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# Article

# Performance of women-managed plots compared to men-managed plots among smallholder maize farmers in western and central Ethiopia

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#### **RESEARCH ARTICLE**

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# Performance of women-managed plots compared to men-managed plots among smallholder maize farmers in western and central Ethiopia

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#### ABSTRACT

A more targeted approach towards improving women's access to agricultural innovations is key to increase the overall agricultural productivity. This paper uses gender-disaggregated household and plot-level survey data from Ethiopia to explore the impacts of multiple agronomic practices disaggregated by the sex of the plot manager. Using a multinomial endogenous switching regression methodology, after controlling for endogeneity arising from observed and unobserved heterogeneity, we found that multiple agronomic practices have a positive and significant effect on maize yields and maize income. Crucially, subject to demographics, plot quality and agronomic practices (among others), we found that women-managed plots (WMP) had treatment effects (yields) that were statistically the same as those of menmanaged plots (MMP) (and nominally higher in a number of cases).

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Technology adoption; gender, heterogeneity; endoaenous switchina regression; welfare; Ethiopia

#### 1. Introduction

In agrarian circumstances, gender inequalities in access to services, market opportunities and resources disfavour women, undermine rural economic transformation (Food and Agriculture Organization (FAO), 2011; von Braun & Webb, 1989) and weaken development aspirations (Doss, Meinzen-Dick, Quisumbing, & Theis, 2018; Peterman, Quisumbing, Behrman, & Nkonya, 2011). Gender issues in Africa and the developing world continue to generate interest among researchers and policymakers in particular because African women play a key role in farm and non-farm intra-household resource allocation and production (Meinzen-Dick et al., 2010). Gender inequalities in agriculture are manifested in many ways. These range from lower access to land (Doss et al., 2015), to public services such as extension and, reduction in market participation as the net sellers of produce (Kassie, Jaleta, Teklewold, & Erenstein, 2015; Marenya, Kassie, Jaleta, & Rahut, 2016; Quisumbing, 1995).

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The potential of the agriculture sector is tied to the performance of smallholder men and women farmers, who make up to 81% of farmers in Ethiopia (Salami, Kamara, & Brixiova, 2010). The literature shows that, particularly in Africa, women constitute 25– 60% of the labour supplied into agriculture (Food and Agriculture Organization (FAO), 2011). The proportion of women who are landowners and farm operators are estimated at 22% in Africa and 18% in Ethiopia, respectively (Doss et al, 2015). Nevertheless, the agricultural yields and productivity of women's plots (those under their exclusive control) is often less than that of their male counterparts (Quisumbing, 1996). The share of agricultural incomes that they control is often estimated at 30.5% (Aromolaran, 2004). Where women have access to land, these are often 30–50% smaller landholdings than the average land sizes owned by male farmers (Food and Agriculture Organization (FAO), 2011).

This paper uses intra-household production data to compare the yield performance of plots under different combinations of multiple agronomic technologies (MATs) dissagregated by whether the plots are managed by female and male household members separately, as well as those managed jointly. The reason for this disaggregation is that the majority of women and, therefore, the core of gender issues are found in dual (or multiadult) households (Doss et al., 2018; Peterman, 2011) and 75% in Ethiopia. By comparing women-managed plots (WMP), men-managed plots (MMP) and jointly-managed plots (JMP), this study provides evidence that women's disadvantage in agriculture arises not so much from some perceived lack of capacity but from constrained access to agricultural inputs and services. There is some evidence, albeit not universal, that women fare relatively better in cases where they are household heads. (Quisumbing, Haddad, & Peña, (2001), in a survey of 10 developing countries, found no statistically significant higher incidence of poverty in households headed by women in two-thirds of those countries. This may arise from the greater control these women have, highlighting the fundamental issue of access and control in generating gender issues in development (Food and Agriculture Organization (FAO), 2011). A 1999 IFAD assessment of poverty in the West and Central Africa (cited in Food and Agriculture Organization (FAO), 2011) reported results from a study on 19 countries and found that the rate of poverty was lower among households headed by women as compared to those headed by men in 9 of those 19 countries.

In many developing countries, agricultural production is a complex process that involves multiple household members managing land and sharing household resources (Haider, Smale, & Theriault, 2018). Members of the household cultivate a mixture of individually and collectively managed plots. These distinctions have important policy implications. First, women's access to inputs should be an important agricultural policy goal, which can be pursued through better intra-household targeting of extension and training, input access and related programmes. Second, if social norms constrain women's access to inputs, and if these norms can be shown to hurt social development through serious empirical work, it follows that reforming such norms would advance overall agricultural productivity and development. We come back to these issues in the final sections of this study. This study is consonant with the on-going interest in the sources and consequences of agricultural productivity differences between male and female farmers (Peterman et al., 2011). As we have posited, the main drivers of lower agricultural productivity among female farmers are associated with women's limited access to agricultural innovations, technologies and markets (Peterman et al., 2011; Quisumbing, 1995; von Braun & Webb, 1989). A study by FAO, IFAD and WFP (FAO, IFAD, & WFP, 2015) revealed that if female farmers were given the same access to resources and opportunities as male ones, their productivity would be increased by about 20–30%, which would increase aggregate agricultural productivity (FAO, 2014; Juma, Tabo, Wilson, & Conway, 2013). A more targeted approach to improving women's access to agricultural innovations is, therefore, key to increase the overall agricultural productivity. It should be recalled that this refers to all the women, the majority of whom are members of households headed by men.

The contribution of this study is, therefore, at least twofold. First, we examined the differential effects of agronomic practices on maize yield and maize income based on the gender of the plot manager, as observed within each household. Despite its social and economic significance, a limited number of studies have shown the link between the gender of the plot manager and the adoption and impacts of better technologies. To our understanding, ours is the first to examine the heterogeneous effects of the gender of the plot- and household-level data, combined with the weather data extracted from the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS), allowing us to test the gender differentiated impacts of MATs on productivity under varying rainfall conditions.

The rest of this paper is organised as follows. Section 2 outlines the methods used and describes in detail the econometric approach and why it is appropriate. Section 3 presents the sampling and data sources and describes the key variables used in the analyses including the demographic and other covariates. Section 4 presents the results from the empirical model after describing the data and provides a broad discussion of the results with a focus on the relative impact of gender and rainfall heterogeneities in the econometric results. Section 5 concludes the study.

#### 2. Empirical strategy

In this study, the three pillars of MATs considered were maize-legume diversification (D), fertilizer application (F) and soil and water conservation measures (S). We defined the MATs as binary variables that take the value one if the plot manager uses the MATs or zero otherwise. The empirical strategy used in this study was derived from discrete choice models common in the agricultural technology adoption literature (Khonje, Manda, Mkandawire, Tufa, & Alene, 2018; Teklewold, Kassie, Shiferaw, & Köhlin, 2013; Teklewold, Mekonen, Köhlin, & Di Falco, 2017).<sup>1</sup> The choice of whether a plot manager adopted a particular combination was not by random assignment, as would be achieved in a controlled social experiment. Farmers themselves self-selected into different adoption categories, thereby raising econometric challenges around self-selection. When the analyst tries to determine the factors that influence technology adoption and

<sup>&</sup>lt;sup>1</sup>Considering these three MATs, it is possible to generate eight (23) combinations of packages the plot manager could potentially choose from based on what works best for her, subjected to perceived utility.

impact, the issues such as factors of influence need to be disentangled. These relate to both observable (but unmeasured) and unobservable characteristics (such as managerial skills, risk attitudes, innovativeness, motivation, entrepreneurial ability, taste preferences, etc.). The latter may be correlated with the outcome variables of interest – in our case, maize yield and maize income (Wooldridge, 2010). Unobserved biophysical confounders can also lead to heterogeneities in the returns to the adoption of agricultural technologies (Suri, 2011).

In adoption and impact evaluation, correcting for self-selection bias is critical. Without a randomisation and an identification strategy, common regression techniques will generate biased estimates of impact, perhaps exaggerating the impact if unobserved factors positively affect the outcome (Heckman, 1979) or vice versa. Self-selection bias can be corrected by the use of instrumental variables (IV), Heckman selection or propensity score matching (PSM) methods (Wooldridge, 2010). As a parsimonious alternative to IV, Heckman and matching approaches, we employed a switching regression approach by using the multinomial endogenous switching regression framework (MESR) to control for both observed and unobserved heterogeneity (Lokshin & Sajaia, 2011). In the MESR framework, the correction for selection bias was achieved by including the inverse Mills ratio (IMR), which is based on the notion of truncated normal distribution (Khonje et al., 2018;). The adoption and the consequential impact were modelled in the following two stages: first, adoption was estimated using the multinomial logit selection (MNLS) mode.<sup>2</sup> Second, the relationship between the different combinations of packages and the outcome variables of interest were estimated using an Ordinary Least Square (OLS). Additionally, IMRs were also included.

The regression model which estimates the impact of MATs on plot level yields  $(W_{ij})$  by regressing the observed outcome on  $j^{th}$  specific plot with plot, farm, household and village specific variables  $(S_{ij})$ . The Mundlak (1978) and Wooldridge (2010) strategy of using the mean values of plot-level varying characteristics ( $\bar{S}$ ) (e.g, plot soil fertility, plot manager, plot distance from home, etc.) was implemented here. The regime switching regression is specified as follows:

$$\begin{cases} Regime0: W_{i0} = S_{i0}\alpha_0 + S_{i0}\theta_0 + v_{i0}, ifj = 0 \\ ... \\ ... j = 1, 2, 3, 4 \\ ... \\ RegimeJ: W_{iJ} = S_{iJ}\alpha_J + \bar{S}_{iJ}\theta_J + v_{iJ}, ifJ = 5 \end{cases}$$
(1)

The  $v_{ij}$  constituted a composite error term that accounted for unobserved effects from the plot and household effects as well as a random error. The resulting estimates from (using OLS) may be biased in the cases where  $(\varepsilon_{ij})$  and the outcome  $(v_{ij})$  equations are correlated. To get consistent estimates of the parameters  $\alpha_j$  and  $\theta_j$ , a selection correction variable recovered from the adoption estimation step was included in the regression in the following manner

<sup>&</sup>lt;sup>2</sup>Please see online supplementary material for details of the adoption and impact models described in this section. Those supplementary materials also have more details on some of the results.

$$Regime0: W_{i0} = S_{i0}\alpha_0 + \bar{S}_{i0}\theta_0 + \hat{\lambda}_{i0}\gamma_0 + \epsilon_{i0} = 1, 2, 3, 4...j = 1, 2, 3, 4...RegimeJ: W_{iJ} = S_{iJ}\alpha_J + \bar{S}_{iJ}\theta_J + \hat{\lambda}_{iJ}\gamma_J + \epsilon_{iJ}, ifJ = 5$$
(2)

Here,  $\in_{ij}$  is an error term with a mean of 0 and  $\gamma_j$  is the coefficient of covariance between  $v_{ij}$  and  $\varepsilon_{ik}$  in each equation. Moreover,  $\hat{\lambda}_{ij}$  is the inverse mill's ratio estimated from the estimated probabilities of the MNL model. The formula for the IMR is computed as  $\lambda_{ij} = \sum_{k\neq j}^{J} \rho \left[ \frac{\hat{P}_{ik} ln(\hat{P}_{ik})}{1-\hat{P}_{ik}} + \ln(\hat{P}_{ij}) \right]$ , where  $\rho$  denotes the correlation between the equations

and  $\hat{P}$  is the estimated probability of adopting any of the MATs.

#### 2.1. Survey design and data collection

The data used in this study came from a survey of farmers in areas where a research for development project was implemented for several years. Coordinated by the International Maize and Wheat Improvement Center, in collaboration with local research partners, the project focused on testing and scaling conservation farming methods to promote sustainable intensification among smallholder farmers in multiple regions of Ethiopia.

The data were collected from a random sample of 873 households and 1624 maize plots. The sampling procedure involved a continuous random sampling approach for the evaluation of the impacts. This was a two-stage approach. The first stage was the selection of primary sampling units (PSUs). Below the districts (*woredas*), the villages (*kebeles*) were deemed to be the lowest administrative units. Within these PSUs (*kebeles*), households were randomly selected as units of analysis. The study, therefore, limited itself to PSUs that were found to be within a 25-km radius of project demonstration plots (as the region of project influence). Prior to data collection, the research protocols were reviewed by the lead authors' research ethics committee (Institutional Research Ethics Committee) – IREC. The study was deemed low risk with appropriate protections for personal identifying information. The IREC was approved under file number IREC 2018.014

The actual data collection was conducted through recall techniques for the farmers to provide responses based on a structured questionnaire. The questionnaire was administered by teams of graduate-level field enumerators (who spoke the local language). The data generated included household composition as well as demographic information related to sex, age and education. Other farm- and household-related information included land holdings, access to agricultural and market information and distance to output and input markets, among others. At the level of plots, the data included information related to the plot characteristics, inputs used on the plots, the distance of the plots from homestead. Table 1 provides summary statistics of the outcome and control variables used in the empirical model (see the following for similar variables: Kassie et al., 2018; Manda, Alene, Gardebroek, Kassie, & Tembo, 2016; Teklewold et al., 2013).

In addition to the survey data and in order to control for weather-induced impact heterogeneity, we extracted historical rainfall data from CHIRPS. The CHIRPS repository is a 30-year global rainfall dataset with 0.05° resolution satellite imagery with *in situ* station that creates gridded time series rainfall information (Michler, Baylis, Arends-Kuenning, & Mazvimavi, 2019). During the survey, the households 528 ( P. P. MARENYA ET AL.

	D1	D0	F1	FO	S1	S0		
Package Code	(ML diversification)	No ML diversification	Fertilizer	No fertilizer	SWC	No SWC	Ν	Percent
D0F0S0		$\checkmark$		√		$\checkmark$	77	4.6
D1F0S0	$\checkmark$			$\checkmark$		$\checkmark$	60	3.58
D0F1S0 <sup>3</sup>		$\checkmark$	$\checkmark$			$\checkmark$	407	24.31
D0F0S1A		$\checkmark$		$\checkmark$	$\checkmark$		21	1.25
D1F1S0	$\checkmark$		$\checkmark$			$\checkmark$	636	37.99
D1F0S1	$\checkmark$			$\checkmark$	$\checkmark$		29	1.73
D0F1S1		$\checkmark$	$\checkmark$		$\checkmark$		153	9.14
D1F1S1	$\checkmark$		$\checkmark$		$\checkmark$		291	17.38

#### Table 1. Adoption of MAT categories.

D, F and S refer to maize-legume diversification, chemical fertilisers and soil and water conservation measures. Subscript "1" denotes the adoption of the MATs, while "0" denotes non-adoption. The number of maize plots is 1624.

were geo-referenced using the global positioning system (GPS), and, therefore, each household had a GPS coordinate associated with its main location. We made use of the household GPS information from the survey to download the historical rainfall-related information from CHIRPS. The dataset provided monthly rainfall information from 2001 to 2017.

#### 2.2. Descriptive statistics

Of the 1624 maize plots enumerated, there were no MAT packages on 77 (4.6%) of them. Plot managers implemented maize-legumes diversification as the only MAT in about 3.6% of the plots. The adoption rate of maize-legume diversification is comparable with the findings of the study conducted by Kassie et al. (2018), which reported an adoption rate of 3.8% in Ethiopia. Fertilisers alone were applied in about 24.3% of the plots. The adoption rate of soil and water conservation measures alone was implemented on only 1.25% of the maize-legume plots. However, soil and water conservation (SWC) was found in 17.38% of the maize-legume plots, where it was implemented with maize-legume diversification and fertilisers. The two-package combination of maize-legume diversification with soil and water conservation measures as well as the combination of the full package was estimated at 1.73% and 9.14%, respectively.<sup>3</sup>

Table 2 below presents the descriptive statistics of demographic, rainfall and plot characteristics of the households that adopted the different combinations of MATs as well as pairwise comparison with the non-adopters. The selection of the explanatory variables included in the empirical analysis (Kassie et al., 2018; Khonje et al., 2018; Teklewold et al., 2017). The summaries suggest that the users of the MATs operate larger plots, own more livestock, and used more maize seed than the non-adopters.

<sup>&</sup>lt;sup>3</sup>Owing to low numbers of observations, we dropped the MAT categories of soil and water conservation measures (N = 21), maize-legume diversification and soil and water conservation measures (N = 29) from the analysis because including them in the analysis would make the model face difficulties in converging. However, we produced the impact estimates (Table S11 in the online appendix) by combining these two dropped categories with the others as a robustness check and to minimize self-selection bias. The results were almost similar with those obtained by dropping the two categories (see Table 5 and Table S11 in the supplementary material).

Table 2. Descriptive statistics of the variak	bles used in the mo	odel based on MAT a	adoption status.			
Variables	$D_0F_0S_0$	$D_1 F_0 S_0$	D <sub>0</sub> F <sub>1</sub> S <sub>0</sub>	D <sub>1</sub> F <sub>1</sub> S <sub>0</sub>	D <sub>0</sub> F <sub>1</sub> S <sub>1</sub>	D <sub>1</sub> F <sub>1</sub> S <sub>1</sub>
Outcome Variables						
Maize yield per ha	2280	2684**	3897***	3608***	3801***	3847***
Maize marginal returns	16,713	19,775**	26,106***	23,674***	25,678***	25,332***
Explanatory Variables						
Gender head	0.857	0.883	0.845	0.923**	0.869	0.856
Age head	44.78	45.82	44.74	43.57	44.77	43.49
Education head	3.987	3.733	3.518	4.041	3.85	4.271
Household size	6.286	6.65	6.032	6.256	6.209	6.134
Farm size	1.348	1.447	1.367	1.437	1.57	1.699**
TLU	3.403	4.632**	4.255	4.532***	5.546***	5.097**
Maize seed per ha	27.96	22.29***	24.55**	21.83***	24.23***	21.38***
Access to credit (yes $= = 1$ )	0.61	0.65	0.855***	0.635	0.752**	0.797***
Government support (yes = 1)	0.636	0.683	0.597	0.514**	0.353***	0.632
Plot Size	0.447	0.342**	0.394	0.415	0.570**	0.540*
Plot distance from home (min)	13.42	10.97	18.05	15.75	30.38***	17.29
Women managed plot (yes $= 1$ )	0.117	0.083	0.12	0.058**	0.111	0.096
Jointly managed plot	0.792	0.883	0.803	0.890**	0.621***	0.777
Men managed plot (yes = 1)	0.091	0.017*	0.076	0.052	0.268***	0.127
Good fertile soil (yes $= 1$ )	0.351	0.45	0.452	0.604***	0.464	0.375
Medium fertile soil (yes $= 1$ )	0.584	0.483	0.491	0.374***	0.497	0.601
Low fertile soil (yes $= 1$ )	0.065	0.05	0.057	0.022**	0.039	0.024*
Region (Oromia = 1)	0.805	0.650**	0.575***	0.321***	0.621***	0.488***
Region (SNNP = 1) <b>Rainfall Shock</b>	0.195	0.35	0.425***	0.679***	0.379***	0.512***
Total rainfall of the growing season	773.2	879.1***	1011***	1006***	954.7***	942.8***
Rainfall shock index	0.62	0.647	0.619	0.595	0.512***	0.552**
Instrumental Variables						
Total Rainfall 2016 (ln)	802.78	883.55***	991.94***	986.36***	925.05***	926.21***
Distance to input market	1.57	1.67	1.51	1.48	1.5	1.302***
Distance to nearest market	8.221	7.267	6.369***	6.972*	5.948***	6.916**
Awareness of project activities (yes $= 1$ )	0.026	0.067	0.133***	0.230***	0.242***	0.392***
Group membership	0.065	0.183**	0.317***	0.219***	0.333***	0.399***
Z	77	60	407	636	153	291

(1) D0F0S0 is the reference category. Every group is tested against the reference category. \*\*\* P < 0.01, \*\* P < 0.05, \* P < 0.1. (1) D0F0S0 is the reference category. Every group is tested against the reference category. \*\*\* P < 0.01, \*\* P < 0.05, \* P < 0.1.

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# 2.3. Descriptive statistics by the gender of the plot manager

The descriptive statistics of plot-level characteristics based on the gender of the plot manager have been presented in Table 3 below. Each gendered MAT category was tested against the base category of non-adoption. For example, the maize yields from WMP, MMP and JMP ranged from 1765–3665 kg/ha, 1915–3788 kg/ha and 2398–3915 kg/ha, respectively. The descriptive results further showed that the average maize yield per hectare for WMP, MMP and JMP and JMP is estimated as 3493 kg/ha, 3504 kg/ha, and 3676 kg/ha, respectively. The average plot size of WMP, MMP, and JMP is estimated at 0.447 ha, 0.542 ha, and 0.435 ha, respectively. Women tended to manage a nearby plot with an average walking time of 13 minutes (roughly a quarter an hour which was similar to the average walking time of JMP of about 17 minutes). On the other hand, men tended to manage plots that are relatively distanced from home, with an average walking distance of about 32 minutes (roughly half an hour, which was twice the walking time to WMP or JMP).<sup>4</sup>

# 3. Results and discussion

## 3.1. Adoption determinants of MATs

We present the marginal effects in Table 4 and discuss some of the statistically significant correlates of adoption. Among the socio-economic characteristics, being a male household head was significantly and positively associated with the use of the combination of maize-legume diversification and fertiliser while it was significantly and negatively associated with the use of the D1F1S1 combination (which contains all the three MATs). Farm size was negatively associated with maize-legume diversification, and larger farms were associated with the likelihood of adopting the D1F1S1 combination. Access to credit appeared to positively correlate with the fertiliser-only category (i.e., fertiliser applied without any other MAT combinations). The access to credit was negatively associated with combining the fertiliser with maize/legume combination. The compensatory effects of legumes on soil nutrients may make it less likely that plot managers will use their limited liquidity on fertilisers. Moreover, the receipt of government-support appeared significantly and negatively correlated with fertiliser use in combination with SWC. Government support could also proxy for being in a vulnerable economic situation, which may explain the reduced adoption of better agricultural practices. The WMPs were likely to be planted to maizelegume diversification while MMPs were likely to have maize-legume diversification only. The propensity of WMP to have D1F0S0 is consistent with the common observation that legumes are mostly grown by women . The correlates of adoption also showed that JMP were less likely to have fertilisers, which is consistent with the findings of Marenya, Kassie, and Tostao (2015) whose overall conclusion is not that joint management of plots cause less fertiliser use but that it reflects the dynamics of intra-household input allocation that are yet to be fully understood. It is conceivable that JMPs are not the main priority plots compared to MMPs, which are often considered to be the main food and income plots for the households (Doss et al., 2015).

<sup>&</sup>lt;sup>4</sup>Consider that the average walking speed for a human is typically thought of as 3–4 miles/hour.

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Variable	D0F0S0	D1F0S0	D0F1 S0	D1F1S0	D0F1S1	D1F1S1	Total
Women-managed plots							
Maize yield	1765	2843	3830***	3307**	3748***	3665***	3493
Maize returns	12,679	21,061	25,597***	21,200**	26,400***	24,438**	23,387
Plot size	0.439	0.262**	0.398**	0.355***	0.735	0.449	0.447
Plot distance from home (min)	6.44	5	12.65	9.92	8.24	24.64	13.1
Women managed plot (yes = 1)	0.117	0.083	0.12	0.058**	0.111	0.096	0.089
Good fertile soil (yes $= 1$ )	0.333	0.6	0.429	0.622	0.412	0.393	0.47
Medium fertile soil (yes $= 1$ )	0.556	0.4	0.469	0.324	0.588	0.571	0.469
Pesticide use(yes $= 1$ )	0.00	0.00	0.408**	0.378**	0.412**	0.357**	0.352
Manure use (yes $= 1$ )	0.778	0.8	0.345***	0.243***	0.353**	0.393**	0.345
Men-managed plots							
Maize yield	1915	2800	3595***	3353**	3788**	3569**	3504
Maize returns	13,804	21,620	23,761*	21,488*	25,088*	20,258	22,281
Plot size	0.536	0.25	0.569	0.561	0.516	0.538	0.542
Plot distance from home (min)	43.57	10	25.61	17.18	48.17	30.78	31.93
Men managed plot (yes = 1)	0.091	0.017*	0.076	0.052	0.268***	0.127	0.092
Good fertile soil (yes $= 1$ )	0.429	0.00	0.387	0.667	0.659	0.568	0.567
Medium fertile soil (yes $= 1$ )	0.571	0.00	0.548	0.303	0.268	0.405	0.387
Pesticide use(yes $= 1$ )	0.00	0.00	0.387**	0.091	0.073	0.135	0.152
Manure use (yes $= 1$ )	0.286	0.00	0.00	0.121	0.219	0.189	0.147
Jointly-managed plots							
Maize yield	2398	2642	3936***	3642***	3816***	3915***	3676
Maize returns	17,642	19,421	26,405***	23,963***	25,804***	26,274***	24,618
Plot size	0.408	0.355	0.377	0.41	0.564**	0.552**	0.435
Plot distance from home (min)	10.98	11.47	18.14	16.04	26.66**	14.17	16.58
Jointly managed plot	0.792	0.883	0.803	0.890**	0.621***	0.777	0.818
Good fertile soil (yes $= 1$ )	0.344	0.453	0.462*	0.599***	0.389	0.341	0.489
Medium fertile soil (yes $= 1$ )	0.59	0.491	0.489	0.382***	0.579	0.637	0.48
Pesticide use(yes = 1)	0.016	0.057	0.199***	0.175***	0.337***	0.319***	0.205
Manure use (yes $= 1$ )	0.492	0.453	0.171***	0.133***	0.358*	0.199***	0.199

Table 3. Some descriptive statistics of gendered plot level characteristics.

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# Table 4. Marginal effects of the determinants of combinations of MATs.

Explanatory variables	(1) D1F0S0	(2) D0F1S0	(3) D1F1S0	(4) D0F1S1	(5) D1F1S1
Condex hand	0.011	0.000	0.121*	0.002	0.112**
Gender head	-0.011	-0.000	0.131"	0.002	-0.113""
And based	(0.025)	(0.060)	(0.070)	(0.043)	(0.047)
Age nead	0.000	0.000	-0.000	0.000	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Education head	0.000	-0.003	0.002	-0.002	0.003
	(0.002)	(0.003)	(0.004)	(0.002)	(0.003)
Household size (In)	0.020	-0.015	-0.003	-0.025	0.011
	(0.018)	(0.036)	(0.039)	(0.023)	(0.031)
Farm size (In)	-0.032*	-0.058	0.070	-0.035	0.087***
	(0.018)	(0.041)	(0.043)	(0.025)	(0.033)
TLU (In)	0.005	-0.017	0.026	0.031**	-0.026
	(0.009)	(0.021)	(0.022)	(0.013)	(0.017)
Maize seed (kg/ha) (ln)	-0.029***	0.050*	-0.057**	0.030	-0.046**
	(0.008)	(0.026)	(0.025)	(0.020)	(0.021)
Access to credit (yes $=$ 1)	-0.010	0.176***	-0.167***	0.008	0.013
	(0.011)	(0.028)	(0.027)	(0.016)	(0.023)
Government support (yes $= 1$ )	0.019*	0.036	-0.020	-0.074***	0.019
	(0.011)	(0.023)	(0.025)	(0.015)	(0.020)
Plot distance from home (min) (ln)	-0.009	0.008	-0.028**	0.025***	0.005
	(0.006)	(0.013)	(0.013)	(0.008)	(0.010)
Women managed plot (ves $= 1$ )	0.285***	-0.659	0.224	0.241	0.014
inennen managea piet (jes 1)	(0.109)	(0.457)	(0.479)	(0.233)	(0.355)
lointly managed plot (yes $= 1$ )	-0.009	-0.154**	0.165*	-0.020	0.062
solitity managed plot (jes 1)	(0.037)	(0.078)	(0.091)	(0.038)	(0.058)
Good fertile soil (ves $= 1$ )	-0.028	-0.017	0 112	-0.046	-0.019
	(0.020	(0.077)	(0.089)	(0.052)	(0.073)
Medium fertile soil (ves – 1)	-0.017	(0.077)	0.087	-0.004	-0.060
Weddin Tertile son (yes = 1)	(0.027)	(0.074)	(0.086)	(0.050)	(0.072)
Posticido uso (vos $-1$ )	(0.027)	(0.074)	(0.080)	(0.050)	0.153***
resticide use (yes = 1)	(0,022)	(0.025)	(0.000	(0.013	(0.020)
Manura usa $(yas - 1)$	(0.023)	(0.033)	(0.039)	(0.022)	(0.030)
Manufe use (yes = 1)	(0.029	-0.000	-0.105	(0.017)	(0.040
Maan plat dictance from home	(0.010)	(0.026)	(0.031)	(0.017)	(0.024)
Mean plot distance from nome	0.008	0.000	0.012	-0.006	-0.016
Maan warran managed plat	(0.008)	(0.019)	(0.020)	(0.012)	(0.016)
Mean women managed plot	-0.291^^	0.726	0.025	-0.363	-0.183
Manu fatada manana dinta	(0.114)	(0.462)	(0.486)	(0.241)	(0.359)
Mean jointly managed plot	0.049	0.189^^	0.031	-0.119^^^	-0.196^^^
	(0.041)	(0.090)	(0.098)	(0.042)	(0.064)
Mean good fertile plot	0.008	-0.052	-0.074	0.059	0.077
	(0.039)	(0.098)	(0.111)	(0.067)	(0.100)
Mean medium fertile plot	-0.004	-0.089	-0.188*	0.036	0.251**
	(0.037)	(0.096)	(0.109)	(0.066)	(0.099)
Total rainfall growing season	-0.030	0.151**	0.308***	-0.040	-0.270***
	(0.029)	(0.063)	(0.073)	(0.039)	(0.059)
Rainfall shock index	0.038*	0.029	0.084*	-0.112***	-0.051
	(0.022)	(0.044)	(0.044)	(0.033)	(0.036)
Oromia (yes = 1)	0.032**	0.168***	-0.247***	0.074***	-0.067**
	(0.013)	(0.029)	(0.032)	(0.023)	(0.028)
Distance to input market	0.012*	0.035**	0.005	0.014	-0.067***
	(0.007)	(0.016)	(0.018)	(0.012)	(0.016)
Distance to nearest market	0.015*	-0.036*	0.011	-0.042***	0.026
	(0.009)	(0.019)	(0.020)	(0.013)	(0.016)
Participated in project extension activities (yes = 1)	-0.027	-0.085***	0.023	0.029	0.115***
· · ·	(0.018)	(0.031)	(0.030)	(0.019)	(0.021)
Group membership	-0.007	-0.026	-0.004	0.017	0.056***
· ·	(0.013)	(0.027)	(0.028)	(0.017)	(0.021)
Observations	1624	1624	1624	1624	1624

Standard errors in parentheses. D0F0S0 is the reference category. \* p < 0.10, \*\* p < 0.05, \*\*\* p < 0.01

Outcome	MATs		Adoptio	n Status	ATT
Variable	Choice	N	А	С	(A-C)
Maize yield (kg/ha)	D1F0S0	60	2569(114)	2352(134)	217(176)
	D0F1S0	407	3625(47)	2802(74)	833(87)***
	D1F1S0	636	3321(41)	2372(54)	949(68)***
	D0F1S1	153	3595(110)	2544(115)	1051(159)***
	D1F1S1	291	3618(77)	1999(61)	1619(98)***
	D1F0S0	60	18,753(9129)	18,142(1280)	611(1572)
Maize	D0F1S0	407	23,957(328)	22,574(713)	1383(785)*
income	D1F1S0	636	21,153(276)	18,670(513)	2483(582)***
Birr/ha	D0F1S1	153	23,742(778)	19,474(1071)	4268(1324)***
	D1F1S1	291	23,182(482)	14,848(523)	8334(711)***

Table 5. Impacts of multiple agricultural technologies (MATs) on maize yield (the full sample).

We report actual outcome (A) with the adoption of the different combinations of MATs and counterfactual outcome (C) without the MATs and difference between actual and counterfactual outcomes as impact (ATT). The standard errors in parenthesis. \* p < 0.10, \*\* p < 0.05, \*\*\* p < 0.01. Legumes equivalent were added to the maize yield.

#### 3.2. The impacts of MATs on maize yield and maize income

Table 5 demonstrates the impacts of the different combinations of MAT bundles on maize yield and maize returns. To estimate the true average effects, plots that were under specific MAT combinations were compared with these same plots had they not been under any of the MATs. Moreover, to determine the average adoption effects of the bundles of MATs, we compared columns A and C of Table 5. The full sample average treatment effect on the treated (ATT) results in Table 5 shows the impacts of adoption of MATs on maize net incomes, which are computed as the difference between columns A and C. In general, we found that plots with MATs had significantly higher maize yields and net incomes, both of which increase with the intensity of adoption.

The results show that the average impact of the adopting fertilisers is estimated at 833 kg/ha and 1383 birr/ha,<sup>5</sup> after controlling for observed and unobserved determinants. Moreover, the impacts of the combination of fertiliser and maize-legume diversification (D1F1S0) is estimated at 949 kg/ha and 2483 birr/ha. These are in accordance with the findings of Kassie et al. (2018) who found a positive impact of D1F1S0 in the Ethiopian context. The impact of fertilisers and soil and water conservation packages (D0F1S1) on maize yield and maize marginal returns is estimated at 1051 kg/ha and 4268 birr/ha, respectively. Expectedly, we found that the largest effects of MATs were realised with the adoption of all the three MATs (1619 kg/ha and Birr 8334/ha). These findings are consistent with the extant literature (Kassie et al., 2018; Teklewold et al., 2013) in Ethiopia (Khonje et al., 2018; Manda et al., 2016) and Zambia.

#### 3.3. Heterogeneity effects of MATs by gender

We now turn to the effects of the MATs packages as disaggregated by the gender of the plot manager (Table 6). Overall, we find positive and significant impacts of the combination of MATs on maize yield and maize marginal returns across all the MATs groups when disaggregated by the gender of the plot manager, except for the maize-legume diversification only package. The results in Table 6 showed that WMPs had higher yield returns than those managed jointly. However, we did not find significant differences

<sup>&</sup>lt;sup>5</sup>At the time of the study, the Birr (official currency in Ethiopia) was exchanging at 1 = 22 Birr.

	in inharin of	יוומורוחור מ	או ובמונים	ורכוווסוסקורז	011 11101EC )	1.1.1.						
Outrome	MATs	Mol	men-manag	ed plots	Me	en-managed	l plots	Joir	ntly-manage	d plots		
OULCOTE	Category											
Variable		А	U	ATTa (A-C)	А	U	АТТЬ (А-С)	A	U	ATTc (A-C)	ATTa-ATTb	ATTa-ATTc
Maize	D1F0S0	2743	2214	529	NA	NA	NA	2523	2399	124	NA	405
Yield		(558)	(631)	(843)				(117)	(139)	(182)		(676)
(kg/ha)	D0F1S0	3667	2316	1351***	3444	2154	1290***	3635	2936	***669	61	652***
1		(143)	(172)	(131)	(189)	(217)	(287)	(51)	(84)	(86)	(232)	(194)
	D1F1S0	3026	1802	1224***	3313	1899	1414***	3341	2437	904***	-190	320*
		(130)	(169)	(213)	(250)	(239)	(345)	(43)	(57)	(72)	(258)	(192)
	D0F1S1	3769	2199	1560***	3455	2257	1198***	3624	2729	895***	371	675
		(315)	(299)	(435)	(249)	(166)	(299)	(131)	(160)	(207)	(496)	(431)
	D1F1S1	3532	1540	1992***	3348	1613	1735***	3673	2119	1554***	257	438*
		(314)	(120)	(336)	(242)	(119)	(270)	(82)	(73)	(109)	(378)	(265)
Maize net income	D1F0S0	19771	16214	3557	NA	NA	NA	18395	18609	(-)214		3770
(Birr/ha)		(3920)	(4595)	(6040)				(926)	(1373)	(1673)		(6050)
	D0F1S0	23506	18450	5056**	22359	16864	5495**	24176	23733	443	-439	4613**
		(266)	(1714)	(1983)	(1270)	(1661)	(2362)	(361)	(817)	(893)	(2042)	(1889)
	D1F1S0	18832	13420	5412***	20919	14664	6255**	21318	19247	2071***	-843	3341*
		(850)	(1554)	(1771)	(1656)	(2169)	(2729)	(288)	(549)	(620)	(2153)	(1819)
	D0F1S1	26627	16992	9635***	22140	16364	5776***	23917	21259	2658	3859	6977**
		(2307)	(2539)	(3431)	(1609)	(1292)	(2064)	(954)	(1547)	(1818)	(3481)	(3809)
	D1F1S1	21959	11303	10656***	19429	11269	8160***	23948	15873	8075***	2496	2581
		(1915)	(1027)	(2173)	(1234)	(952)	(1558)	(527)	(628)	(820)	(2260)	(1979)
	Z		136			143			1267			
Note. We report actual the treated (ATT) Ct	outcome with	MATs (A), co	unterfactual	outcome withou	t MATs scena	irio (C) and c	lifference betwee	en the actual	and counter	rfactual scenario:	s as average treat	ment effect on
יריייייייייייייייייייייייייייייייייייי		ווו המובוונובי		יוחוו <sub>־</sub> מאשוירמי	זוב הברמתזב ה	ו ווטט ובעי ט	ק ינויטווא וסנע	л (у г.) У (у г.)	- 'rn'n /	0 / 0.01.		

Table 6. Gendered impacts of multiple agricultural technologies on maize yield.

between WMPs and MMPs, but we did find that the adoption of fertiliser alone increased maize yield by 1351 kg/ha for WMP, by 1290 kg/ha for MMP and 699 kg/ha for JMP (Table 6). Similarly, the average treatment effect of the adoption of fertilisers and maize-legume diversification was estimated to be 1224 kg/ha, 1414 kg/ha and 904 kg/ha for WMP, MMP and JMP, respectively. Similarly, the average treatment effect of D1F1S0 on maize marginal returns was estimated to be 5412 birr/ha, 6255 birr/ha and 2071 birr/ha for WMP, MMP and JMP, respectively. The average treatment effects of the adoption of fertilisers and water conservation measures is estimated to be 1560 kg/ha and 9635 birr/ ha for WMP, 1198 kg/ha and 5776 birr/ha for MMP and 895 kg/ha for JMP. Similar to the results resented in Table 5, the higher impact of MATs was realised with the adoption of the full package (D1F1S1) in all the gender groups.

Notably, the results in Table 6 showed that there was no statistical difference regarding the impact of fertilisers on the maize yield or financial returns between WMP and MMP. Nominally, the ATTs of the MAT packages were higher for WMPs (except in the case of D1F1S0, although it was still not statistically significant). On the other hand, some differences between WMPs and JMPs were found to be statistically significant. The average maize yields on WMPs was found to be statistically higher at 652 kg/ha and 4613 birr/ha than JMPs under D0F1S0. Similarly, the ATTs for WMPs were statistically higher under D1F1S0 and D1F1S1 by 320 kg/ha and 438 kg/ha, respectively. In relative terms, WMPs had ATTs that were 93% higher for D0F1S0 and 35% and 28% higher for D1F1S0 and D1F1S1, respectively. In brief, the yield and marginal return performance of the MATs of WMPs were either equal to those of MMPs or, in some cases, higher than those of JMPs.

#### 3.4. Heterogeneity effects by gender and rainfall endowment

Table 7 presents the estimates for the impacts of MATs on maize yield and maize marginal returns disaggregated by gender and rainfall endowments. Analysing the differential impacts of MATs on plots that are managed by different genders and are exposed to different rainfall exposure (rainfall stress and rainfall surplus) can help in further understanding how the patterns observed in Table 6 hold when the weather variables are included, given that these impacts are likely to be context specific (Tomich et al., 2019;). In general, we find positive results of the different combinations of MATs disaggregated by gender and rainfall endowments. However, plots with rainfall surplus have better performances than plots with rainfall shortage. Moreover, similar to the results in Table 6, the plots managed solely by women have nominally higher outcomes than the ones managed jointly and by men in both the rainfall endowment scenarios.

#### 3.5. Brief Discussion: gender intentional agricultural development

Which is the best way to achieve gender intentional agricultural development: promoting individual or joint control of agricultural resources? The implications of the results presented in Table 6 and Table 7 are twofold. First, after controlling for demographic factors, improved agronomy, input use and other covariates such as market access and locational and rainfall differences, the productivity in plots controlled by women is at

Randiolicitic plots         Antholicitic plots         MMF         <	mainful-effecti plots         mainful-effecti plots         MMF				•							
MAT         WMPs         MMPs	MMT         MMFs		Rai	nfall-deficit plots								
Classion         A         C         ATTIA-CI         A         C         ATTIA-CI         ATTIA-CI         A         C         ATTIA-CI           D1F050         2433         2030         (1173)         1173         1173         1133	Classon         A         C         ATTIA-C         A         C         A         C         A         C         A         C         A         C         A         TO		MAT		WMPs			MMPs			JMPs	
DIFOSO         243         2068         (117         M         M         M         M         M         523         2338         193           DIFISO         3107         1937         1110***         2706         1639         1035         2475         759***           DIFISO         3107         110***         2706         1639         1037         1039         1039           DIFISO         3043         1471         1572***         3179         1771         1039         1339         1077***           DIFISO         2039         1449         1544**         3407         2183         12317         1319         1057***         1339         1057****           DIFISO         2039         1449         1544**         3407         1339         1339         1057****         1339         1339         1057****           DIFISO         1887         10230         6657****         1387         10230         6657*****         13370         1339         1339         1339         1339         1339         1339         1339         1339         1339         1339         1339         1339         1339         1339         1339         1339         1339 <t< td=""><td>D1F630         2433         2608         (1)75         NA         NA         221         2338         193           D1F50         3107         1937         1170***         2339         1373         13333         1333         1333</td><td></td><td>Category</td><td>A</td><td>U</td><td>ATT(A-C)</td><td>A</td><td>U</td><td>ATT(A-C)</td><td>A</td><td>U</td><td>ATT(A-C)</td></t<>	D1F630         2433         2608         (1)75         NA         NA         221         2338         193           D1F50         3107         1937         1170***         2339         1373         13333         1333         1333		Category	A	U	ATT(A-C)	A	U	ATT(A-C)	A	U	ATT(A-C)
DFISO         34(3)         9327         1480         3431         9321         1480         3431         3531         3331         <	DFF150         3107         3223         (430)         3223         (135)         (		D1F0S0	2433	2608	(-)175	NA	NA	NA	2521	2328	193
DFISO         3107         1937         1170***         2706         1639         1057***         2333         2473         778***           DFISO         303         1471         1572***         3179         1733         2133         2133         2133         753         753           DFISO         3043         1471         1572***         3179         1539         1733	D0F150         3107         9377         1170****         2706         6393         1077         3233         2473         773***           D1F150         3033         1471         1572***         3179         1773         1693         1673         1693         1673         1673         1673         1673         1673         1733*         1673         1673         1673         1673         1733         1673         1673         1673         1673         1673         1673         1673         1733         1673			(443)	(922)	(480)				(119)	(135)	(183)
Diffsion         (165)         (133)         (116)         (114)         (201)         (193)         (73)         (73)           Diffsion         (183)         (173) <td< td=""><td>DIFISO         (65)         (133)         (114)         (201)         (193)         (114)         (201)         (193)         (133)         <th< td=""><td></td><td>D0F1S0</td><td>3107</td><td>1937</td><td>1170***</td><td>2706</td><td>1639</td><td>1067***</td><td>3253</td><td>2475</td><td>778***</td></th<></td></td<>	DIFISO         (65)         (133)         (114)         (201)         (193)         (114)         (201)         (193)         (133) <th< td=""><td></td><td>D0F1S0</td><td>3107</td><td>1937</td><td>1170***</td><td>2706</td><td>1639</td><td>1067***</td><td>3253</td><td>2475</td><td>778***</td></th<>		D0F1S0	3107	1937	1170***	2706	1639	1067***	3253	2475	778***
DIFISO         3043         1471         1572**         3173         1774         1405***         2102         1055***           DFISO         3093         1439         1471         1572**         3173         2330         2193         1517           DFISI         2093         1439         1544**         3407         2183         1323         1337         1393         1373           DFISI         3093         1337         1687*         3433         3433         1337         1393         1373           DFISI         3093         1337         1687*         3433         1337         1337         1393         1337           DFISI         1939         1111         3800         265         1133         1337	DIFISO         3443         1471         1722***         3173         1734         1465**         3219         2162         1057**           DFISI         2033         (163)         (165)         (283)         (173)         (133)         (133)         (133)         (133)         (173)           DFISI         2033         (133)         (134)			(165)	(183)	(116)	(114)	(201)	(193)	(54)	(83)	(75)
Derist         (169)         (163)         (162)         (289)         (230)         (131)         (133) <t< td=""><td>Diff         (169)         (153)         (521)         (239)         (231)         (313)</td><td></td><td>D1F1S0</td><td>3043</td><td>1471</td><td>1572***</td><td>3179</td><td>1774</td><td>1405***</td><td>3219</td><td>2162</td><td>1057***</td></t<>	Diff         (169)         (153)         (521)         (239)         (231)         (313)		D1F1S0	3043	1471	1572***	3179	1774	1405***	3219	2162	1057***
D0F151         2933         1449         144****         3407         2165         1222****         3151         2235         86****           D1F051         2030         1342         16876         1730         1337         1339         1337         1339         1337         1339         1337         1339         1337         1339         1337         1339         1337         1339         1337         1339         1337         1339         1337         1339         1337         1337         1339         1337         1337         1337         1337         1337         1337         1337         1337         1337         1337         1537*         557	D0F1S1         2933         1440         1544***         3407         2185         1222***         3151         2255         86**           D1F1S1         2039         1347         1615         2339         1341         701         933         1733           D1F1S1         2039         1347         1696         1323         1593         1333         1593         1333         1593         1593         1573         933         1533         933         1533         933         1533         933         1533         933         1533         933         1533         933         1533         933         1533         933         1533			(169)	(185)	(162)	(289)	(230)	(215)	(49)	(58)	(56)
The construction         (227)         (415)         (289)         (113)         (133)	Diff 1         2050         7370         4150         2890         (133)         (133)         (139)         (130)         (1		D0F1S1	2993	1449	1544***	3407	2185	1222***	3151	2255	896***
DIFISI         3039         1342         1688**         3423         1592         1831***         3530         1933         1537***           DIFDS         (389)         (111)         (380)         (111)         (381)         (111)         (1541)         (93)           DIFDS         (387)         (177)6         (392)         (3573)         (3553)         (3573)         (3573)         (571)         (371)         (1541)         (1541)           DIFDS         (172)         (1416)         (943)         (356)         (1461)         (943)         (533)         (543)         (533)         (543)         (543)         (543)         (543)         (543)         (543)         (543)         (543)         (543)         (5	DiFISI         3039         11342         1668***         3423         1592         1831***         5330         1993         1537**           DiFOS         (389)         (111)         (6578)         (5578)         (322)         (314)         (956)         (111)         (1541)           DiFOS         (578)         (5578)         (5578)         (5578)         (5578)         (5578)         (5578)         (579)         (951)           DiFOS         (1723)         (1323)         (146)         (946)         (1371)         (1561)         (1561)         (1561)         (1561)         (1561)         (1561)         (1561)         (1571)         (1531)         (1531)         (1531)         (1531)         (1533)         (1403)         (1403)         (1403)         (1403)         (1403)         (1403)         (1403)         (1403)         (1531)         (1232)         (1403)         <			(205)	(297)	(415)	(289)	(183)	(337)	(139)	(139)	(173)
Diffect         (389)         (111)         (380)         (502)         (123)         (251)         (88)         (76)         (94)           Diffect         (3025)         (172)6         (3578)         (378)	DiFos         (38)         (11)         (38)         (76)         (94)           DiFos         16376         (17)96         (354)         (17)96         (354)         (77)6         (94)           DiFos         19738         (112)         (1416)         (637)         (657)         (637)         (637)           DiFiso         19738         (1320)         (647)         (137)         (146)         (353)         (657)         (637)         (637)           DiFiso         (1416)         (637)         (714)         (732)         (746)         (746)         (746)         (746)         (746)         (746)         (746)         (746)         (746)         (746)         (746)		D1F1S1	3039	1342	1698***	3423	1592	1831***	3530	1993	1537***
DIFOS         16,876         17,796         (-)920         M         MA         NA         NB22,4         17,267         957           DIF1S         13,873         65733         55543         55543         13,854         11,479         6605         11,479         6605         11,479         66178         13,850         311,887         11,479         66178         13,850         311,887         13,860         311,887         13,860         311,887         13,860         311,886         14,461         14,461         14,461         14,461         16,174         43,333           DIF1S1         21,261         10,224         11,037***         21,714         15,330         63,84***         20,477         16,174         43,333***           DIF1S1         21,261         10,224         11,037***         21,714         15,330         63,84***         20,779         16,174         43,333***           DIF1S1         71,568         9490         8077         10,827         10,807         16,174         43,333***           N         N         7         7         13,101         13,101         13,203         13,486         14,466           N         N         7         7         13,231	DIFGS         16,376         17,396         ()92,0         NA         NA         182,24         17,367         957           DIF150         19,738         (35534)         17,364         (13578)         (35534)         (1361)         (1361)           DIF150         19,738         (35534)         17,864         (1568)         (1461)         (993)         (6573)         (3534)         (1364)         (1363)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1322)         (1312)         (1476)         (1476)         (1476)         (1526)         (1476)         (1476)         (1526)         (1476)         (1476)         (1526)         (1476)         (1476)         (1526)         (1476)         (1476)         (1526)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1476)         (1480)         (1476)         (1480)         (1476)         (1480)         (1480)         (1480)         (1480)         (1480)         (1480)         (1480)         (1480)         (1480)         (1480)         (1			(389)	(111)	(380)	(262)	(123)	(251)	(88)	(76)	(64)
Diff 10         (3025)         (6578)         (3354)         (111)         (141)         (141)           Diff 130         (112)         (114)         (1416)         (937)         (657)         (631)         (611)           Diff 130         (112)         (1416)         (937)         (1534)         (1331)         (611)         (141)         (141)           Diff 131         21,261         (0224)         (1324)         (1580)         (1461)         (332)         (6397)         (633)           Diff 131         21,261         (0224)         (1327)         (1862)         (1321)         (233)         (649)         (633)           Diff 131         21,568         (1461)         (1321)         (2324)         (307)         (633)           Diff 131         17,568         9490         8078***         17,714         (533)         (548)         (146)           N         72         110,37***         17,166         870,719         (143)         (143)           N         72         110,37***         17,166         870,7***         22,280         (144)           N         7         7         110,55         870,7****         213,7************************************	Deris         (3025)         (6578)         (3554)         (1111)         (1541)         (1541)           Deris         13,587         6051***         17,844         14,79         6405***         21,678         85,500         3118**           DiFis         11,290         (1476)         (1294)         (1566)         (1477)         15,330         6591***         20,497         16,174         4333**           DiFis         21,561         10,230         8641***         19,761         113,290         (5595         4148**           DiFis         21,561         10,230         8641***         19,761         113,210         (5917)         (697)         (639)         (446)           DiFis         17,561         9490         8078***         19,761         113,210         (5354)         (446)         (439)         (617)         (430)         (613)         (440)         (440)         (440)         (440)         (440)         (441)         (440)         (430)         (413)         (430)         (413)         (430)         (413)         (440)         (440)         (440)         (440)         (440)         (440)         (441)         (440)         (441)         (440)         (441)         (441)		D1F0S0	16,876	17,796	(-)920	NA	NA	NA	18224	17,267	957
D0F150         19,738         13,867         6051***         17,884         11,479         6405***         21,678         85,60         3118***           01F150         1129)         (1416)         (941)         (1729)         (1416)         (937)         (631)           01F150         18,871         10,224         10,37***         17,14         (1526)         (323)         (647)         (433)           0         D1F151         17,568         9490         807***         21,714         (1526)         (323)         (648)         (446)           0         D0F151         17,568         9490         8078***         21,714         (1526)         (323)         (683)         (643)           N         (1514)         (943)         (2025)         (1310)         (973)         (1467)         (533)         (648)         (649)           N         N         72         NMPs         110         72         2353         (1467)         (533)         (643)         (613)           N         N         72         110         70         (711)         (7167)         (710)         (710)         (710)         (710)         (710)         (710)         (710)         (710)	D0F1S0         19738         13.867         6001***         17.884         11.479         6405****         21.578         18.560         3118**           D1F1S0         1871         10.230         8641****         17.863         (1461)         (397)         (6173)         (637)         (633)           D1F1S0         18871         10.230         8641****         17.843         (1864)         (1863)         (1461)         (397)         (613)         (633)           D1F1S1         17.568         2.0779         (1864)         (1862)         (1324)         (1326)         (1461)         (397)         (699)         (633)           D1F1S1         17568         2.0779         (1307)**         21.714         15.330         6384***         20.779         (446)           N         72         (1914)         (943)         (2025)         (1310)         (978)         (1467)         (538)         (446)         (446)           N         N         72         (1914)         723         (1307)         (1366)         (1467)         (538)         (446)         (449)           N         N         72         110         (1457)         (238)         (1461)         (236)         (147			(3025)	(6578)	(3554)				(926)	(1111)	(1541)
(1129)         (1146)         (948)         (874)         (1586)         (1461)         (397)         (677)         (633)           0F150         (1867)         (10230         8841***         13,170         65391***         20,497         (677)         (633)           0F151         21,261         10,224         11,037***         21,714         15,330         65391***         20,497         (677)         (633)           0F151         21,560         (2275)         (3077)         (1862)         (1321)         (2254)         (1675)         (1476)           011151         17,568         9490         8078***         13,701         (1321)         (2254)         (1476)         (639)           N         (1914)         (943)         (2025)         (1310)         (798)         (747)         (699)         (639)           N         72         (1914)         (933)         (2025)         (1310)         (798)         (146)         (446)           Mis         11056         (1321)         (1253)         (1363)         (146)         (1470)           N         72         (1462)         (1321)         (1253)         (146)         (1476)         (146)         (146)	DIF150         (1129)         (1416)         (948)         (874)         (1568)         (1461)         (397)         (697)         (633)           DIF150         18871         10,2330         8641***         19,761         13,170         (591)***         (643)         (436)           DIF151         10,666         (1704)         (1324)         (1326)         (5595         4184**           DIF151         17,560         9490         (1862)         (1321)         (1256)         (3297)         (613)           DIF151         17,560         9490         (1862)         (1371)         (1256)         (1467)         (328)         4184**           DIF151         17,560         9490         (1862)         (1321)         (1256)         (1472)         8048***           N         N         72         (1310)         (978)         (1321)         (1326)         (1472)         8048***           N         N         72         (1310)         (978)         (1467)         (538)         (648)         (449)           N         N         72         (110)         (1467)         (538)         (641)         (147)         (1461)         (157)         (147)         (1461)		D0F1S0	19,738	13,687	6051***	17,884	11,479	6405***	21,678	18,560	3118***
DIFISO         18,871         10,230         8641***         19,761         13,170         6591***         20,497         16,174         4323***           0         015151         21,561         10,224         11,037***         21,714         15,26)         (1328)         (466)         (1446)           0         015151         17,568         9490         8078***         19,761         (1323)         (328)         (466)         (1448)           0         015151         17,568         9490         8078***         19,761         (1321)         (2254)         (1055)         (1498)           0         (1914)         (943)         (2025)         (1310)         (978)         (1321)         (2254)         (1468)         (698)           N         72         11105         8078***         19,761         11056         8705***         22,820         14,772         8048***           Rainfall surplus plots         NMPs         1110         870         8705         8144****         899         16490         (698)         (649)         (693)           Rainfall surplus plots         NMPs         110         873         22,820         14,772         8048***********************************	DIFISO         18,871         10,230         8641***         19,761         13,170         6591***         20,497         16,174         4323**           DFISI         10666         (1476)         (1234)         (1864)         (1864)         (1320)         (5955         4184)           DFISI         10560         (1224)         (1864)         (1337***         21,713         (2254)         (1065)         (1152)         (1466)           N         (1914)         (943)         (2025)         (1310)         (1978)         (1467)         (538)         4184         (430)           Rainfall surplus plots         N         72         2025)         (1310)         (978)         (1467)         (538)         (648)         (698)           Rainfall surplus plots         N         72         11056         8705****         22,820         14,772         8048**           Rainfall surplus plots         N         72         11056         8705****         22,820         14,772         8048**           Rainfall surplus plots         N         N         7         7         7         7         1408           1150         (1467)         72         7         7         7         1414**			(1129)	(1416)	(948)	(874)	(1568)	(1461)	(397)	(26)	(633)
(1066)         (1476)         (1294)         (1864)         (1864)         (1864)         (1864)         (1864)         (1864)         (1864)         (1461)         (2217)         (2017)         (2055)         (148)         (1408)           DIF1S1         17,560         22753         (3077)         (1864)         (1321)         (2253)         (1467)         (533)         (466)         (446)           N         (1914)         (943)         (2025)         (1310)         (978)         (1467)         (533)         (480)         (483)           N         (1914)         (943)         (2025)         (1310)         (978)         (1467)         (533)         (489)         (693)           Rinfall surplus plots         N         72         2025)         (1310)         (978)         (1467)         (533)         (438)         (693)           Re         MATS         N         7         A         C         ATT(A-C)         A         C         ATT(A-C)         B         (1467)         (533)         (348)         (513)         (1463)         (533)         (446)         (693)           Rinfall surplus plots         MMPs         A         C         ATT(A-C)         A         C	(1066)         (1476)         (1294)         (1864)         (1890)         (1526)         (328)         (486)         (446)           DFISI         21,261         10,224         11,037***         21,714         15,330         6384***         20,779         16,555         1498           DFISI         17,568         9490         807***         19,761         11,321         23,273         16,480         (446)           Nainfall surplus plots         (1914)         (943)         (2025)         (1310)         (978)         (1467)         (538)         (648)         (698)           Rainfall surplus plots         (1914)         (943)         (2025)         (1310)         (978)         (1467)         (538)         (648)         (698)           Rainfall surplus plots         MMPs         72         NMPs         110         (1467)         (533)         (648)         (698)           Re MATS         WMPs         72         ATT(A-C)         A         C         ATT(A-C)         A         C         (147)         (699)         (612)         (142)           Re MATS         WMPs         ATT(A-C)         A         C         ATT(A-C)         A         C         (114)         (114)		D1F1S0	18,871	10,230	8641***	19,761	13,170	6591***	20,497	16,174	4323***
D         DF151         21,261         10,224         11,037***         21,714         15,330         6384***         20,779         16,595         4184***           DF151         1,560         (2275)         (3077)         (1862)         (1321)         (2254)         (1655)         (1132)         (408)           DF151         17,568         9490         8078***         19,761         (1321)         (2254)         (1655)         (1132)         (4408)           N         (1914)         (943)         (2025)         (1310)         (976)         (375***         22,820         14,772         8048***           Rainfall surplus plots         72         NMPs         110         (1457)         (238)         (448***)         (693)           Reinfall surplus plots         NMPs         NMPs         NMPs         MMPs         JMPs           Rainfall surplus plots         N         C         ATT(A-C)         A         C         ATT(A-C)           Reinfall surplus plots         N         MPs         JMPs         JMPs         JMPs         JMPs           Reinfall surplus plots         N         ATT(A-C)         A         C         ATT(A-C)         A         C         ATT(A-C)	) D0F151 21,261 10.224 11,037*** 21,714 15,330 6384*** 20,779 16,595 4184** (1408) (1450) (2253) (1350) (2253) (1408) (1420) (1420) (1420) (1420) (1420) (1420) (1420) (1420) (1420) (1420) (1420) (1420) (1420) (1420) (1421) (1420) (1421) (1421) (1421) (1421) (1421) (1421) (1421) (1421) (1421) (1421) (1421) (1421) (1232) (1421) (1421) (1421) (1232) (1421) (1521) (14			(1066)	(1476)	(1294)	(1864)	(1890)	(1526)	(328)	(486)	(446)
DIF1S1         (1560)         (2275)         (3077)         (1862)         (1321)         (2254)         (1065)         (1152)         (1408)           N         (1914)         (943)         (2025)         (1310)         (1978)         (1477)         (538)         (648)         (698)           N         N         72         (2025)         (1310)         (1978)         (1477)         (538)         (648)         (698)           Rainfall surplus plots         N         72         ATT(A-C)         A         C         ATT(A-C)         A         (7005)         (1477)         (698)         (698)           Rainfall surplus plots         NMPs         NMPs         NMPs         MMPs         MMPs         MMPs           0 D1F050         3207         16.23         1584         C         ATT(A-C)         A         C         ATT(A-C)           0 D1F150         3207         16.23         13584         4323         2333         1441*         361         500****           0 D1F150         2480         7239         2346         7239         1436         6612         6714           0 D1F150         2704         1528***         4356         6793         670**************	Interview         (1560)         (2275)         (3077)         (1862)         (1321)         (1055)         (1152)         (1105)         (1152)         (1408)           N         (1914)         733         (1914)         (938)         (1457)         (538)         (648)         (699)           N         N         72         22,820         14,772         8048***         (943)           Rainfall surplus plots         7         7         10         7         (1467)         (538)         (648)         (698)           Rainfall surplus plots         7         7         10         10         10         849         (693)         (612)           Rainfall surplus plots         WMPs         MMPs         MMPs         MMPs         10         7         10         14,772         8048         (693)         (612)           Portiso         1623         1584         C         ATT(A-C)         A         A	~	D0F1S1	21,261	10,224	11,037***	21,714	15,330	6384***	20,779	16,595	4184***
DIF1S1         17,568         9490         8078***         19,761         11,056         8705***         22,820         14,772         8048***           N         (1914)         (943)         (2025)         (1310)         (978)         (1467)         (538)         (648)         (698)           Rainfall surplus plots         NMPs         110         943)         (2025)         (1310)         (978)         (1467)         (538)         (648)         (698)           Rainfall surplus plots         NMPs         NMPs         110         89         389         (619)           Rainfall surplus plots         WMPs         NMPs         110         533)         1646         (7141)           D1F050         3207         1623         1584         4232         2704         1528***         4261         (612)           D0F150         1473         (923)         (2346)         (733)         (346)         (71)         (152)         (147)           D1F150         3000         2286         714**         3734         2293         1441**         3614         3052         562***           D1F150         2303         (246)         (672)         (674)         (71)         (152)	DIF151         17,568         9490         8078***         19,761         11,056         8705****         22,820         14,772         8048**           N         (1914)         (943)         (2025)         (1310)         (978)         (1467)         (538)         (648)         (699)           Rainfall surplus plots         72         NMPs         110         889         889           Rainfall surplus plots         WMPs         110         933)         (1467)         (538)         (648)         (699)           P MATs         WMPs         NMPs         NMPs         NMPs         110         889         17(A-           P C category         A         C         ATT(A-C)         A         C         ATT(A-C)         A         C           D1F0S0         3207         1623         1584         2395)         (336)         (512)         (346)         (512)           D0F1S0         4021         2555         1466***         4232         2704         1528***         4261         3691         570**           D1F1S0         2000         (277)         (2393)         (346)         (71)         (152)         (142)           D1F1S0         2704         1			(1560)	(2275)	(3077)	(1862)	(1321)	(2254)	(1065)	(1152)	(1408)
(1914)         (943)         (2025)         (1310)         (978)         (1467)         (538)         (648)         (698)         (612)           e         MATs         MMPs         C         ATT(A-C)         A         C         ATT(A-C)         A         C         (710)         (710)         (712)         (711)         (112)           D1F1S0         3000         2286         714**         3734         2293         1441**         3614         3052         562****           D1F1S0         3000         2286         714**         3734         2293         1441***         3614         3052         562****           D1F1S0         2301         2373         2467         (346)         (710)         (122)         (142)         (142)	(1914)         (943)         (2025)         (1310)         (978)         (1467)         (538)         (648)         (699)           Rainfall surplus plots         72         N         110         978)         (1467)         (538)         (648)         (693)           Rainfall surplus plots         WMPs         MMPs         JT(A-C)         A         C         ATT(A-C)         A         C         C         ATT(A-C)         C         ATT(A-C)         C         ATT(A-C)         C         ATT(A-C)         C         ATT(A-C)         C         C         C         C         C         C <td></td> <td>D1F1S1</td> <td>17,568</td> <td>9490</td> <td>8078***</td> <td>19,761</td> <td>11,056</td> <td>8705***</td> <td>22,820</td> <td>14,772</td> <td>8048***</td>		D1F1S1	17,568	9490	8078***	19,761	11,056	8705***	22,820	14,772	8048***
N         72         110         889           Rainfall surplus plots         MMPs         JMPs         JMPs         JMPs           Rainfall surplus plots         WMPs         MMPs         JMPs         JMPs           Rainfall surplus plots         WMPs         MMPs         JMPs         JMPs           DIF050         3207         1623         1584         JMPs         JMPs           DIF150         3207         1623         1584         Z555         1466***         4232         Z704         15239         2670         (-1141)           DIF150         3200         22555         1466***         4232         Z704         1528***         4261         3691         570***           DIF150         3000         2286         714**         3734         2293         1441**         3614         3052         562***           DIF151         453         (346)         (537)         (449)         (71)         (152)         (142)           DIF151         453         (357)         (294)         (71)         (152)         (142)           DIF151         4573         3646         (274)         (357)         (349)         (31)         (389)	N         72         110         89           Rainfall surplus plots         MMPs         JMPs         JMPs           Rainfall surplus plots         MMPs         MMPs         JMPs           Rainfall surplus plots         MMPs         MMPs         JMPs           Rainfall surplus plots         MMPs         MMPs         JMPs           DiFOSO         3207         1623         1584         2570         (-)141           DiFTSO         3207         1623         1584         2539         2670         (-)141           DiFTSO         3207         1623         1584         23395         (436)         (612)         (142)           DiFTSO         4021         2555         1466***         4232         2704         1528***         4261         3691         570**           DiFTSO         4021         2555         1466***         4232         2704         1528***         4261         3691         570**           DiFTSO         4021         2274)         (231)         (232)         (346)         (71)         (152)         (142)           DiFTSO         2118         3734         2293         1441**         3614         3052         562**			(1914)	(943)	(2025)	(1310)	(978)	(1467)	(538)	(648)	(869)
Rainfall surplus plots         MMPs         JMPs           0 Ti FoS0         3207         1623         1584         C         ATT(A-C)         A         A         C         ATT(A-C)         A         ATT(A-C)	Rainfall surplus plots         MMPs         MMPs         JMPs         JMPs           Rainfall surplus plots         WMPs         C         ATT(A-C)         A         C         ATT		Z		72			110			889	
e MATs WMPs MMPs MMPs MMPs MMPs MMPs MMPs A C ATT(A-C) A C ATT(A-C) A C C ATT(A-C) A C C ATT(A-C) C ATT(A-C) C ATT(A-C) C ATT(A-C) C ATT(A-C) C ATT(A-C) C C C C C C C C C C C C C C C C C C	e MATs WMPs JIFAC A TT(A-C) A C ATT(A-C) A C ATT(A-C) A C ATT(A-C) A C C A ADS A		Rainfall surplu.	s plots								
<ul> <li>Category A C ATT(A-C) A C ATT(A-C) A C ATT(A-C)</li> <li>D1F050 3207 1623 1584</li> <li>D1F050 3207 1623 1584</li> <li>C (1473) (923) (923) (1384</li> <li>C (1473) (1232) (1239) (1353) (1353) (136) (-[-1]1</li> <li>D0F150 4021 2555 1466*** 4232 2704 1528*** 4261 3691 570***</li> <li>D1F150 3000 2273 (144* 3734 2293 1441** 3614 3052 562***</li> <li>D0F151 4642 3044 1598*** 3732 2676 1056* 4513 3621 892**</li> <li>D0F151 4673 (244) (445) (234) (357) (489)* (198) (31) (38)</li> <li>D1F151 4573 1958 2615*** 2727 1781 946 4454 2306 1648***</li> <li>D1F151 4573 1360 (445) (564) (487) (433) (168) (183) (198)</li> <li>D1F151 24,13 13,841 10,272 NA NA NA 19047 23,730 (-)4683</li> </ul>	Category         A         C         ATT(A-C)         (-1141)         (-1141)         (-1142)	e	MATs		WMPs			MMPs			JMPs	
D1F050         3207         1623         1584         2559         2670         (-)141           0F1750         3207         1623         1584         2395)         2460         (-)141           0F170         3207         (1473)         (923)         (2395)         (346)         (57)         (436)         (612)           0F150         4021         2555         1466***         4232         2704         1528***         4261         3691         570***           0F150         2000         2286         714**         3745         (204)         (71)         (152)         (142)           0F151         (210)         (277)         (274)         (497)         (692)         (549)         (81)         (120)         (88)           0F151         445         3044         1598***         3372         2676         1056*         4513         3621         892**           0F151         4573         1958         2616         (147)         (146)         (178)         (188)         (188)         (198)           0F1151         4573         1958         2616         (445)         (234)         (357)         (489)*         (198)         (131)         (381)<	D1F050       3207       1623       1584       2529       2670       (-)141         (1473)       (923)       (2395)       (353)       (436)       (612)         00F150       4021       2555       1466***       4232       2704       1528***       4261       3691       570**         00F150       4021       2555       1466***       4232       2704       (71)       (152)       (142)         01F150       3000       2286       714**       3734       2293       1441**       3614       3052       562**         01F151       (210)       (277)       (274)       (497)       (692)       (549)       (81)       (120)       (88)         01F151       4642       3044       1598**       3732       2676       1056*       4513       3621       892**         01F151       4573       1958       2615***       2727       1781       946       4454       2806       1648**         01F151       (337)       (244)       (950)       (564)       (487)       (133)       (138)       (198)         01F151       4573       13581       10,272       N       N       19047       23,730       <		Category	A	υ	ATT(A-C)	A	υ	ATT(A-C)	A	U	ATT(A-C)
(1473)         (923)         (2395)         (3353)         (436)         (612)           D0F150         4021         2555         1466***         4232         2704         1528***         4261         3691         570***           D1F150         3000         2286         714**         3734         2293         1441**         3614         570***           D1F150         3000         2277)         (274)         (497)         (692)         (346)         (71)         (152)         (142)           D1F151         4642         3044         1598***         473         3052         562***         562***           D0F151         4643         3044         1598***         373         2576         1056*         4513         3621         893           D0F151         4573         1958         2615***         2727         1781         946         454         2806         1648***           01F151         4573         13541         10,272         NA         NA         19047         23,730         (198)           01F050         24,113         13,841         10,272         NA         NA         19047         23,730         (-948****	(1473)       (923)       (2395)       (3353)       (436)       (612)         D0F150       4021       2555       1466***       4232       2704       1528***       4261       3691       570***         D1F150       2000       2253       1466***       4232       2704       (71)       (152)       (142)         D1F150       3000       2286       714**       3734       2293       1441**       3614       3052       562***         D1F150       2000       2277)       (274)       (497)       (692)       (549)       (81)       (120)       (88)         D0F151       4573       1598***       3732       2676       1056*       4513       362.**       892**         D1F151       4573       158       2727       1781       946       4454       2806       1648**         D1F153       1337)       (244)       (490)       (564)       (487)       (183)       (193)       (198)         D1F050       24,113       13,3841       10,272       NA       7731       1781       946       4454       2806       1648**         01F050       24,113       13,3841       10,272       NA       NA		D1F0S0	3207	1623	1584				2529	2670	(-)141
D0F1S0         4021         2555         1466***         4232         2704         1528***         4261         3691         570***           (182)         (182)         (248)         (251)         (239)         (346)         (204)         (71)         (152)         (142)           01F1S0         3000         2286         714**         3734         2293         1441**         3614         3052         562***           01F1S1         (210)         (277)         (274)         (497)         (692)         (549)         (81)         (120)         (88)           00F1S1         4642         3600         (274)         (377)         (534)         3577         (149)**         (36)         (31)         (389)           00F1S1         4672         3600         (445)         (234)         (357)         (489)**         (120)         (89)           01F1S1         4573         1958         2615***         2727         1781         946         4454         2806         1648***           (337)         (244)         (490)         (564)         (574)         (487)         (168)         (183)         (198)           01F0S0         24,113         13,841	D0F1S0         4021         2555         1466***         4232         2704         1528***         4261         3691         570***           (182)         (248)         (251)         (239)         (346)         (71)         (152)         (142)           01F1S0         3000         2286         714**         3340         (71)         (152)         (142)           01F1S0         3000         2286         714**         3373         2293         1441**         361         352         562**           0F1S1         4642         3004         1579         (692)         (5549)         (81)         (120)         892**           0F1S1         4673         360         (445)         (334)         (357)         (489)*         (198)         (331)         (382)           01F1S1         4573         1958         2615***         2727         1781         946         4454         2806         1648*           01F0S0         24,113         13,341         10,272         NA         NA         19047         23,730         (-3468           01F0S0         24,113         10,272         NA         NA         NA         19047         23,730         (-3468 <td></td> <td></td> <td>(1473)</td> <td>(923)</td> <td>(2395)</td> <td></td> <td></td> <td></td> <td>(353)</td> <td>(436)</td> <td>(612)</td>			(1473)	(923)	(2395)				(353)	(436)	(612)
(182)         (248)         (251)         (239)         (346)         (204)         (71)         (152)         (142)           D1F150         3000         2286         714**         3734         2293         1441**         3614         3052         562***           0710         (277)         (274)         (497)         (692)         (549)         (81)         (120)         (88)           0711         4642         3304         1538*         3732         2576         1056*         4513         3621         889           071151         4573         1958         2737         1781         946         4454         2806         1648***           01F151         4573         1958         2615***         2727         1781         946         4454         2806         1648***           01F151         4573         1337)         (244)         (490)         (564)         (487)         (487)         (168)         (193)         (198)           01F050         24,113         13,841         10,272         NA         NA         19047         23,730         (-)4683	(182)       (248)       (251)       (239)       (346)       (204)       (71)       (152)       (142)         D1F150       3000       2286       714**       3734       2293       1441**       3614       3052       562***         0       (210)       (277)       (274)       (497)       (692)       (549)       (81)       (120)       (88)         0       0       (71)       (172)       (170)       (182)       562***       562***       562***       562***       562***       562***       562***       562***       562***       562***       562***       563**       563**       563**       563**       563**       563**       563**       563**       564**       577       1781       946       4454       230*       1648**       1748**       1768       1648**       1648**       1648**       1648**       1648**       176**       1781       1448**       1981       1648**       1648**       1727       1781       946       4454       236       1648**       1988       1648**       1988       1648**       1988       1648**       1988       1648**       176**       1781       1648**       176***       1781       1648**       <		D0F1S0	4021	2555	1466***	4232	2704	1528***	4261	3691	570***
D1F1S0         3000         2286         714**         3734         2293         1441**         3614         3052         562***           (210)         (277)         (274)         (497)         (692)         (549)         (81)         (120)         (88)           D0F1S1         4642         3044         1598***         3732         2676         1056*         4513         3621         889           07F1S1         4773         (360)         (445)         (234)         (357)         (489)*         (198)         (331)         (388)           01F1S1         4573         1958         2615***         2727         1781         946         4454         2806         1648***           (337)         (244)         (490)         (564)         (487)         (433)         (168)         (183)         (198)           01F0S0         24,113         13,841         10,272         NA         NA         NA         19047         23,730         (-)4683	D1F1S0     3000     2286     714**     3734     2293     1441**     3614     3052     562***       (210)     (277)     (274)     (497)     (692)     (549)     (81)     (120)     (88)       D0F1S1     4642     3044     1598***     3732     2676     1056*     4513     3621     892**       D0F1S1     4642     3004     1598***     3732     2676     1056*     4513     3621     (389)       D1F1S1     4573     (360)     (445)     (234)     (357)     (489)*     (198)     (331)     (388)       D1F1S1     4573     1958     2615***     2727     1781     946     4454     2806     1648*       01F0S0     24,113     13,341     10,272     NA     NA     NA     19047     23,730     (198)       01F0S0     24,113     13,341     10,272     NA     NA     19047     23,730     (-)468			(182)	(248)	(251)	(239)	(346)	(204)	(11)	(152)	(142)
(210)         (277)         (274)         (497)         (692)         (549)         (81)         (120)         (88)           D0F1S1         4642         3044         1598***         3732         2676         1056**         4513         3621         892**           (473)         (360)         (445)         (234)         (357)         (489)*         (198)         (331)         (388)           D1F1S1         4573         1958         2615***         2727         1781         946         4454         2806         1648***           (337)         (244)         (490)         (564)         (487)         (433)         (168)         (183)         (198)           D1F0S0         24,113         13,841         10,272         NA         NA         NA         19047         23,730         (-)4683	(210)       (277)       (274)       (497)       (692)       (549)       (81)       (120)       (88)         D0F151       4642       3044       1598***       3732       2676       1056*       4513       3621       892**         (473)       (360)       (445)       (234)       (357)       (489)*       (198)       (331)       (388)         D1F151       4573       1958       2615***       2727       1781       946       4454       2806       1648**         (133)       (244)       (490)       (564)       (487)       (433)       (168)       (183)       (198)       (198)       (198)         D1F050       24,113       13,841       10,272       NA       NA       19047       23,730       (-)468         D1F050       24,113       10,272       NA       NA       19047       23,730       (-)468		D1F1S0	3000	2286	714**	3734	2293	1441**	3614	3052	562***
D0F151         4642         3044         1598***         3732         2676         1056*         4513         3621         892**           (473)         (360)         (445)         (234)         (357)         (489)*         (198)         (331)         (388)           01F151         4573         1958         2615***         2727         1781         946         4454         2806         1648***           01F151         (337)         (244)         (490)         (564)         (487)         (433)         (168)         (183)         (198)           01F050         24,113         13,841         10,272         NA         NA         19047         23,730         (-)4683	D0F151       4642       3044       1598***       3732       2676       1056*       4513       3621       892**         (473)       (360)       (445)       (234)       (357)       (489)*       (198)       (331)       (388)         01F151       4573       1958       2615***       2727       1781       946       4454       2806       1648**         01F151       (337)       (244)       (490)       (564)       (487)       (433)       (168)       (183)       (198)         01F050       24,113       13,841       10,272       NA       NA       19047       23,730       (-)468         01F050       24,113       13,841       10,272       NA       NA       19047       23,730       (-)468			(210)	(277)	(274)	(497)	(692)	(549)	(81)	(120)	(88)
(473)         (360)         (445)         (234)         (357)         (489)*         (198)         (331)         (388)           D1F1S1         4573         1958         2615***         2727         1781         946         4454         2806         1648***           (337)         (244)         (490)         (564)         (487)         (433)         (168)         (183)         (198)           D1F0S0         24,113         13,841         10,272         NA         NA         19047         23,730         (-)4683	(473)       (360)       (445)       (234)       (357)       (489)*       (198)       (331)       (388)         D1F151       4573       1958       2615***       2727       1781       946       4454       2806       1648**         (181)       (1337)       (244)       (490)       (564)       (487)       (433)       (168)       (183)       (198)         D1F050       24,113       13,841       10,272       NA       NA       19047       23,730       (-)468         O1F050       24,113       13,841       10,272       NA       NA       19047       23,730       (-)468		D0F1S1	4642	3044	1598***	3732	2676	1056*	4513	3621	892**
D1F151 4573 1958 2615*** 2727 1781 946 4454 2806 1648*** (337) (244) (490) (564) (487) (433) (168) (183) (198) D1F050 24,113 13,841 10,272 NA NA 19047 23,730 (-)4683	D1F151 4573 1958 2615*** 2727 1781 946 4454 2806 1648** 1648** 2727 1781 946 4454 2806 1648** 1648** 216 (198) (118 (118 (118 (118 (118 (118 (118 (1			(473)	(360)	(445)	(234)	(357)	(489)*	(198)	(331)	(388)
(198) (337) (244) (490) (564) (487) (433) (168) (183) (198) (198) (198) (198) (198) (198) (198) (13,841 10,272 NA NA 19047 23,730 (-)4683	(198) (198) (198) (198) (198) (198) (113) (198)		D1F1S1	4573	1958	2615***	2727	1781	946	4454	2806	1648***
D1F050 24,113 13,841 10,272 NA NA NA 19047 23,730 (-)4683	D1F050 24,113 13,841 10,272 NA NA NA 19047 23,730 (-)468. (Continu			(337)	(244)	(490)	(564)	(487)	(433)	(168)	(183)	(198)
	(Continu		D1F0S0	24,113	13,841	10,272	NA	NA	NA	19047	23,730	(-)4683

Table 7. Gendered impacts of MATs on maize yield by rainfall endowment.

		Rainfall-deficit plots								
		(6737)	(8483)	(18,219)				(2924)	(4959)	(6113)
Maize	D0F1S0	25,892	21,466	4426*	27,132	22,608	4524**	28,264	32,201	(-)3937***
		(1297)	(2519)	(2284)	(1766)	(3191)	(1899)	(516)	(1554)	(1442)***
Income	D1F1S0	18,776	18,099	677	24,539	19,335	5204	23,153	26,112	(-)2960***
		(1442)	(2811)	(2400)	(3465)	(6810)	(5246)	(555)	(1261)	(686)
(Birr/ha)	D0F1S1	32,664	24,607	8057*	24,623	22,395	2228	29,812	30,022	(-)210
		(3591)	(3003)	(3575)	(1611)	(3696)	(4408)	(1402)	(3437)	(3597)
	D1F1S1	31,229	15,130	16,099**	16,688	13,017	3671	30,105	21,880	8225***
		(2299)	(2037)	(3387)	(3918)	(3876)	(3439)	(1312)	(1664)	(1893)
			64		33			378		
We report actual	outcome with	multiple MATs (A), co	ounterfactual out	come without MATs	scenario (C) and	difference betwee	in the actual and c	ounterfactual scer	arios as average	treatment effect

Table 7. (Continued).

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least equal to (or potentially higher) than those managed jointly or by men. The significantly higher yields on WMPs compared to JMPs is noteworthy. In some cases, the joint management of resources (i.e., inputs and agricultural plots) may appear as one way to achieve better redistribution and control for men and women (Haider et al., 2018). For example, Ethiopian law now requires that both the husband and wife be jointly listed in land lease certificates (Holden & Bezu, 2014) in order to improve women's access to land. The impacts of this policy shift remain to be analysed. Our findings suggest that this may not be straightforward.

Autonomous management of agricultural plots will require fundamental changes not only in the legal regimes but, more importantly, in social norms and women's bargaining power. For example, in many rural areas, a larger piece of land (constituting the farm) is often subdivided into separate tiny plots among family members, to be operated individually or jointly. In situations where further sub-division of land and individual titling is not feasible (and only small pieces of land can be shared) among household members, the issue of intra-household bargaining power becomes paramount (Marenya et al., 2015).

## 4. Conclusions

There are well-documented disparities among men and women in rural areas with regards to access to and control agricultural resources. Therefore, a more targeted approach to improve women's access to agricultural innovations can increase the overall agricultural productivity. This study uses gender-disaggregated household and plot-level survey data from Ethiopia to explore the impacts of multiple agronomic practices disaggregated by the sex of the plot manager. Using a multinomial endogenous switching regression methodology and controlling for observed and unobserved heterogeneity as well as endogeneity, the study found that MATs have a positive and significant effect on maize yields and maize marginal returns. Moreover, when we controlled for demographics, plot quality and agronomic practices (among others), we found that women managed plots had treatment effects (yields) that were statistically the same as those of male managed plots (and nominally higher in a number of cases). The study confirms that once access to inputs, agronomy, market and extension are controlled for, women farmers' productivity is commensurate with that of male farmers. Implicitly, our results point to the need for more studies on strengthening women's bargaining power (through education and inclusive financial services) and modernising legal regimes to safeguard women's property rights as part of the toolkit for reducing gender-mediated gaps in access to agricultural inputs or resources more broadly.

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