies		36.3	44.8	83.7	35.5	22.2	0.000***
Model women farmers in your locality?		3.1	0	1.1	0	0	0.253
Access to Information on the risks and Profitability CSA technologies?		4.9	10.3	55.4	2.8	0	0.000***
Access to information about CSA from farmers in your social networks		36.8	6.2	34.3	21.9	0.8	0.000***

Women Users in Male-Headed Households (WUMHHs) = 223. Women Users in Female-Headed Households (WUFHHs) = 29. Men Users (MUs) = 92. Women Non-Users in Male-Headed Households (WNUMHHs) = 107. Women Non-Users in Female-Headed Households (WNUFHHs) = 9. N = 460. Responses = Numbers refer to the percentage of "Yes" responses. Test statistics are X^2 (Chi-square test). P-values indicate significant associations between variables and individual farmers in the group: Significant at $^{***}P < 0.001$, $^{**}P < 0.01$, $^{*}P < 0.05$.

decision-making on how to use these technologies differ due to gendered constraints. The major aim of this study was therefore to expose these gendered constraints that affect women's uptake of CSA technologies.

The extent to which gendered constraints affect women users in male and female-headed households are compared to three other farmer groups: (i) men users; (ii) women non-users in male-headed households and (iii) women non-users in female-headed households. This was done to show how far women users in male and female-headed households are constrained compared to men users and non-user groups using descriptive and chi-square analysis, which are also prerequisite statistics to the later regression model. Only women and men users were incorporated into the logistic regression model.

Results

Socio-demographic background

The descriptive analysis shows that the majority of women survey respondents were in monogamous marriages (77.1 % for women users, and 74.8 % for women non-users) –Interview results demonstrate that first wives in polygamous marriages have better access to rural institutional services and access to agricultural inputs compared to women in monogamous marriages. This is because husbands often live with younger wives on a separate plot, so first wives are considered as household heads since they farm small plots of land allocated by the husband. Conversely, the presence of men as household heads means that women are not considered as legitimate receivers of rural institutional services. Interview results also show that despite fewer resources, first wives possess better user rights on their small plots compared to women in monogamous marriages.

Most women users of CA and SSIS from male-headed (76.2%) and female-headed households (31%) (those included in the model) were between 19 and 40 years of age – that is the majority were at their productive age. The majority of men CSA users, (46.6%) were between 41-73 years of age (Table 1). Age is negative in the logistic model exp (-0.51) = 0.59 OR (Table 2). It means that the older the individual is, the lesser constrained they are by other gendered constraints in the model. Hence, men's chance of being constrained by gendered constraints is decreased by 41 % compared to women. Most women users of CA and SSIS from male-headed (82.5%) and female-headed households (96.4%) never attended school. The majority of men CSA users, (58.7 %) attended elementary and above (Table 1). Education status indicates negative result in the logistic model exp (- 2.54) = 0.07 OR (Table 2). The interpretation demonstrates that men who have attended elementary and above have 93% decreased chance of being constrained by gendered constraints compared to women users in the model. Interview findings indicate that a lower education status constrains women's use of herbicides and pesticides as this demands reading skills.

Table 2
Prediction of gendered constraints with greater effects on women users based on self-reported responses.

Variables in the equation	β	St. Error	P-value	Adjusted OR (95% Confidence Interval)
Age	−0.51	0.47	0.277	0.59 (0.23 – 1.51)
Education status	−2.54	0.53	0.000	0.07 (0.02 – 0.22)
Access to land	2.37*	1.15	0.042	10.35 (1.08 – 98.94)
Off-farm income	−0.69	0.61	0.263	0.50 (0.14 – 1.68)
Access to credit	1.99***	0.54	0.000	7.33 (2.52 – 21.25)
Access to collateral	−0.31	0.52	0.558	0.73 (0.26 – 2.06)
Access to extension	2.67***	0.49	0.000	14.55 (5.54 – 38.19)
Membership in cooperatives and WUAs	1.41**	0.52	0.007	4.11 (1.48 – 11.42)
DAs identify your needs	0.96	0.62	0.121	2.62 (0.77 – 8.90)
Access to crop residue	−1.43	0.66	0.032	0.23 (0.06 – 0.88)

Model: Chi-Square is (8) of 6.72, p-value 0.567 (p >.05), Model fit = Classification table overall percentage = 91.6. – 2 Log likelihood = 219.24. Pseudo R-Square = 0.75. Women Users = 252. Men Users = 92. N= 344.
Significant at ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$.

Gendered constraints related to agricultural resources and inputs

Men CA and SSIS users, and women users in female-headed households have better access or user rights to agricultural land than women users and non-users in male-headed households (Tables 1 and 2). The regression result shows that men have higher odds in accessing agricultural land compared to women, OR =10.35, 95% CI (1.08 - 98.94) (Table 2). In-depth interviews in all study areas revealed that customary laws dictate that land must be transferred from the man's kin. The findings from FGD among gravity-based SSIS users and in-depth interviews with women in the same study context demonstrate that land ownership is different when it comes to widows. If a woman does not have any child from the deceased husband, and if the brother of the deceased is not interested in marrying her, she must leave the land. Most of the women and men are not involved in off-farm income-generating activities (Tables 1 and 2). In-depth interviews with women CA users indicated that they engage in intermittent petty trading during market days (often twice a week). They buy and sell butter, wheat flour, and small quantities of "women's coffee" (coffee residue that women collect from a coffee tree after men have collected the quality coffee). A small amount of profit from this petty trading helps them to buy sugar, salt, oil, and gas for household consumption, but it is often not enough to buy agricultural inputs.

Access to collateral, which is a precondition to access credit, is lower among women users in male-headed households (Table 2). Access to credit is one of the difficulties faced by women users and non-users – regression result shows that men users have greater odds in accessing credit compared to women OR = 7.33, 95 % CI (2.52 – 21.25) (Table 2). FGDs indicated that male-dominated institutions believe that women will fail to pay back loans unless they apply together with their husbands. Recurrent droughts further prevent both men and women smallholders from accessing credit, as they may not be able to pay back the loan in the case of production failure. Excessive interest rate is another constraint that affects farmers' access to credit, which was particularly indicated by FGD discussants among pump-based SSIS users. The lack of access to credit and high prices of herbicides reduce the applicability of ZT; this increases weed infestation, which in turn increases labor demands on women, as weeding is often their productive role (this was indicated by women during in-depth interviews).

DAs indicated that the expense of agricultural inputs forces many farmers to stop practicing CA. Women CA users in female-headed households stated that their farm income is not sufficient even to pay back the fertilizer loans they receive from *Kebeles*. They reported that expensive inputs sometimes even force them to rent out land to a person who can work on the land using his inputs, taking half the crops after harvest. Both gravity and pump-based SSIS users commented that costly inputs and declining vegetable prices are significant constraints common to all: "Tomato demands three times more pesticide application than onion." A pump-based SSIS user said, "It requires money to buy poles, which is necessary to support the plants. This needs 5000 Ethiopian birr for only 0.25 hectares." Women FGD participants among pump-based SSIS users indicated that improved varieties of onion seed are costly. They sometimes plant only cabbage, as this crop type is accessible – this is particularly common among women in female-headed households.

Recurrent droughts reduce water availability in irrigated areas – and limited control over available water is a problem mainly for women in female-headed households. Control over irrigation water is the same for both men and women users in male-headed households (Table 1). Nevertheless, in-depth interviews with women users indicated that men and WUA committee members have better control over irrigation water compared to women. FGDs with both gravity and pump-based SSIS users revealed that the water levels of the river and the lake decrease whenever rainfall decreases. As a result, competition among farmers for water is a common phenomenon during dry seasons. FGD participants spoke of the general decline of water levels in the Bilate River and Lake Ziway, since the capacity is determined by the amount of rainfall. Women indicated increased workloads caused by drought – they are involved in deepening canals for water passage during dry seasons and clearing canals of sediment during rainy seasons. Interviews with women in female-headed households highlighted complaints that they have lost vegetables in many seasons owing to lack of access to water. These women users do not fully access water as power relations between users negatively affect them more so than other groups. A gravity-based SSIS woman user in a female-headed household reflected on the degree to which she is affected by water competition as follows:

> "I have 25 hectares within the scheme. However, water competition in the dry season forced me to give away my land to another person. As a woman, nobody listens to me. The man who is sharing the production assists me in providing water to my field."

Large irrigation pumps are group owned, and water committee members are given priority to access irrigation water. Women's use of rights to large pumps is not even considered to be an issue since they are expected to be represented by their husbands. Men are traditionally perceived as sole owners of individually owned small pumps within households.

Limited access to crop residues (an essential input for mulching in CA) is a hindrance for all groups (Tables 1 and 2). The results of FGDs and individual interviews indicate that crop residues are often used for cattle feed and as a source of heat for cooking. Using straw as mulch increases women's workload, as they then have to look for other sources to make fire. Interview results show that those who do not have two oxen are obliged to rent another ox and those who do not have any oxen are often forced to rent out their irrigated land to a person who demands half of the final harvested produce. The lack of oxen for plowing in SSIS is a common challenge. Interviewees mentioned that men are commonly considered as owners of oxen, and this limits women's decision-making ability in using oxen on SSIS farms.

Some CA users indicated that since 2005, CA projects have provided them with inputs such as bean varieties and herbicides. Farmers use the inputs provided, which seems to have contributed to averting risk. However, problems arise regarding access to inputs after the completion of projects. DAs indicated during interviews that many farmers drop out of CA (particularly after project interventions cease) for fear of crop failure due to drought after they have invested in inputs. A woman CA user reflected on how drought affects the success of CA as follows: "The drought of this year reduced the yield in CA plots. Last year we were able to harvest 15 quintals from 0.5 hectares, while this year we got only 9 quintals." CA adopters indicated, however, that their user status helped them to produce a small amount of maize and haricot beans, whereas non-users did not harvest at all and were forced to sell cattle to support family food demands. It means that CA at least helped farmers to produce for subsistence within the context of a changing climate.

Gendered institutional, knowledge- and information-related constraints

Membership in cooperatives and WUAs was low among women in male-headed households, compared to men users (Table 2). The logistic regression result indicates that men have higher odds regarding membership in cooperatives and WUAs compared to women OR = 4.11, 95 % CI (1.48 – 11.42) (Table 2). Women indicated during interviews that secured land rights and household headship are preconditions for membership in cooperatives, and for individuals to be members of WUAs it is necessary to be registered as owners of land within the irrigated area. Most women in the study areas were members of *Idir* (petty associations that often engage women in assisting people during mourning). Among pump-based irrigation users, only a considerable number of women in male-headed households' were members in a cooperative. In-depth interviews further revealed that this has occurred because of the policy that no farmer is allowed to own more than 0.5 hectares of irrigated land within the irrigation scheme. As a result, where there are more than 0.5 hectares, a few women in male-headed households get the chance to be registered as owners and become members in their name. FGD findings further demonstrate that gender norms in both irrigated areas restrict women from being committee members in WUAs.

Women users (20.2 %) and non-users (6.5%) in male-headed households have limited access to extension services compared to men (83.7%) (Table 1). Regression results of the relative comparison of men and women users show that men have better odds in accessing extension services compared to women OR = 14.55, 95 % CI (5.54 – 38.19) (Table 2). A DA who was interviewed reflected on who is eligible to access extension services as follows: "I am not required to give extension services to everyone in the house; I am only obliged to provide service to the taxpayer of the land who is usually a man." Women who were interviewed indicated that they sometimes acquire extension information when they overhear conversations between their husbands and the DAs. A woman stated that she cannot participate in these kinds of sessions if the DA arrives before 3 o'clock in the morning owing to household chores. She also said, "DAs neither consider me nor call me to the field." First wives have relatively better access to extension and other institutional services as they live on a separate plot and are considered as household heads. FGDs demonstrated that cultural norms restrain women from communicating with men in the absence of their husbands, which also restricts women from accessing extension services and information. Access to extension services from women DAs is rarely available (Table 1). There are usually three DAs in each *Kebele*, but across the *Kebeles* (eight in Locabaya, five in Halaba and five in Ziway) in this study, there were only two women DAs. Interview results show that cultural prohibition prevents women from plowing. Only a few women in female-headed households are involved in plowing on SSIS farms.

Women users and non-users in male-headed households hardly travel for skills training sessions. The in-depth interviews revealed that very few women pump-based SSIS users access training provided by local non-governmental organizations. In FGDs, men users of gravity-based SSIS stated that over 11 years they have participated in a minimum of six training sessions that required travel. Those who access training that requires traveling include first wives in polygamous marriages (living on separate plots), women in female-headed households, women who have at least grade six education, and male committee members. Apart from a few women in female-headed households, women CA users do not apply herbicides and pesticides among SSIS users due to a lack of knowledge on how to implement these inputs. The lack of knowledge to determine the amount and the skills to apply these inputs are major problems. It has been identified that women have restricted access to information on the risk and profitability of agricultural technologies (Table 1). A woman user of gravity-based SSIS said that she wants to grow carrots instead of potato, as carrots are perceived to yield higher profits. A woman CA user said, "Producing *khat* [herbal stimulant] is very rewarding as it gives three harvests per year. Once planted one can collect without putting too much labor in it." Both men and women CA users are more inclined to produce *khat* than cereals.

Identifying farmers as model farmers may encourage them to adopt agricultural technologies. A difference has not been, however, indicated in the regression results regarding whether women or men observed women model farmers in their vicinity that confirms women are not often identified as model farmers. The FGDs confirmed a similar finding. A wife of a model farmer stated, "Even though we worked together, my husband was recognized as the model farmer." Women in male-headed households, in particular, have restricted mobility, which inhibits their access to information (Table 1). Men have better mobility and knowledge of CSA compared to women (Table 1). The in-depth interviews demonstrated that women in all study areas have limited leisure time and are often not considered as owners of the radio within the household. Most women users and non-users do not have direct contact with input suppliers from *Woredas* and *Kebeles* as husbands are considered as the right input collectors and this constrains women users' ability to identify their input needs.

Discussion

The investigation demonstrates what has been conceptualized in the contested agronomy framework, namely that agronomic development schemes often claim "participation of the poor" without actually addressing inequalities within the process and among scheme users [57]. This study shows that different marriage systems affect women's access to agricultural inputs and rural institutional services. Women in monogamous marriage possess limited access and decision-making rights over agricultural inputs and land as they work under the supervision of their husband, who is acknowledged as the household head. First wives in polygamous marriages have better access and use rights over land and other agricultural inputs, as they often live separately on a small plot of land assigned by the husband, and are considered as household heads. This and another study demonstrated that limited access to education affects women's uptake of agricultural technologies as the proper application of herbicides and pesticides demand writing and reading skills [64]. Although it is a household head analysis, Teklewold et al. [59] also confirm that education status determines the adoption level of sustainable agricultural practices in rural Ethiopia.

Women smallholders' user rights or access to agricultural land is low compared to that of men. This is in line with earlier research that identified intra-household inequality in accessing or using agricultural land in Ethiopia [21,63]_ENREF_17. Gender inequality restricts women's decision-making ability on how to use land for CA and SSIS in this study. In-depth interview findings with DAs and women smallholders in this study demonstrate that input expensiveness or lack of access to external inputs is a common constraint for both men and women that force them to drop out CA practices in the context of CA user study area. Giller et al. [28], similarly state that limited access to external inputs is constraining the success of CA. This is also a confirmation to what has been stated in Knowler and Bradshaw [36], that success in CA differs from context to context and is determined by the particular condition of the locales and individual farmers.

Off-farm income does not contribute to CA and SSIS uptake among men and women smallholders, as the expansion of off-farm activities is restricted. Access to collateral, which is required for accessing credit, is limited for both men and women users but is more inaccessible for women in male-headed households, as women are culturally prohibited from inheriting land and are not customarily accepted as landowners. Although land is currently controlled by the state in Ethiopia, men can at least, use land as collateral in accessing a fixed amount of agricultural inputs as credit from rural institutions. However, smallholders, in general, cannot use land as collateral in its real sense; for instance, they cannot use it to access credit from financial institutions or individuals. They only access a small and predetermined amount of credit from public microfinance rural institutions. It means that farmers cannot access the amount of credit they need for the proper use of CSA and a viable increase in production. Farmers' inability to use land as collateral and absence of off-farm diversification in study areas are linked to the state-controlled land tenure system. This situation further limits women smallholders' opportunities to be involved in off-farm activities and employment opportunities, vital to buying agricultural inputs for the proper use of CSA technologies.

Women SSIS users in female-headed households encounter problems during dry seasons in accessing water due to water competition and unequal power relations between users. Together with expensive inputs, this often forces them to rent out land to another person who can provide the necessary resources. Women in male-headed households are not accepted as owners of pumps, thus this study found that irrigated water is more accessible by men household heads, committee members, and those managing the maintenance of canals. These findings show that the use of irrigation may cause negative impacts on women and the poor if the equality impacts are not investigated and adequately addressed. Neglecting the equality impacts of irrigation schemes further contests the success of SSIS which is indicated in the contested agronomy framework [42,57].

Limited access to crop residues is a common constraint indicated as a barrier to adopting CA among African smallholders [28]. This study found the same, as farmers use crop residue for animal feed and a source of energy. Further, the use of crop residues as mulch increases the work burden on women, as they are responsible for collecting other sources of fuel, such as firewood. A study based on a review of literature and field experiences in Zambia and Mexico similarly indicates that CA increases women's workload as they have to look for alternative sources of energy [11]. Regarding ZT in particular, the lack of herbicides increases weed infestation and thus the labor demand on women, since they are responsible for weeding and have to do weeding manually. This problem is also specified in the contested agronomy framework [4,59].

Women's restricted membership in cooperatives constrains their ability to engage in CA and to use improved seed varieties in SSIS. Planel [46] states that cooperatives facilitate access to markets and seed varieties, as identified by local needs in Ethiopia. However, prerequisites for becoming a member of cooperatives and WUA include secured land rights and household headship, a finding similar to those in a review of studies in sub-Saharan Africa by Quisumbing and Pandolfelli [47]. This study found that in both irrigated areas, there are no women committee members in WUAs. Quisumbing and Pandolfelli [47], similarly show that gender norms prohibit women's membership in WUAs.

Women in male-headed households have limited access to extension services. Customary law accepts that men are the main "owners" of land. This indirectly limits women's access to extension services as DAs anticipate providing extension services and information to the "owner" of the land. The finding that DAs provide agricultural extension only to men household heads is in line with the study by Buchy and Basaznew [14]. The same authors also found that cultural factors restrict men DAs from delivering extension services to women which is also confirmed in this study. Men household heads with better education status have more access to skills training on the use of technologies, compared to women. This study found similar results with other studies that women smallholders have limited access to extension, credit and skills training, all of which constrain their uptake of agricultural technologies [16,48].

Model or "lead" farmers in Ethiopia are those who are active in local politics and as a result, they enjoy relatively better support from local rural institutions [37]. However, in an empowerment assessment study, Alsop and Heinsohn [3] found that it is less likely for rural Ethiopian women to be active in public life and politics. This study found that the number of women model farmers was restricted in the study areas. This trend demonstrates how the mainstream rural institutional structure works based on the patriarchal norm that assigns men as proper farmers [9,16,39]. Women are affected by knowledge related gendered constraints that can limit their uptake of CSA technologies. A study conducted by Aregu et al. [5] in ten *Woredas* in four regions in Ethiopia, similarly indicates that lack of knowledge and information is one of the gendered constraints in adopting agricultural technologies.

Conclusions and policy implications

In this empirical study, the gendered constraints that have a greater effect on women smallholders' uptake of CSA have been investigated. Lack of access to credit, extension services, land, skills training, information on CSA, limited membership in cooperatives and WUAs and limited mobility were identified as significant gendered constraints with a greater effect on women smallholders' use of CSA (CA and SSIS) compared to men users. This study recommends that the agricultural extension system needs to be redesigned to better serve the needs of women smallholders. Facilitating women-only credit schemes and linking the service to their use of agricultural technologies is another important recommendation. Rural cooperatives and WUAs should not consider women as being "represented" by their husbands. Cooperatives should directly involve women in male-headed households as input buyers so that they can identify their input needs.

Limited access to land has a negative impact on women farmers' uptake of CSA technologies, as customary laws deny them user rights and inheritance of farmland. Although legal documents allow women to access or use agricultural land, they do not enjoy recognition in practice. Changing customary laws would require the engagement of rural, regional and national organizations. Stakeholders such as rural institutions and NGOs should advocate and take measures to change the inequality embedded in the norms of the society and accept and take into consideration that joint farm administration does not necessarily imply equal use rights within the household. Agricultural development should be viewed and implemented from the point of view of individual farmer's entitlement or rights to development by rural institutions and agricultural interventions. Such a framework could serve as a guideline to improving women's land use rights, access to credit and extension, membership in cooperatives and WUAs, access to skills training and information related to the use of agricultural technologies. Changing state-owned land tenure laws could be a key instrument in improving off-farm diversification and employment opportunities that are useful and could provide women with the opportunity of access to agricultural inputs. Linking the use of agricultural technologies with urban investments and making women beneficiaries in the process could provide women with the opportunity to develop assets required to access agricultural inputs. Gender inequalities among farmers should be identified and addressed by responsible rural agricultural institutions and those managing irrigation schemes and CA interventions. The important message from this study for development interventions and institutions working on agronomic development (those promoting CA and SSIS, or other CSA technologies) is, success in the use of agricultural technologies for improved food security and livelihoods in developing economies depends not only on agronomic performance but also on eliminating the gendered constraints of the use of agricultural technologies.

Funding

This work was funded by the Norwegian Program for Capacity Development in Higher Education and Research for Development (NORHED), specifically, the Research and Capacity Building in Climate-Smart Agriculture in the Horn of Africa (CSA-NORHED) project between NMBU (Norwegian University of Life Sciences) and Hawassa University (Ethiopia).

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

References

[1] D. Abebaw, M.G. Haile, The impact of cooperatives on agricultural technology adoption: empirical evidence from Ethiopia, Food Policy 38 (2013) 82–91.
[2] A. Agresti, An Introduction to Categorical Data Analysis, Wiley, New Jersey, 2007.
[3] R. Alsop, N. Heinsohn, Measuring Empowerment in Practice: Structuring Analysis and Framing Indicators, World Bank Policy Reasearch Working Paper, Washington, 2005 (3510).
[4] J. Andersson, K. Giller, On heretics and God's blanket salesmen: contested claims for Conservation Agriculture and the politics of its promotion in African smallholder farming, in: J. Sumberg, J. Thompson (Eds.), Contested Agronomy, Routledge, London, 2012, pp. 34–58.
[5] L. Aregu, C. Bishop-Sambrook, R. Puskur, E. Tesema, (2010). *Opportunities for Promoting Gender Equality in Rural Ethiopia Through the Commercialization of Agriculture*. (Working Paper 18). Nairobi.
[6] S. Asfaw, G. Branca, Introduction and overview, in: L. Lipper, N. McCarthy, D. Zilberman, S. Asfaw, G. Branca (Eds.), Climate Smart Agriculture: Building Resilience to Climate Change, 52, Springer, Switzerland, 2018, pp. 3–12.
[7] J.B. Aune, M.T. Bussa, F.G. Asfaw, A.A. Ayele, The ox ploughing system in Ethiopia: can it be sustained, Outlook Agric. 30 (4) (2001) 275–280.
[8] F. Baudron, M. Corbeels, F. Monicat, K.E. Giller, Cotton expansion and biodiversity loss in African savannahs, opportunities and challenges for conservation agriculture: a review paper based on two case studies, Biodiver. Conserv. 18 (10) (2009) 2625–2644.
[9] C. Becher, Engendering agriculture and natural resource managment in ethiopia: negotiations of the gender order and public spaces, in: S. Uhlig (Ed.), Proceedings of the XVth International Conference of Ethiopian Studies, Hamburg, 65, Otto Harrassowitz, Wiesbaden, 2006, pp. 15–23. July 20–25, 2003.
[10] J.A. Behrman, R. Meinzen-Dick, A.R. Quisumbing, Understanding gender and culture in agriculture: the role of qualitative and quantitative approaches, in: Q. Agnes R, M.-D. Ruth, L.R. Terri, C. Andre, B. Julia A, P. Amber (Eds.), Gender in Agriculture: Closing the Knoweldge gap, Springer, New York, 2014, pp. 31–53.
[11] T. Beuchelt, L. Badstue, Gender, nutrition-and climate-smart food production: opportunities and trade-offs, Food Secur. 5 (5) (2013) 709–721.
[12] H. Bjornlund, A. van Rooyen, R. Stirzaker, Profitability and productivity barriers and opportunities in small-scale irrigation schemes, Int. J. Water Resour. Development 33 (5) (2017) 690–704.
[13] R.E. Boyatzis, Transforming Qualitative Information: Thematic Analysis and Code Development, sage, Thousand Oaks, 1998.
[14] M. Buchy, F. Basaznew, Gender–blind organizations deliver gender–biased services the case of Awasa bureau of agriculture in southern Ethiopia, Gender, Technology and Development 9 (2) (2005) 235–251.
[15] L. Christiaensen, L. Demery, J. Kuhl, The (evolving) role of agriculture in poverty reduction—An empirical perspective, J. Dev. Econ. 96 (2) (2011) 239–254.
[16] M.J. Cohen, M. Lemma, in: Agricultural Extension Services and Gender Equality, International Food Policy Research Institute, Addis Ababa, 2011, p. 1094. Discussion paper.
[17] G. Degu, D. Markos, A. Bekele, M. Kassie, Community survey and on-farm trials for conservation agriculture to enhance adoption and its impact, SNNPR, Ethiopia, Int. J. Sci. Eng. Res. 4 (8) (2013) 1225–1235.
[18] C. Doss, Designing agricultural technology for African women farmers: lessons from 25 years of experience, World Dev. 29 (12) (2001) 2075–2092.
[19] Doss, C., Mwangi, W., Verkuijl, H., & de Groote, H. (2003). Adoption of Maize and Wheat Technologies in Eastern Africa: a synthesis of the findings from 22 Case studies. CIMMYT Economics Working Paper, 03-06.
[20] M. Fafchamps, A. Quisumbing, Control and ownership of assets within rural Ethiopian households, J. Dev. Stud. 38 (6) (2002) 47–82.
[21] M. Fafchamps, A.R. Quisumbing, Assets at marriage in rural Ethiopia, J. Dev. Econ. 77 (1) (2005) 1–25.
[22] FAO. (2015). *What is Conservation Agriculture*Retrieved from http://www.fao.org/ag/ca/1a.html 07-02-2017
[23] FAO. (2016). *Eastern Africa Climate Smart Agriculture Scoping Study: Ethiopia, Kenya and Uganda*. Addis Ababa: Ethiopia.
[24] FAO. (2017). *Climate-Smart-Agriculture*Retrieved from http://www.fao.org/climate-smart-agriculture/en/ 11-05-2017
[25] D. Fletschner, L. Kenney, Rural women's access to financial services: credit, savings, and insurance, in: Q. Agnes R, M.-D. Ruth, L.R. Terri, C. Andre, B. Julia A, P. Amber (Eds.), Gender in Agriculture, Springer, New York London, 2014, pp. 187–208.
[26] K.E. Giller, J.A. Andersson, M. Corbeels, J. Kirkegaard, D. Mortensen, O. Erenstein, B. Vanlauwe, Beyond conservation agriculture, Front. Plant Sci. 6 (2015) 870.
[27] K.E. Giller, M. Corbeels, J. Nyamangara, B. Triomphe, F. Affholder, E. Scopel, P. Tittonell, A research agenda to explore the role of conservation agriculture in African smallholder farming systems, Field Crops Res. 124 (3) (2011) 468–472.
[28] K.E. Giller, E. Witter, M. Corbeels, P. Tittonell, Conservation agriculture and smallholder farming in Africa: the heretics' view, Field Crops Res. 114 (1) (2009) 23–34.
[29] D.N. Gujarati, Basic Econometrics, McGraw-Hill, New York, 2003.
[30] M.A. Hanjra, T. Ferede, D.G. Gutta, Reducing poverty in sub-Saharan Africa through investments in water and other priorities, Agric. Water Manag. 96 (7) (2009) 1062–1070.
[31] S. Harding, Whose Science? Whose Knowledge?: Thinking from Women's Lives, Cornell University Press, New York, 1991.
[32] F. Harrell, Regression Modeling Strategies: With Applications to Linear Models, Logistic and Ordinal Regression, and Survival Analysis, Second Edition, Springer, New York, 2001.
[33] D.W. Hosmer, S. Lemeshow, Applied Logistic Regression, John Wiley & Sons, New York, 2000.
[34] I. Hussain, M.A. Hanjra, Irrigation and poverty alleviation: review of the empirical evidence, Irrigation Drainage 53 (1) (2004) 1–15.
[35] A. Kassam, T. Friedrich, F. Shaxson, J. Pretty, The spread of conservation agriculture: justification, sustainability and uptake, Int. J. Agric. Sustain. 7 (4) (2009) 292–320.
[36] D. Knowler, B. Bradshaw, Farmers' adoption of conservation agriculture: a review and synthesis of recent research, Food Policy 32 (1) (2007) 25–48.
[37] R. Lefort, Free market economy,'developmental state'and party-state hegemony in Ethiopia: the case of the 'model farmers', J. Modern Afr. Stud. 50 (04) (2012) 681–706.
[38] L. Lipper, P. Thornton, B.M. Campbell, T. Baedeker, A. Braimoh, M. Bwalya, …, K. Henry, Climate-smart agriculture for food security, Nat. Clim. Change 4 (12) (2014) 1068.
[39] J.C. McCann, People of the Plow: An Agricultural History of Ethiopia, 1800–1990, Univ of Wisconsin Press, 1995.
[40] R. Meinzen-Dick, Nancy Johnson, Agnes R. Quisumbing, Jemimah Njuki, Julia A. Behrman, Deborah Rubin, …, E. Waithanji, The gender asset gap and its implications for agricultural and rural development, in: Q. Agnes R, M.-D. Ruth, L.R. Terri, C. Andre, B. Julia A, P. Amber (Eds.), Gender in Agriculture, Springer, New York London, 2014, pp. 91–115.
[41] C. Mwongera, K.M. Shikuku, J. Twyman, P. Läderach, E. Ampaire, P. Van Asten, …, L.A. Winowiecki, Climate smart agriculture rapid appraisal (CSA-RA): a tool for prioritizing context-specific climate smart agriculture technologies, Agric. Syst. 151 (2017) 192–203.
[42] R.E. Namara, M.A. Hanjra, G.E. Castillo, H.M. Ravnborg, L. Smith, B. Van Koppen, Agricultural water management and poverty linkages, Agric. Water Manage. 97 (4) (2010) 520–527.
[43] P.H. Nyanga, Food security, conservation agriculture and pulses: evidence from smallholder farmers in Zambia, J. Food Res. 1 (2) (2012) 120.
[44] C.-Y.J. Peng, K.L. Lee, G.M. Ingersoll, An introduction to logistic regression analysis and reporting, J. Educ. Res. 96 (1) (2002) 3–14.

[45] A. Peterman, J.A. Behrman, A.R. Quisumbing, A review of empirical evidence on gender differences in nonland agricultural inputs, technology, and services in developing countries, in: Q. Agnes R, M.-D. Ruth, L.R. Terri, C. Andre, B. Julia A, P. Amber (Eds.), Gender in Agriculture: Closing the Knoweldge Gap, Springer, New York London, 2014, pp. 145–186.
[46] S. Planel, A view of a bureaucratic developmental state: local governance and agricultural extension in rural Ethiopia, J. East. Afr. Stud. 8 (3) (2014) 420–437.
[47] A.R. Quisumbing, L. Pandolfelli, Promising approaches to address the needs of poor female farmers: Resources, constraints, and interventions, World Dev. 38 (4) (2010) 581–592.
[48] C. Ragasa, G. Berhane, F. Tadesse, A.S. Taffesse, Gender differences in access to extension services and agricultural productivity, J. Agric. Educ. Extension 19 (5) (2013) 437–468.
[49] C. Ramazanoglu, J. Holland, Feminist Methodology: Challenges and Choices, Sage, London, 2002.
[50] E. Rathgeber, Dry Taps… Gender and Poverty in Water Resource Management, FAO, Rome, 2003 [Techinical Seminar on Gender and Water]. Field crops research.
[51] J.C. Ribot, N.L. Peluso, A theory of access, Rural Soc. 68 (2) (2003) 153–181.
[52] C.K. Riessman, Narrative Analysis, 30, Sage, London, 1993.
[53] J. Schmidhuber, F.N. Tubiello, Global food security under climate change, Proc. Natl. Acad. Sci. 104 (50) (2007) 19703–19708.
[54] H. Seebens, J. Sauer, Bargaining power and efficiency—rural households in Ethiopia, J. Int. Dev. 19 (7) (2007) 895–918.
[55] J. Sumberg, Constraints to the adoption of agricultural innovations: is it time for a re-think, Outlook Agric. 34 (1) (2005) 7–10.
[56] J. Sumberg, J. Thompson, P. Woodhouse, Contested agronomy: agricultural research in a changing world, in: J. Sumberg, J. Thompson (Eds.), Contested Agronomy, Routledge, London, 2012, pp. 13–33.
[57] J. Sumberg, J. Thompson, P. Woodhouse, Why agronomy in the developing world has become contentious, Agric. Hum. Values 30 (1) (2013) 71–83.
[58] C. Teddlie, A. Tashakkori, Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioral Sciences, Sage, Thousand Oaks, 2009.
[59] H. Teklewold, M. Kassie, B. Shiferaw, Adoption of multiple sustainable agricultural practices in rural Ethiopia, J. Agric. Econ. 64 (3) (2013) 597–623.
[60] M. Temesgen, J. Rockstrom, H. Savenije, W. Hoogmoed, D. Alemu, Determinants of tillage frequency among smallholder farmers in two semi-arid areas in Ethiopia, Phys. Chem. Earth Parts A/B/C 33 (1) (2008) 183–191.
[61] C. Thierfelder, P. Chivenge, W. Mupangwa, T.S. Rosenstock, C. Lamanna, J.X. Eyre, How climate-smart is conservation agriculture (CA)?–its potential to deliver on adaptation, mitigation and productivity on smallholder farms in southern Africa, Food Secur. 9 (3) (2017) 537–560.
[62] C. Thierfelder, P.C. Wall, Rotation in conservation agriculture systems of Zambia: effects on soil quality and water relations, Exp. Agric. 46 (3) (2010) 309–325.
[63] M. Tsige, Who benefits from production outcomes? Gendered production relations among climate-smart agriculture technology users in rural Ethiopia, Rural Soc. (2019) https://doi.org/, doi:10.1111/ruso.12263.
[64] Tsige, M., Synnevåg, G., & Aune, J.B. (2019). Is gender mainstreaming viable? Empirical Analysis of the practicality of policies for agriculture-based gendered development in Ethiopia. Gender Issues, 1–28. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Events/DakAgri2015/Climate_Smart_Agriculture_in_the_African_Context.pdf.
[65] P.C. Wall, Tailoring conservation agriculture to the needs of small farmers in developing countries: an analysis of issues, J. Crop Improv. 19 (1-2) (2007) 137–155.
[66] T. Wheeler, J. Von Braun, Climate change impacts on global food security, Science 341 (6145) (2013) 508–513.
[67] Williams, T.O., Mul, M.L., Cofie, O.O., Kinyangi, J., Zougmoré, R.B., Wamukoya, G., … Amwata, D. (2015). *Climate Smart Agriculture in the African Context: An Action Plan for African Agricultural Transformation*Paper presented at the Feeding Africa, Dakar. https://hdl.handle.net/10568/68944.

Meseret Tsige Abebe is a Ph.D. candidate in the Department of International Environment and Development Studies (Noragric), the Norwegian University of Life Sciences. Her research emphasis is the sociology of rural development in general and investigating the links between gender, agriculture, rural livelihoods and policies in particular. meseret.abebe@nmbu.no or meseretfiker@yahoo.com

Gry Synnevåg is an Associate Professor in Agricultural Development at the Department of International Environment and Development Studies (Noragric), Norwegian University of Life Sciences gry.synnevag@nmbu.no

Jens B. Aune is a Professor in Agricultural Development at the Department of International Environment and Development Studies (Noragric), Norwegian University of Life Sciences jens.aune@nmbu.no