Can participatory video-based extension increase awareness and knowledge of climate adaptation practices?

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Abstract

With growing climate variability and climate change, farmers need to adjust their farming technologies and practices to ensure continued production and income generation. But farmers are often not aware of the most suitable practices under a changing climate. Awareness of adaptation practices is even more limited for women farmers. Traditional extension approaches have mostly retained a status quo or even worsened the gender gap in information provision. In recent years, participatory video screening has been used to show more complex agricultural technologies and practices with the goal to reach both women and men farmers. This study evaluated the impact of a video-based extension on the awareness and adoption of CSA practices among men and women at baseline and endline. Awareness of the promoted CSA practices grew markedly among the treatment farmers, especially with low awareness at baseline. Further, the video-intervention raised awareness more for women than men and thus successfully addressed challenges faced by other extension approaches.

We also find substantial spillover effects of the videos on the awareness of other CSA practices. However, the study found no change in adoption of the practices, suggesting that overcoming the information constraint experienced by farmers is insufficient without also overcoming financial constraints that were particularly severe as a result of the Covid-19 pandemic.

Key words: Climate smart agriculture, Video based extension, Gender sensitive extension, CSA awareness, CSA adoption.

1. Introduction

Climate change threatens global economic development, and the agricultural sector is particularly affected (IPCC 2022; Bakht et al., 2020; Bhuiyan et al., 2017). Between 2004 and 2014, global costs for agriculture associated with climate change, such as crop and animal losses due to flooding and droughts, have surpassed US$100 billion (FAO, 2015b). And climate extreme events are predicted to worsen in the coming decades, with particularly adverse impacts projected for Africa (Ayugi et al., 2022; Nangombe et al., 2018; Serdeczny et al., 2017). The region is expected to be hit particularly strongly due to its reliance on rain-fed agricultural systems. This is due to, among others, Sub-Saharan Africa's high levels of intra- and inter-annual rainfall variability (Ngure et al., 2021) and to the high poverty levels and concomitant limited capacity to adapt (Theis et al., 2019). Drought induced by a poor or failed rainy season occurred once every five to six years before 1999, but the frequency has now increased to every two to three years (Carleton, 2022). Drought-affected areas in East Africa are anticipated to increase by 54% by the end of the century if current trends continue (Haile et al., 2020), exposing millions of people to periods of acute drought (Ayugi et al., 2022; Carleton, 2022). Kenya has experienced several climate-related impacts, including prolonged droughts, frost in some of the country's most productive agricultural areas, hailstorms, extreme flooding, receding lake levels, drying rivers and wetlands, among others. These have resulted in significant economic losses and negatively impacted food security and community livelihoods (Mungai et al., 2017; Waithaka et al., 2013).

To address growing, adverse climate change impacts on agriculture, the concept of Climate Smart Agriculture (CSA) has been promoted over the last decade. CSA is a relatively new set of guiding principles to identify technologies, practices, tools and policies to sustainably increase productivity in the agricultural sector under changing climate regimes while reducing greenhouse gas (GHG) emissions. It includes three pillars: 1) sustainable and equitable increases in agricultural productivity and incomes, 2) greater resilience of food systems and farming livelihoods, and 3) reduction and/or removal of GHG emissions associated with agriculture (Benjamin Arki, 2015; FAO, 2021).

Many projects and interventions have supported CSA approaches and practices in East Africa (FAO, 2021). For instance, in Tanzania, conservation agriculture and agroforestry have raised maize output, increased climate change resilience, and provided mitigation benefits to smallholder farmers (Kimaro et al., 2016, 2019). Improved crop and livestock breeds, crop diversification, mixed cropping, tree planting, irrigation, and enhancing early warning systems with drought monitoring and seasonal forecasts are among the predominant CSA practices identified and implemented in Kenya (Osumba & Rioux, 2015). On the same note, a series of extension approaches ranging from agro-meteorology, farmer field schools, village level participatory approaches (VLPA), to facilitated video screenings, interactive voice response systems, short message reminders, alerts, and collaborative game-based problem solving, among others, have been employed in CSA information dissemination (Chauhan, 2015; David, S., & Asamoah, 2011; FAO, 2015a; GACSA, 2016; Khalak et al., 2018; Villamor et al., 2014). However, there are gender disparities in their effectiveness. For instance, a study on the adoption of composting in Malawi by Cai et al. (2019) involved a participatory video screening approach which lacked focus on the gender dimensions in the sampling strategy. Instead of ensuring that both women and men saw the videos, the first 15 arrivals to the video screening were automatically considered as participants in the post-video screening focus group discussions. Likewise, CSA information dissemination through message reminders and alerts as proposed by Nyasimi et al. (2017) and Waaswa et al. (2022) will most likely reproduce inequitable gender relations as women in Kenya (as other LMICs) are still less likely than men to own a smartphone, and a gender gap of 16% in mobile internet usage still exists (Shanahan, 2022). In a previous study, Jost et al. (2016) found that in Uganda, male farmers understood seasonal weather forecasts sent through SMS and their implication for agricultural production and decision making better than their female counterparts. Further, several CSA programs have been shown to produce inequitable power/authority relations in favor of men which induce vulnerability among women, hence widening gender disparities (Arora-Jonsson, 2011; Eriksen et al., 2019; Karlsson et al., 2017).

In most instances, extension assumes a unitary household model where resources are pooled, and collective decisions are made to promote household utility (Agarwal, 1997). This assumption, however, ignores the influence of men's and women's bargaining power in the home and how gender impacts social norms (e.g., childcare) and incentives (Agarwal, 1997; Bernier et al., 2015). Women, who are crucial contributors to the welfare of their farms and households are disadvantaged in such a model. They are often preoccupied with household chores, thus limiting their time interacting with extension officers and utilizing other sources of CSA information (Agholor, 2019). For instance, in Bangladesh, Ghana, Kenya and Uganda, male farmers dominate in receiving information and extension services, reducing women's opportunities to learn about and eventually adopt CSA practices (Jost et al., 2016; Oniang'o, 2005). Furthermore, goals vary significantly between men and women; women are generally more interested in whether or not the household is food and nutrition secure, while men are often concerned with increasing revenues (Bernier et al., 2015; Jost et al., 2016). There is therefore a need for innovative participatory information sharing and extension models that deliver knowledge of CSA practices and promote their adoption among both men and women. Many research organizations and government institutions have tried to inform farmers on climate change and CSA using different approaches (Brisebois et al., 2022; FAO, 2015a; GACSA, 2016; Mungai et al., 2017; Villamor et al., 2014; FAO, 2021). There is, however, limited information on the effectiveness, acceptance, and adoption of such extension approaches, particularly their application to CSA sensitization and training. There is even less information on the effectiveness of extension approaches in reducing the gender gap in CSA information and adoption. In this light, we designed and implemented an RCT to empirically evaluate participatory video screenings that were developed to enhance reach to women farmers. The study sought to understand the impact of this approach on awareness, knowledge, and adoption of locally available CSA practices. The specific study objectives were to determine the levels of CSA awareness and adoption of CSA practices among men and women at baseline and endline and to examine the effect of an innovative extension approach, participatory video screening, on awareness, knowledge, and adoption of locally viable CSA practices. This study was implemented in 20 clusters in Kenya's Busia, Nakuru, and Laikipia counties.

2. Methodology and data

2.1 Study experimental design

This study is a cluster level randomized controlled trial (RCT) with one treatment and one control group. To avoid contamination, treatment assignment was at cluster level, where administrative locations acted as the study clusters. Treatment households (from treatment clusters) were invited to watch videos on locally viable pre-selected CSA practices while control households (from control clusters) were not. The RCT was preceded by focus group discussions and key informant interviews which informed the design of the RCT and also the selection of the locally viable CSA practices that were included in the videos. The CSA practices targeted by the videos were zai pits, minimum tillage/no till, and cover cropping. The videos featured women farmers from the grassroots women's organization GROOTS Kenya, who also implemented the video roll out. The videos featured lead farmers who were already adopting some CSA practices in the study counties where the specific practices had been identified during the qualitative formative research. Videos were shown to groups of farmers followed by a group discussion of the video content with input and support from a location extension officer as well as from GROOTS Kenya. We assess participation as well as household-level awareness and application of the filmed CSA practices.

1.1. Sampling

The study was implemented in three counties of Kenya namely, Busia, Laikipia and Nakuru. The counties were purposively selected in conjunction with the local implementing partner, GROOTS Kenya, because of its presence in different agro-ecological zones. Two sub-counties were then purposively selected from Nakuru (Molo and Kuresoi North sub-counties) and Laikipia (Laikipia East and Laikipia West sub-counties) counties and one subcounty was selected from Busia (Budalangi sub-county). Based on lists of all the locations from the selected sub-counties, and after excluding peri-urban, pastoralist and other nonagricultural locations, stratified random selection was used to identify 4 locations per sub-county (2 where GROOTS was present and 2 where they were not) and hence 20 locations in total, 10 with GROOTS interventions and 10 without. These locations serve as the clusters for this study which serve as the units for random assignment to either control or treatment groups. Survey supervisors met with local chiefs of the respective locations who provided them with the list of sublocations in their locations where they, using raffles, randomly selected two sub-locations, and then got a list of the villages in each of the two sublocations and using the same method, randomly selected one village per sublocation, and hence two villages per location and 40 villages in total. Later, the supervisors met with the village elders and GROOTS local representatives who provided them with the lists of households within their villages. After dropping all the households without a principal female, the supervisors used a web-based research randomizer application (https://www.randomizer.org/) to randomly select 25 households per village. We required 18 households per village (36 per location) to reach our target of 740 households in total. We inflated the randomly selected households per village to 25 to allow for potential replacements if households could not be reached.

1.2. Survey instruments and data collection

The study involves panel data – a baseline survey conducted in February 2020, prior to intervention implementation, and a follow-up survey conducted in February 2022 after the treatment implementation was completed. The initial plan was to implement the interventions immediately after the baseline survey followed by a follow-up survey about one year later. This was however disrupted by the COVID-19 pandemic and associated restrictions leading to staggered implementation over a period of about 1.5 years. To capture gender dynamics in CSA practices, information sources and access as well as production, we conducted dual-headed household surveys where we interviewed the principal male and principal female in each household where possible, and the principal female only where a principal male was absent. Households without principal females were excluded at sampling stage. The interviews were conducted using pretested questionnaires with modules covering information on household characteristics, household assets, crop and livestock production, agricultural input and output markets, CSA practices and a knowledge test on CSA in the endline and information on agricultural information sources.

1.3. Data

1.3.1. Respondents' characteristics and covariate balancing

Table 1 presents the mean for the control group and the socioeconomic covariates balancing tests between treatment and control groups. The parenthesis in the control mean column contains standard deviations while all the others contain standard errors from the respective regression estimations. The covariate balance test assesses the effectiveness of our randomization and experimental design. For these tests, we estimated a series of regression equations where each selected covariate was regressed against the binary treatment assignment variable equal to zero for control and one for treatment, viz farmers who were randomly selected and invited to watch videos on selected CSA practices. Both the control and treatment groups were statistically similar in all the selected covariates (see the Coeff column). Further, we test for joint orthogonality (not in the table) where we model a multinomial logit with treatment category as the outcome variable and the selected baseline covariates as the predictors. The test for joint orthogonality yields a F-value of 0.5997 and hence, rejecting the null hypothesis, the covariates can be considered as jointly orthogonal. This implies there was no selection bias in treatments assignment suggesting confidence in our experimental design.

Table 1: Covariate balancing and participants characteristics – baseline measurements.

	Control characteristics		Covariate balance test (Treated=1, Control=0)			
VARIABLES	N	Mean	Coeff	Constant	N	R-sqr
Female adult only Vs both male and female adult household	361	0.77	-0.03	0.773***	719	0.001
		(0.42)	(0.032)	(0.023)		
How long has the household been involved in farming?	361	21.46	-0.211	21.457***	719	0.001
		(13.80)	(1.059)	(0.747)		
Gender of household head	361	0.75	-0.036	0.745***	719	0.002
		(0.44)	(0.033)	(0.023)		
Age of household head	356	53.33	0.646	53.333***	710	0.001
		(14.59)	(1.082)	(0.764)		
Age of spouse	275	44.39	1.369	44.387***	531	0.002
		(14.15)	(1.243)	(0.863)		
Household head years of formal education	356	7.62	-0.257	7.617***	709	0.001
		(4.01)	(0.308)	(0.218)		
Spouse years of formal education	275	7.27	-0.31	7.275***	531	0.002
		(3.58)	(0.320)	(0.222)		
Size of the household	361	5.09	-0.038	5.089***	719	0.001
		(2.36)	(0.176)	(0.124)		
Dependency ratio	339	102.39	-7.881	102.390***	674	0.002
		(94.07)	(6.799)	(4.793)		

Source: Authors.

1.3.2. Measuring participation and compliance rate

In an RCT, treatment individuals are presented with an opportunity to participate in an intervention, but participation is not enforced but left to their own volition. In this study, 572 (325 women and 247 men) farmers were offered an opportunity to watch the videos described above. Table 2 presents participation and compliance rate among the treatment households. About 60% of them indicated that they were aware of the videos that had been screened at some point during the previous 1.5 years by the implementing partner, GROOTS, and about 56% stated they had received an invitation to watch them. A higher percentage of women (just above 60%) than men (below 60%) were aware of and received an invitation to watch the videos. The invitations were mostly from GROOTS (48%) community mobilizers who included GROOTS local volunteers (57%) and extension agents (11%) who collaborated with GROOTS in the field. Out of 572 farmers in the treatment group, about 46% indicated that they got to watch the videos, indicating a fair compliance rate. Compliance was substantially higher among women (51%) than men (41%).

Table 2: Assessing participation and compliance rate among treatment farmers

	Women		Men		Overall	
	N	Mean	N	Mean	N	Mean
Aware of the videos that were shown by GROOTS and extension officers?	325	0.637	247	0.555	572	0.601
		(0.482)		(0.498)		(0.490)
Did you receive an invitation to watch the videos?	325	0.612	247	0.498	572	0.563
		(0.488)		(0.501)		(0.496)
From whom did you receive the invitation - GROOTS	199	0.467	123	0.504	322	0.481
		(0.500)		(0.502)		(0.500)
From whom did you receive the invitation - Extension agents	199	0.101	123	0.114	322	0.106
		(0.301)		(0.319)		(0.308)
From whom did you receive the invitation - Community mobilizers	199	0.583	123	0.537	322	0.565
		(0.494)		(0.501)		(0.497)
From whom did you receive the invitation - Neighbor/friend	199	0.000	123	0.008	322	0.003
		(0.000)		(0.900)		(0.056)
Did you personally watch the videos when they were brought?	325	0.505	247	0.405	572	0.462
		(0.501)		(0.492)		(0.499)
Got opportunity to watch the videos at a later time from another source?	161	0.006	147	0.007	308	0.006
		(0.079)		(0.082)		(0.080)
Got an opportunity to talk about the videos with someone who had watched them?	161	0.186	147	0.245	308	0.214
		(0.391)		(0.431)		(0.411)
How many times did you watch the videos?	165	1.315	101	1.406	266	1.35
		(0.795)		(1.097)		(0.920)

Source: Authors.

1.4. Analysis and empirical framework

In this study, we provide evidence on the role of a gender sensitive information dissemination method in improving awareness and use of CSA practices among women and men farmers. To do so, we first estimate intent to treat (ITT) effects and then local average treatment effects (LATE). ITT estimates represent the average effect of being randomly assigned to a treatment group and being offered the opportunity to participate in the video screenings, whether one attends the screening sessions or not. With an overall compliance rate of about 46% (51% among women and 41% among men), ITT effects are diluted by noncompliance among the treatment households (Angrist, 2006). Although important for policy formulation, ITT are not a true representation of the treatment effect on the participating individuals (Angrist & Pischke, 2008; Armitage, 1979; Duflo et al., 2007; Soderbom et al., 2015). LATE, on the other hand, represents the effect of participating in the videos' screening sessions, or complying with the treatment.

For robustness checks, we rely on two different estimators to estimate both ITT and LATE. They are i) simple means difference (SMD) and ii) analysis of covariance (ANCOVA). Both are estimated from post intervention data or the follow-up. ANCOVA, however, controls for baseline heterogeneity in both household characteristics by use of covariates and in the baseline outcome of interest by including the baseline measurements of the outcome variable as a control variable and is hence a more efficient estimator than SMD.

To estimate the ITT effects, we specify the equation below:

$$y_i = \alpha + \beta_{SMD} T_i + \varepsilon_i \qquad (1)$$

We first estimate this as simple means difference (SMD) using the post treatment observations where y_i is a vector of the observed outcome variables for household i post treatment; T_i is the household-level treatment indicator equal to one if a household was randomly assigned to the treatment group and zero otherwise, and ε_i is the idiosyncratic error term. The parameter of interest is β_{SMD} which captures the ITT simple means difference effects, or the effect of being randomly assigned to the treatment group. We then estimate the equation using analysis of covariance (ANCOVA) approach where we control for baseline heterogeneity in the outcome variable as shown in the equation below:

$$y_i = \alpha + \beta_{\text{ANCOVA}} T_i + \beta_1 y_{i0} + \varepsilon_{it} \qquad (2),$$

where, in addition to the already described abbreviations, y_{i0} represents the baseline measurement of the outcome variable, and hence an autoregressive model. Here, the parameter of interest is β_{ANCOVA}, giving the ITT effects, viz. the effect of being randomly assigned to the treatment group.

To estimate LATE, we rely on the instrumental variable technique to account for imperfect compliance. We employ a two-stage least squares (2SLS) approach where participation in video screenings is instrumented for by random assignment to either treatment or control group. In RCTs, random assignment to treatment and control groups is the ideal instrument which meets the validity, relevance, and strength conditions. In the first stage, participation in video screenings is regressed on treatment random assignment. The first stage estimation equation (3) predicts individual level participation P_i in video screenings:

$$P_i = \alpha + \delta_{Stage1} T_i + \varepsilon_{it} \quad (3)$$

We then estimate LATE using the IV specification as below where we use the predicted participation in the second stage equation to estimate the actual effect of participation in video screenings on our outcome variables. We start with simple means difference estimation as below:

$$y_i = \alpha + \delta_{SMD} \hat{P_i} + \varepsilon_i \quad (4)$$

Where $\hat{P_i}$ represents the first stage predicted participation values and δ_{SMD} the IV parameter of interest which gives the LATE. Again, we estimate the above equation with ANCOVA where we include the baseline measurement of the respective outcome variable (y_{i0}) to control for any observed baseline heterogeneity among the treatment and control groups and hence estimate the equation below:

$$y_i = \alpha + \delta_{ANCOVA} \hat{P_i} + \beta_1 y_{i0} + \varepsilon_i \quad (5)$$

2. Results

2.1. Assessing awareness and adoption levels of CSA practices

Here, we compare CSA awareness and adoption between women and men farmers both at baseline and endline (Table 3). To provide some descriptive insights into the possible changes over time and between experimental groups, we disaggregate follow-up observations between control and treatment farmers. Results indicate that awareness and adoption of zai pits was very low at baseline. Only 12% of women and 18% of men farmers were aware of Zai pits as a CSA practice, and the gender difference was statistically significant at p<1%. Among those aware of the practice, adoption was also low with 38% of women and 29% of men adopting zai pits in their farms, with no statistically significant gender differences. Similarly, only 38% of women and 44% of men were aware of minimum tillage as a CSA practice at baseline, and the gender difference was significant at p<5%. About half of those aware of minimum tillage said that they were practicing it on their farms and there were no significant gender differences in adoption of the practice.

On the other hand, awareness and adoption of cover crops as a CSA practice was considerably high at baseline. About 60% of women and 66% of men were aware of the practice and over 70% were adopting it in their farms. Like the other two practices, there was a statistically significant gender difference in awareness ($p<10\%$) but not in adoption.

There was a substantial (and un-expected) increase among control farmers in awareness of zai pits and minimum tillage between baseline and follow-up; the trend was similar for both women and men farmers. They both increased by about 20%. The increase is also reflected in the adoption of minimum tillage which increased by about 20% for both women and men. The adoption of zai pits among women in the control group was constant between baseline and endline while that of men grew by about 10%. Awareness and adoption of cover cropping among women and men in the control group remained consistent between baseline and endline.

Awareness of the promoted CSA practices grew markedly among the treatment farmers, especially for the practices whose awareness at baseline was very low, namely zai pits and minimum tillage. The increase in awareness of these two practices is seemingly higher among women than men. Awareness of zai pits among women in treatment group grew about 4-fold from 12% to 45% and about 3-fold from 18% to 48% among men. Awareness of minimum tillage among women in the treatment group grew about 2-fold from 38% to 71% and about 1.5-fold from 44% to 70% among their men counterparts. Awareness of cover cropping, which was already high at baseline, grew modestly among both women and men in the treatment group, with slightly higher improvement among women. We do not see much change in the adoption of zai pits and cover cropping between baseline and follow-up among women and men from the treatment group. It is however worth noting that an increase in awareness and consistency in adoption rate conditional on awareness translates to more adopters in terms of absolute numbers. Further, adoption of zai pits and minimum tillage was substantially lower than that of cover cropping across women and men, for treatment and control farmers. The two are more capital, labor and decision intensive, which may be curtailing their adoption.

These results point to some interesting reflections. First, awareness helps break the adoption bottlenecks. We see adoption following awareness trends where the practices whose awareness level was high also had higher adoption levels. We also see increased adoption in absolute numbers at endline, which follows increased awareness. Second, awareness breaks gender differences in adoption. We see statistically significant gender differences in awareness of the three CSA practices at baseline, while no statistically significant differences in adoption among men and women who are aware of a practice. Further, our interventions raised awareness more for women than men and thus successfully addressed challenges faced by other extension approaches.

Table 3: Assessing awareness and adoption levels of CSA practices

	CSA awareness			CSA adoption - Conditional on awareness		
	Female (N=716)	Male (N=442)	Sig. (N=115)	Female (N=716)	Male (N=442)	Sig. (N=1158)
Panel A: Baseline						
Zai Pits/Planting Pits	12%	18%	0.006	38%	29%	0.232
No till/Minimum tillage	38%	44%	0.025	45%	46%	0.791
Cover Cropping	60%	66%	0.08	77%	73%	0.29
Panel B: Endline control						
Zai Pits/Planting Pits	37%	41%	0.399	37%	40%	0.615
No till/Minimum tillage	59%	68%	0.023	64%	61%	0.528
Cover Cropping	57%	61%	0.387	73%	71%	0.668
Panel C: Endline treatment						
Zai Pits/Planting Pits	45%	48%	0.457	35%	36%	0.781
No till/Minimum tillage	71%	70%	0.900	64%	61%	0.494
Cover Cropping	67%	71%	0.393	73%	66%	0.132

Source: Authors.

2.2. Intent-to-treat effects on awareness of promoted CSAs

We assessed the effect of being randomly offered an opportunity to attend the video screening on the awareness of CSA practices promoted through videos, regardless of whether farmers participated in the treatment (screening days) or not, also called ITT, using simple mean differences (SMD) as well as analysis of covariance (ANCOVA). Results are presented in Table 4. We find that the videos were effective in increasing awareness of the promoted CSA practices, with some variations between women and men. The videos increased the awareness of zai pits by about 8% among women. They also increased awareness of zai pits among men; but with a substantial difference between SMD (9%) and ANCOVA estimates (18%). The videos also increased awareness of minimum tillage and no till as CSA practices by about 12% among women without a statistically detectable effect on men. They further increased awareness of cover cropping among women by about 10% and among men by about 11% when SMD is estimated and 13% when ANCOVA is estimated. The ITT ANCOVA are the preferred results compared to ITT SMD results because they eliminate substantial biasness by controlling for baseline (lagged) outcome values. We are more confident about the results since the ITT ANCOVA and ITT SMD give consistent significant results. In this case, we see awareness impacts on cover crops, zai and minimum tillage, the technologies directly targeted by the videos.

Table 4: CSA awareness ITT results

	ITT SMD				ITT ANCOVA			
	Female		Male		Female		Male	
VARIABLES	Coeff	Constan	Coeff	Constan	Coeff	Y-lag	Coeff	Y-lag
Zai Pits/Planting Pits	0.088**	0.401**	0.091*	0.126	0.078**	-0.023	0.180**	0.139*
	(0.039)	(0.121)	(0.045)	(0.146)	(0.039)	(0.059	(0.050)	(0.066)
No till/Minimum	0.120**	0.602**	0.030	0.663**	0.121**	-0.01	0.022	0.04
	(0.038)	(0.117)	(0.042)	(0.137)	(0.038)	(0.039	(0.048)	(0.048)
Cover Cropping	0.100**	0.635**	0.109*	0.620**	0.099**	0.071	0.130**	0.046
	(0.039)	(0.119)	(0.043)	(0.140)	(0.039)	(0.039	(0.049)	(0.051)

Source: Authors.

2.3. Local average treatment effects on awareness of promoted CSAs

We also examined the effect of participating in the treatment, or watching the videos, on the awareness of the same CSA practices explained earlier. This is commonly referred to as average treatment effect on the treated (ATT) or local average treatment effect (LATE). We use two-stage least squares approach to account for imperfect compliance, where random assignment to either treatment or control groups was used as an instrument for actual participation in the treatment/watching the videos. We estimate LATE first as simple mean differences (SMD) and then as analysis of covariance (ANCOVA). The results are presented in Table 5.

As expected, LATE results are consistent with the ITT results, particularly on the direction of the relationship and the statistical significance. Further, the effect coefficients are substantially larger here than the ITT coefficients. ITT is normally attenuated by imperfect compliance and hence an understatement of the actual effect size, which is corrected by LATE. Participation in the treatment (watching the videos) increased awareness of zai pits among women by about 18% when SMD was estimated and about 16% when ANCOVA was estimated. It also increased awareness of zai pits among men by about 23% when SMD was estimated and by about 37% when ANCOVA was estimated. The same increased the awareness of minimum tillage among women by about 25% from both SMD and ANCOVA estimations. Further, participation increased the awareness of cover cropping among women by about 21% and among men by about 27% under both SMD and ANCOVA estimations.

Table 5: CSA awareness LATE results

	LATE SMD				Late ANCOVA					
	Female		Male		Female			Male		
VARIABLES	Coeff	Constant	Coeff	Constant	Coeff	Y-lag	Constant	Coeff	Y-lag	Constant
Zai Pits/Planting	0.183**	0.365***	0.232**	0.144	0.161**	-0.022	0.372***	0.365***	0.11	0.328***
Pits	(0.081)	(0.124)	(0.113)	(0.145)	(0.081)	(0.059)	(0.030)	(0.107)	(0.069)	(0.039)
No till/Minimum	0.249***	0.554***	0.076	0.668***	0.252***	-0.01	0.586***	0.045	0.04	0.664***
tillage	(0.078)	(0.120)	(0.104)	(0.135)	(0.079)	(0.039)	(0.032)	(0.097)	(0.048)	(0.041)
Cover Cropping	0.206***	0.594***	0.275**	0.643***	0.207***	0.069*	0.526***	0.265***	0.049	0.555***
	(0.079)	(0.121)	(0.109)	(0.139)	(0.079)	(0.039)	(0.037)	(0.101)	(0.052)	(0.050)

Source: Authors.

2.4. Treatment effects on awareness of other CSA practices

We also tested ITT and LATE effects of the videos on a host of other CSA practices which were not directly targeted by the videos. A summary of these results is presented in Figure 1 which shows the treatment effect sizes of all the practices which were significantly affected by our interventions. The ITT effects are in Panel A and LATE in Panel B of the figure. Detailed results can be found in Annex Table 1 and Annex Table 2 for the ITT and LATE (respectively) in the annex section.

Considering the ITT results in Panel A of Figure 1 and Annex Table 1, the videos increased awareness of terraces and bunds as CSA practices by about 7% among women but the effect among men was not statistically detectable. Similarly, they increased awareness of water harvesting as a CSA practice by about 9% among women without a statistically significant effect among men. On the other hand, they increased awareness of irrigation use as a CSA practice by about 4% among men without a significant effect among women. They increased awareness of livestock manure management of men by about 51% when measured with SMD and 17% when measured with ANCOVA but had no statistically significant effect on women. They also increased the awareness of use of improved grain storage by about 7% (SMD) and 8% (ANCOVA) among women and about 10% (SMD) and 13% (ANCOVA) among men. They increased awareness of destocking/restocking as a CSA practice among women by about 6% but this was significant only in the ANCOVA model. They further increased switching to drought and pest tolerant species or breeds as a CSA practice among men by about 7% under SMD and 11% under ANCOVA estimation although the former was not statistically significant. The effect on women was neither substantial nor statistically significant. They increased the awareness of integrated pest management by about 8% among women and by about 12% (SMD) and 10% (ANCOVA) among men. They increased the awareness of composting chicken manure by about 16% among women. They also increased the awareness of integrated soil fertility management as CSA by about 17% among women but not men.

Considering the LATE results in Panel B of Figure 1 and Annex Table 2, participating in the treatment (watching the videos) increased awareness of terraces and bunds as CSA practice by about 14% among women but the effect among men was not statistically detectable. Awareness of water harvesting increased by about 19% among women but with an insignificant effect among men, while awareness of irrigation increased by about 10% for men, but had an insignificant effect among women. Moreover, awareness of livestock manure management increased by about 18% among men when SMD was estimated and by about 14% when ANCOVA was estimated although the later, albeit substantial, was not statistically significant. Additionally, watching the videos followed by the group discussions increased awareness of improved grain storage by about 15% under SMD and by about 17% under ANCOVA among women and by about 25% under SMD and 27% under ANCOVA among men. It also increased awareness of destocking/restocking by about 13%, although this was only statistically significant under ANCOVA but not the SMD estimation. The effect among men's awareness of this practice was also substantial (14% and 9% under SMD and ANCOVA, respectively) but not statistically significant. It increased awareness of switching to drought and pest tolerant species or breeds as a CSA practice by about 17% under SMD and 21% under ANCOVA but the former, although substantial, was not statistically significant. The effect of watching the videos on awareness of this practice among women was substantial (about 10% in both SMD and ANCOVA) but not statistically significant. It increased awareness of IPM among women by about 17% under both SMD and ANCOVA estimations and among men by about 30% and 21% under SMD and ANCOVA, respectively. Awareness of use of composted chicken manure as a CSA practice increased by about 51% among women without any statistically significant effect among men. Finally, awareness of integrated soil fertility management increased by about 54% among women and about 16% among men. The effect among men, although substantial, was not statistically significant.

We expect the spill-over effects to be linked to the group discussion following the showings of the four videos in the villages that was facilitated by an extension officer and supported by GROOTS Kenya. The group discussion focused on answering questions that were raised as a result of the videos. Recorded discussion topics included implications of climate change, more in-depth explanations of the practices shown on videos as well as topics on integrated soil fertility management, managing fields during floods and droughts, and water management.

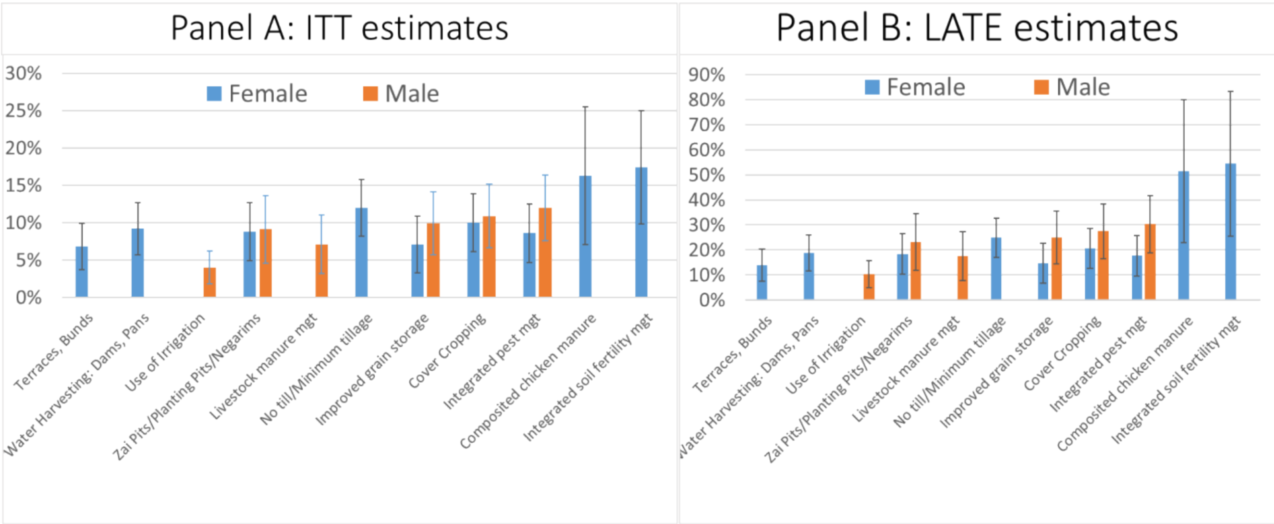

Figure 1: ITT and LATE estimates on targeted and non-targeted CSA practices
Source: Authors.

2.5. ITT effects and LATE on adoption of CSA practices

We also analyzed if there was an uptake of CSA practices following the video showings. ITT results are in Panel A and LATE results in Panel B of Table 6. The videos did not have any direct positive effect on the adoption of the listed CSA practices. Counterintuitively, we see some negative correlation between treatment and adoption of zai pits. However, this is only with ANCOVA estimation and with low statistical significance of p<10%. We see similar results on other CSAs beyond those directly targeted by the videos (see Annex Tables 3 and 4 for ITT and LATE results, respectively). These results may be disappointing and counterintuitive. They however suggest that, although information is an important constraint, it is evidently not the only constraint to the adoption of CSA practices. This is indeed supported by the responses on the important constraints to practicing CSAs asked to those who indicated they were aware of a particular practice but did not use it on their farms. The results, summarized in Figure 2, place information constraint in third place after capital costs and the expectation of no benefits. Other important constraints include lack of in-depth training besides awareness, misfit to soil conditions, labor and inputs insufficiency and failure with past attempts. Further, two of the targeted CSAs, zai pits and minimum tillage, are more time and/or capital intensive and thus might take more than a video showing to adopt. As such, CSA information campaigns need to be bundled with interventions that mitigate other constraints. Further, extended intervention/exposure to the videos/CSAs beyond a single showing might be needed; moreover, farmers were facing multiple other constraints during the video showings linked to the Covid-19 pandemic.

Table 6: CSA practice ITT and LATE results

	SMD				ANCOVA					
	Female		Male		Female			Male		
VARIABLES	Coeff	Constant	Coeff	Constant	Coeff	Y-lag	Constant	Coeff	Y-lag	Constant
Panel A: ITT										
Zai Pits/Planting Pits	0.003	-0.027	-0.053	0.194	-0.335*	-0.202		0.067	-0.113	
	(0.061)	(0.193)	(0.067)	(0.221)	(0.170)	(0.168)		(0.169)	(0.179)	
No till/Minimum tillage	0.001	0.657***	0.007	0.649***	-0.026	0.105		0.001	0.063	
	(0.049)	(0.143)	(0.053)	(0.180)	(0.075)	(0.076)		(0.088)	(0.088)	
Cover Cropping	-0.006	0.621***	-0.064	0.551***	-0.049	0.116*		-0.026	0.07	
	(0.046)	(0.142)	(0.052)	(0.174)	(0.057)	(0.066)		(0.073)	(0.082)	
Panel B: LATE										
Zai Pits/Planting Pits	0.006	-0.029	-0.125	0.214	-0.558*	-0.266	0.682***	0.105	-0.104	0.411***
	(0.103)	(0.197)	(0.155)	(0.224)	(0.326)	(0.200)	(0.195)	(0.258)	(0.173)	(0.122)
No till/Minimum tillage	-0.001	0.657***	0.017	0.652***	-0.053	0.103	0.654***	0.003	0.062	0.639***
	(0.094)	(0.147)	(0.126)	(0.176)	(0.150)	(0.075)	(0.071)	(0.161)	(0.087)	(0.075)
Cover Cropping	-0.011	0.623***	-0.154	0.517***	-0.09	0.115*	0.669***	-0.049	0.072	0.648***
	(0.087)	(0.144)	(0.122)	(0.172)	(0.105)	(0.067)	(0.071)	(0.136)	(0.081)	(0.076)

Source: Authors.

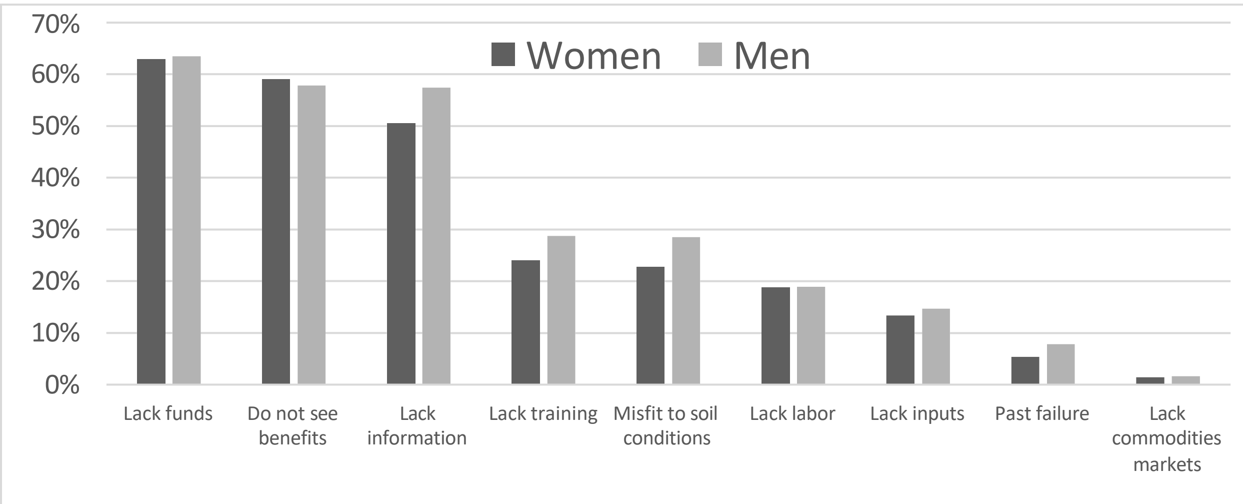

Figure 2: Constraints to adoption of CSA practices
Source: Authors.

3. Conclusions

Climate change continue to devastate agricultural production in most parts of the globe with African farmers, who are already resource constrained and have low capacity to adapt, bearing the brunt of it. Seasons of poor and/or failed rains have double in frequency in the last two decades and the geographical areas affected by drought has significantly expanded too, especially in the sub-Saharan region. In the last one decade or so, the concept of climate smart agriculture (CSA) has been widely promoted in this region as a way of mitigating the effects of climate change on smallholders livelihoods and well-being. There, however, exists a gender disparity in the awareness, knowledge and adoption of CSA practices. This can be attributed to gender insensitive extension an dissemination approaches used which mostly assume a unitary household model, which is in most instances not the case. In such traditional extension approaches, male farmers dominate in receiving information and extension services which reduces women's opportunity to learn about and adopt CSAs. In this study, we empirically evaluate participatory video screening extension approach as a model of promoting knowledge and adoption of CSA practices to both women and men farmers, in a way that minimizes the existing gender disparities. The CSA practices selected for this study were zai pits, minimum/zero tillage and cover cropping. We offered 572 farmers (325 women and 247 men) an opportunity to participate in video screenings about the selected CSAs, which were relevant for their agro-ecologies and the common agricultural activities in their regions, yet not widely adopted, as revealed by pre-RCT qualitative scoping work. Endline data reveals that 46% of the treatment farmers participated in the video screening sessions, indicating a fair compliance rate. Substantially more women (51%) than men (41%) participated in the screening sessions. Of the three promoted CSA practices, we see that low awareness translates to low adoption, as with zai pits and minimum/zero tillage, while high awareness translates to high adoption, as with cover cropping. We also see gender differences in awareness of promoted CSA practices but not in their adoption (conditional on awareness). This suggests that, with awareness, men and women are equally likely to adopt CSA practices. Further, our intervention was effective in increasing the awareness of the three promoted CSAs, with a markedly lager effect on zai pits and minimum/zero tillage whose awareness at baseline was very low. Notably, the intervention's awareness effects were higher among women than their men counterparts, hence effectively addressing the existing gender gaps in awareness of CSA practices. We also observe some spill-over effects where awareness grew even for some CSA practices which were not included in the intervention. We attribute this to the discussions and Q&A sessions that followed after video screenings within treatment villagzes. However, increased awareness did not necessarily lead to increased adoption of the promoted CSA practices. This suggests that information, although important, is not the only constraint to adoption of CSA practices, and this was corroborated by their responses on important constraints to adoption of CSA practices, where information was third after capital and benefits expectations. There were other important constraints mentioned including misfit to soil conditions, labor and inputs insufficiency and past failures with CSA practices. We recommend that such CSA information campaigns be bundled with interventions that mitigate other constraints such as access to capital via credit, risk mitigation efforts that encourage investment in high-risk high-return options, etc. Further research could be necessary to identify/design such bundled interventions as well as evaluate them empirically prior to widespread scaling. We also recommend that such CSA information campaigns consider extended intervention/exposure to the videos beyond a single showing, couple with some more detailed training to increase technical understanding of CSA practices beyond awareness, which may be necessary for widespread adoption of such practices.

REFERENCES

Agarwal, B. (1997). "Bargaining" and gender relations: Within and beyond the household. In *Feminist Economics* (Vol. 3, Issue 1). https://doi.org/10.1080/135457097338799

Agholor, A. . (2019). Gender Gap in Sub-Saharan Africa, Reminiscence of Rural Extension and Advisory Services: Delineation, Challenges and Strategies. *South African Journal of Agricultural Extension*, *47*(3), 46–60.

Angrist, J. D. (2006). Instrumental variables methods in experimental criminological research: What, why and how. *Journal of Experimental Criminology*, *2*(1), 23–44.

Angrist, J. D., & Pischke, J.-S. (2008). Mostly Harmless Econometrics : An Empiricist's Companion. In *Massachusettts I nstitute of Technology and The London school of Economics*.

Armitage, P. (1979). The Analysis of Data from Clinical Trials. *Journal of the Royal Statistical Society (The Stastician)*, *28*(3), 171–183.

Arora-Jonsson, S. (2011). Virtue and vulnerability: Discourses on women, gender and climate change. *Global Environmental Change*, *21*(2), 744–751. https://doi.org/10.1016/j.gloenvcha.2011.01.005

Ayugi, B., Eresanya, E. O., Onyango, A. O., Ogou, F. K., Okoro, E. C., Okoye, C. O., Anoruo, C. M., Dike, V. N., Ashiru, O. R., Daramola, M. T., Mumo, R., & Ongoma, V. (2022). Review of Meteorological Drought in Africa: Historical Trends, Impacts, Mitigation Measures, and Prospects. *Pure and Applied Geophysics*, *179*(4), 1365–1386. https://doi.org/10.1007/s00024-022-02988-z

Bakht, S., Safdar, K., Khair, K. ., Fatima, A., Fayyaz, A., Ali, S. ., Munir, H., & Farid, M. (2020). The Response of Major Food Crops to Drought Stress: Physiological and Biochemical Responses. In *Agronomic Crops* (Vol. 3, pp. 93–115). Springer. https://doi.org/10.1201/9781351070706-5

Benjamin Arki. (2015). *5 Ways to Reduce the Drivers of Climate Change*. The World Bank. https://www.worldbank.org/en/news/feature/2015/03/18/5-ways-reduce-drivers-climate-change

Bernier, Q., Meinzen-Dick, R., Kristjanson, P., Haglund, E., Kovarik, C., Bryan, E., Ringler, C., & Silvestri, S. (2015). Gender and institutional aspects of climate-smart agricultural practices: evidence from Kenya. *CCAFS Working Paper*, *79*.

Bhuiyan, C., Saha, A. K., Bandyopadhyay, N., & Kogan, F. N. (2017). Analyzing the impact of thermal stress on vegetation health and agricultural drought–a case study from

Gujarat, India. *GIScience and Remote Sensing*, *54*(5), 678–699. https://doi.org/10.1080/15481603.2017.1309737

Brisebois, A., Eriksen, S. H., & Crane, T. A. (2022). The Politics of Governing Resilience: Gendered Dimensions of Climate-Smart Agriculture in Kenya. *Frontiers in Climate*, *4*(June). https://doi.org/10.3389/fclim.2022.864292

Cai, T., Steinfield, C., Chiwasa, H., & Ganunga, T. (2019). Understanding Malawian farmers' slow adoption of composting: Stories about composting using a participatory video approach. *Land Degradation and Development*, *30*(11), 1336–1344. https://doi.org/10.1002/ldr.3318

Carleton, E. (2022). *Climate change in Africa: What will it mean for agriculture and food security?* ILRI News. https://www.ilri.org/news/climate-change-africa-what-will-it-mean-agriculture-and-food-security

Chauhan, N. M. (2015). Krishi Mahotsav , a new TOT tools in Gujarat for Extension Management. *International Journal of Innovative Science, Engineering & Technology*, *2*(1), 9–21.

David, S., & Asamoah, C. (2011). Video as a tool for agricultural extension in Africa : a case study from Ghana Soniia David and Christopher Asamoah Sustainable Tree Crops Program , International Institute of Tropical Agriculture , Ghana. *International Journal of Education and Development Using Information and Communication Technology*, *7*(1), 26–41.

Duflo, E., Glennerster, R., & Kremer, M. (2007). Using Randomization in Development Economics Research: A Toolkit. In *Handbook of Development Economics, Vol 4, Chapter 61* (pp. 3895–3962).

Eriksen, S. H., Cramer, L. K., Vetrhus, I., & Thornton, P. (2019). Can Climate Interventions Open Up Space for Transformation? Examining the Case of Climate-Smart Agriculture (CSA) in Uganda. *Frontiers in Sustainable Food Systems*, *3*(December), 1–17. https://doi.org/10.3389/fsufs.2019.00111

FAO. (2015a). *Building resilient agricultural systems through farmer field schools – Integrated Production and Pest Management Programme (IPPM).*

FAO. (2015b). The impact of natural hazards and disasters on agriculture and food security and nutrition: A call for action to build resilient livelihoods. In *A Call for Action to Build Resilient Livelihoods* (Issue May, p. 16).

FAO. (2021). *Climate-smart agriculture case studies 2021; Projects from around the world*.

GACSA. (2016). *Supporting agricultural extension towards Climate-Smart Agriculture An* *overview of existing tools* (S. Sala, F. Rossi, & S. David (eds.); Issue May).

Haile, G. G., Tang, Q., Hosseini-Moghari, S. M., Liu, X., Gebremicael, T. G., Leng, G., Kebede, A., Xu, X., & Yun, X. (2020). Projected Impacts of Climate Change on Drought Patterns Over East Africa. *Earth's Future*, *8*(7), 1–23. https://doi.org/10.1029/2020EF001502

Huang, F. L. (2018). Using Intrumental Variable Estimation to Evaluate Randomized Experiments with Imperfect Compliance. *Practical Assessment, Research and Evaluation*, *23*(2).

Jost, C., Kyazze, F., Naab, J., Neelormi, S., Kinyangi, J., Zougmore, R., Aggarwal, P., Bhatta, G., Chaudhury, M., Tapio-Bistrom, M. L., Nelson, S., & Kristjanson, P. (2016). Understanding gender dimensions of agriculture and climate change in smallholder farming communities. *Climate and Development*, *8*(2), 133–144. https://doi.org/10.1080/17565529.2015.1050978

Karlsson, L., Naess, L. O., Nightingale, A., & Thompson, J. (2017). 'Triple wins' or 'triple faults'? Analysing the equity implications of policy discourses on climate-smart agriculture (CSA). *Journal of Peasant Studies*, *45*(1), 150–174. https://doi.org/10.1080/03066150.2017.1351433

Khalak, A., Asaduzzaman Sarker, M., & Nasir Uddin, M. (2018). Farmers' Access to ICT Based Media in Receiving Farm Information: A Grassroots Level Study from Bangladesh. *American Journal of Rural Development*, *6*(1), 14–20. https://doi.org/10.12691/ajrd-6-1-3

Kimaro, A. A., Mpanda, M., Rioux, J., Aynekulu, E., Shaba, S., Thiong'o, M., Mutuo, P., Abwanda, S., Shepherd, K., Neufeldt, H., & Rosenstock, T. S. (2016). Is conservation agriculture 'climate-smart' for maize farmers in the highlands of Tanzania? *Nutrient Cycling in Agroecosystems*, *105*(3), 217–228. https://doi.org/10.1007/s10705-015-9711-8

Kimaro, A. A., Sererya, O. G., Matata, P., Uckert, G., Hafner, J., Graef, F., Sieber, S., & Rosenstock, T. S. (2019). Understanding the Multidimensionality of Climate-Smartness: Examples from Agroforestry in Tanzania. In *The Climate-Smart Agriculture Papers* (pp. 153–162). https://doi.org/10.1007/978-3-319-92798-5

Mungai, C., Opondo, M., Outa, G., Nelson, V., Nyasimi, M., & Kimeli, P. (2017). Uptake of Climate-Smart Agriculture Through a Gendered Intersectionality Lens: Experiences from Western Kenya. In *Climate Change Management* (Issue April 2021, pp. 587–601). Springer International Publishing. https://doi.org/10.1007/978-3-319-49520-0_36

Nangombe, S., Zhou, T., Zhang, W., Wu, B., Hu, S., Zou, L., & Li, D. (2018). Record-breaking climate extremes in Africa under stabilized 1.5 °c and 2 °c global warming scenarios. *Nature Climate Change*, *8*(5), 375–380. https://doi.org/10.1038/s41558-018-0145-6

Ngure, M. W., Wandiga, S. O., Olago, D. O., & Oriaso, S. O. (2021). Climate change stressors affecting household food security among Kimandi-Wanyaga smallholder farmers in Murang'a County, Kenya. *Open Agriculture*, *6*(1), 587–608. https://doi.org/10.1515/opag-2021-0042

Nyasimi, M., Kimeli, P., Sayula, G., Radeny, M., Kinyangi, J., & Mungai, C. (2017). Adoption and dissemination pathways for climate-smart agriculture technologies and practices for climate-resilient livelihoods in Lushoto, Northeast Tanzania. *Climate*, *5*(3), 1–22. https://doi.org/10.3390/cli5030063

Ogutu, S. O., Fongar, A., Gödecke, T., Jäckering, L., Mwololo, H., Njuguna, M., Wollni, M., & Qaim, M. (2018). How to make farming and agricultural extension more nutrition-sensitive: evidence from a randomised controlled trial in Kenya. *European Review of Agricultural Economics*, 1–24.

Oniang'o, R. K. (2005). Women are still the key in agriculture and food security in Africa. *South African Journal of Clinical Nutrition*, *18*(2), 150–154. https://doi.org/10.1080/16070658.2005.11734057

Osumba, J., & Rioux, J. (2015). *Scoping study on climate-smart agriculture in Kenya: Smallholder integrated crop-livestock farming systems*. 44.

Serdeczny, O., Adams, S., Baarsch, F., Coumou, D., Robinson, A., Hare, W., Schaeffer, M., Perrette, M., & Reinhardt, J. (2017). Climate change impacts in Sub-Saharan Africa: from physical changes to their social repercussions. *Regional Environmental Change*, *17*(6), 1585–1600. https://doi.org/10.1007/s10113-015-0910-2

Shanahan, M. (2022). The Mobile Gender Gap Report 2022. In *GSMA Connected Women*. https://www.gsma.com/r/gender-gap/

Soderbom, M., Teal, F., Eberhardt, M., Quinn, S., & Zeitlin, A. (2015). *Empirical Development Economics*. Routledge.

Theis, S., Bryan, E., & Ringler, C. (2019). Addressing gender and social dynamics to strengthen resilience for all. In A. R. Quisumbing, R. S. Meinzen-Dick, & J. Njuki (Eds.), *2019 Annual trends and outlook report: Gender equality in rural Africa: From commitments to outcomes* (pp. 126–139). IFPRI.

Villamor, G. B., van Noordwijk, M., Djanibekov, U., Chiong-Javier, M. E., & Catacutan, D.

(2014). Gender differences in land-use decisions: Shaping multifunctional landscapes? *Current Opinion in Environmental Sustainability*, *6*(1), 128–133. https://doi.org/10.1016/j.cosust.2013.11.015

Waaswa, A., Oywaya Nkurumwa, A., Mwangi Kibe, A., & Ngeno Kipkemoi, J. (2022). Climate-Smart agriculture and potato production in Kenya: review of the determinants of practice. *Climate and Development*, *14*(1), 75–90. https://doi.org/10.1080/17565529.2021.1885336

Waithaka, M., Nelson, G. C., Thomas, T. S., & Kyotalimye, M. (2013). *East African agriculture and climate change: A comprehensive analysis* (Eds. 2013). International Food Policy Research Institute (IFPRI). https://doi.org/http://dx.doi.org/10.2499/9780896292055

ANNEX

Annex table 1: Awareness ITT

	ITT SMD				ITT ANCOVA			
	Female		Male		Female		Male	
VARIABLES	Coeff	Constant	Coeff	Constant	Coeff	Y-lag	Coeff	Y-lag
Agroforestry	0.017	0.668***	-0.007	0.799***	0.012	0.189***	-0.02	0.078*
	(0.030)	(0.093)	(0.027)	(0.090)	(0.030)	(0.036)	(0.029)	(0.043)
Terraces, Bunds	0.068**	0.853***	0.042	0.606***	0.060*	0.131***	0.019	0.112**
	(0.031)	(0.094)	(0.036)	(0.119)	(0.031)	(0.033)	(0.040)	(0.044)
Water Harvesting (Dams,	0.092***	0.515***	0.02	0.659***	0.086**	0.068	0.01	0.053
Ditch, Water Pans)	(0.035)	(0.106)	(0.037)	(0.121)	(0.035)	(0.041)	(0.042)	(0.052)
Use of Irrigation	0.031	0.927***	0.040*	0.772***	0.032	0.049*	0.044*	0.026
	(0.023)	(0.070)	(0.022)	(0.071)	(0.023)	(0.027)	(0.025)	(0.031)
Zai Pits/Planting Pits	0.088**	0.401***	0.091**	0.126	0.078**	-0.023	0.180***	0.139**
	(0.039)	(0.121)	(0.045)	(0.146)	(0.039)	(0.059)	(0.050)	(0.066)
Leaving Crop Residue	-0.022	1.083***	0.013	0.952***	-0.024	-0.050*	0.019	0.012
	(0.019)	(0.058)	(0.018)	(0.059)	(0.019)	(0.030)	(0.021)	(0.035)
Composting	0.029	0.514***	-0.032	0.337**	0.039	0.036	-0.038	-0.01
	(0.040)	(0.122)	(0.041)	(0.133)	(0.040)	(0.040)	(0.047)	(0.048)
Livestock manure	0.016	0.512***	0.071*	0.405***	0.028	0.166***	0.068	0.142**
	(0.036)	(0.111)	(0.039)	(0.127)	(0.036)	(0.046)	(0.045)	(0.056)
More efficient use of fertilizer	0.016	0.499***	0.042	0.464***	0.021	0.06	0.043	0.219***
	(0.038)	(0.116)	(0.041)	(0.135)	(0.039)	(0.045)	(0.047)	(0.058)
Use of improved, high	-0.01	1.038***	0.035	0.991***	0.001	0.102***	0.015	0.022
yielding varieties	(0.024)	(0.073)	(0.026)	(0.084)	(0.024)	(0.037)	(0.029)	(0.048)
No till/Minimum tillage	0.120***	0.602***	0.03	0.663***	0.121***	-0.01	0.022	0.04
	(0.038)	(0.117)	(0.042)	(0.137)	(0.038)	(0.039)	(0.048)	(0.048)
Improved grain storage	0.071*	0.363***	0.099**	0.213	0.081**	0.063	0.132***	0.205***
	(0.038)	(0.117)	(0.042)	(0.136)	(0.039)	(0.039)	(0.048)	(0.048)
Improved Stoves (wood or	0.034	0.681***	0.009	0.684***	0.035	0.062*	0.026	0.090*
charcoal burning)	(0.035)	(0.107)	(0.041)	(0.134)	(0.035)	(0.036)	(0.048)	(0.049)
Improved feed management	0.033	0.289**	0.052	0.247*	0.035	0.107***	0.027	0.092*
(livestock)	(0.040)	(0.123)	(0.044)	(0.145)	(0.040)	(0.040)	(0.051)	(0.051)
Destocking/Restocking	0.06	0.577***	0.055	0.572***	0.064*	0.085**	0.046	0.072
	(0.037)	(0.115)	(0.038)	(0.123)	(0.037)	(0.040)	(0.044)	(0.044)
Cover Cropping	0.100**	0.635***	0.109**	0.620***	0.099**	0.071*	0.130***	0.046
	(0.039)	(0.119)	(0.043)	(0.140)	(0.039)	(0.039)	(0.049)	(0.051)
Switching to drought and pest	0.048	0.276**	0.066	0.255*	0.038	0.03	0.105**	-0.006
tolerant species or breeds	(0.040)	(0.122)	(0.045)	(0.148)	(0.040)	(0.042)	(0.052)	(0.053)
Grazing, Pasture, Rangeland	0.01	0.413***	-0.021	0.383***	0.028	0.139***	-0.033	0.100**
Management	(0.040)	(0.123)	(0.044)	(0.143)	(0.040)	(0.040)	(0.051)	(0.051)
Periodic fallowing	0.033	0.891***	0.033	0.611***	0.031	0.04	0.035	-0.04
	(0.035)	(0.108)	(0.038)	(0.125)	(0.035)	(0.036)	(0.043)	(0.044)
Integrated Pest Management	0.086**	0.357***	0.120***	0.215	0.081**	0.009	0.101*	0.042
	(0.039)	(0.120)	(0.044)	(0.146)	(0.039)	(0.040)	(0.052)	(0.052)
Composited chicken manure	0.163*	0.667	-0.05	0.590***				
	(0.092)	(0.582)	(0.055)	(0.187)				
Coating seeds with fertilizer	0.047	0.721	0.097*	0.215				
	(0.076)	(0.478)	(0.050)	(0.167)				
Fluorescent crops that show	-0.02	0.329***	-0.055	0.284**				
water stress	(0.036)	(0.111)	(0.043)	(0.141)				
Use of drought and pest	0.132	0.539	-0.025	0.591***				
tolerant varieties	(0.089)	(0.567)	(0.056)	(0.185)				
Integrated soil fertility	0.174**	0.489	0.058	0.433**				
management	(0.087)	(0.549)	(0.056)	(0.186)				

Annex table 2: Awareness LATE

	LATE SMD				Late ANCOVA					
	Female		Male		Female			Male		
VARIABLES	Coeff	Constant	Coeff	Constant	Coeff	Y-lag	Constant	Coeff	Y-lag	Constant
Agroforestry	0.036	0.661***	-0.019	0.797***	0.026	0.189***	0.669***	-0.04	0.079*	0.854***
	(0.062)	(0.096)	(0.069)	(0.088)	(0.062)	(0.036)	(0.036)	(0.060)	(0.043)	(0.043)
Terraces, Bunds	0.140**	0.826***	0.106	0.614***	0.126*	0.133***	0.691***	0.039	0.110**	0.730***
	(0.064)	(0.097)	(0.090)	(0.117)	(0.064)	(0.033)	(0.032)	(0.080)	(0.044)	(0.041)
Water Harvesting	0.189***	0.478***	0.051	0.663***	0.179**	0.080*	0.629***	0.021	0.052	0.742***
(Dams, Ditch, Water Pans)	(0.072)	(0.110)	(0.093)	(0.119)	(0.073)	(0.042)	(0.043)	(0.086)	(0.052)	(0.049)
Use of Irrigation	0.064	0.914***	0.103*	0.781***	0.066	0.049*	0.855***	0.090*	0.022	0.898***
	(0.047)	(0.072)	(0.055)	(0.070)	(0.047)	(0.027)	(0.028)	(0.051)	(0.031)	(0.030)
Zai Pits/Planting Pits	0.183**	0.365***	0.232**	0.144	0.161**	-0.022	0.372***	0.365***	0.11	0.328***
	(0.081)	(0.124)	(0.113)	(0.145)	(0.081)	(0.059)	(0.030)	(0.107)	(0.069)	(0.039)
Leaving Crop Residue	-0.046	1.092***	0.032	0.954***	-0.05	-0.051*	1.001***	0.038	0.009	0.939***
	(0.039)	(0.059)	(0.045)	(0.058)	(0.039)	(0.030)	(0.031)	(0.043)	(0.034)	(0.034)
Composting	0.06	0.502***	-0.081	0.331**	0.082	0.034	0.520***	-0.078	-0.005	0.732***
	(0.081)	(0.125)	(0.102)	(0.131)	(0.082)	(0.040)	(0.036)	(0.097)	(0.048)	(0.042)
Livestock manure management	0.034	0.505***	0.175*	0.416***	0.058	0.164***	0.563***	0.137	0.151***	0.585***
	(0.074)	(0.114)	(0.098)	(0.129)	(0.075)	(0.045)	(0.046)	(0.093)	(0.058)	(0.060)
More efficient use of	0.032	0.493***	0.108	0.472***	0.044	0.062	0.570***	0.088	0.216***	0.492***
fertilizer	(0.078)	(0.119)	(0.105)	(0.134)	(0.080)	(0.045)	(0.045)	(0.098)	(0.058)	(0.056)
Use of improved, high	-0.022	1.042***	0.089	0.999***	0.002	0.102***	0.810***	0.031	0.018	0.891***
yielding varieties	(0.049)	(0.075)	(0.065)	(0.084)	(0.050)	(0.037)	(0.039)	(0.059)	(0.049)	(0.046)
No till/Minimum	0.249***	0.554***	0.076	0.668***	0.252***	-0.01	0.586***	0.045	0.04	0.664***
tillage	(0.078)	(0.120)	(0.104)	(0.135)	(0.079)	(0.039)	(0.032)	(0.097)	(0.048)	(0.041)
Improved grain storage	0.147*	0.334***	0.250**	0.232*	0.169**	0.068*	0.546***	0.272***	0.192***	0.481***
	(0.079)	(0.120)	(0.106)	(0.137)	(0.081)	(0.039)	(0.038)	(0.102)	(0.050)	(0.043)
Improved Stoves	0.07	0.667***	0.022	0.686***	0.073	0.065*	0.685***	0.052	0.090*	0.619***
(wood or charcoal burning)	(0.072)	(0.110)	(0.102)	(0.132)	(0.072)	(0.036)	(0.036)	(0.096)	(0.049)	(0.046)
Improved feed management (livestock)	0.068	0.276**	0.131	0.256*	0.074	0.110***	0.446***	0.055	0.094*	0.520***
	(0.083)	(0.127)	(0.111)	(0.144)	(0.083)	(0.040)	(0.036)	(0.104)	(0.051)	(0.047)
Destocking/Restocking	0.125	0.552***	0.139	0.584***	0.134*	0.088**	0.604***	0.094	0.072	0.710***
	(0.077)	(0.118)	(0.096)	(0.122)	(0.078)	(0.040)	(0.032)	(0.090)	(0.044)	(0.037)
Cover Cropping	0.206***	0.594***	0.275**	0.643***	0.207***	0.069*	0.526***	0.265***	0.049	0.555***
	(0.079)	(0.121)	(0.109)	(0.139)	(0.079)	(0.039)	(0.037)	(0.101)	(0.052)	(0.050)
Switching to drought	0.1	0.257**	0.165	0.266*	0.08	0.031	0.400***	0.214**	-0.002	0.452***
and pest tolerant species or breeds	(0.081)	(0.125)	(0.112)	(0.146)	(0.082)	(0.042)	(0.033)	(0.105)	(0.053)	(0.043)
Grazing, Pasture,	0.022	0.409***	-0.053	0.379***	0.058	0.139***	0.444***	-0.068	0.094*	0.570***
Rangeland Management	(0.083)	(0.126)	(0.109)	(0.141)	(0.083)	(0.040)	(0.037)	(0.105)	(0.052)	(0.051)
Periodic fallowing	0.069	0.878***	0.082	0.617***	0.065	0.039	0.703***	0.07	-0.042	0.791***
	(0.072)	(0.111)	(0.094)	(0.124)	(0.073)	(0.036)	(0.034)	(0.086)	(0.044)	(0.040)
Integrated Pest	0.177**	0.322***	0.303***	0.239	0.169**	0.005	0.360***	0.205*	0.048	0.413***
Management	(0.081)	(0.124)	(0.115)	(0.148)	(0.082)	(0.039)	(0.035)	(0.106)	(0.052)	(0.046)
Composited chicken manure	0.514*	0.8	-0.141	0.567***						
	(0.285)	(0.568)	(0.152)	(0.183)						
Coating seeds with	0.145	0.773*	0.273**	0.255						
fertilizer	(0.226)	(0.459)	(0.139)	(0.164)						
Fluorescent crops that	-0.042	0.337***	-0.136	0.274*						
show water stress	(0.075)	(0.114)	(0.107)	(0.140)						
Use of drought and	0.415	0.689	-0.069	0.582***						
pest tolerant varieties	(0.274)	(0.548)	(0.150)	(0.182)						
Integrated soil fertility management	0.545*	0.686	0.156	0.453**						
	(0.289)	(0.577)	(0.150)	(0.182)						

Annex table 3: Practice/adoption ITT

	ITT SMD				ITT ANCOVA			
	Female		Male		Female		Male	
VARIABLES	Coeff	Constant	Coeff	Constant	Coeff	Y-lag	Coeff	Y-lag
Agroforestry	-0.086**	0.428***	-0.077*	0.455***	-0.086**	0.088**	-0.079*	0.195***
	(0.039)	(0.122)	(0.041)	(0.137)	(0.042)	(0.042)	(0.048)	(0.048)
Terraces, Bunds	-0.003	0.334**	-0.025	0.463***	0.002	0.136***	0.034	0.134**
	(0.045)	(0.138)	(0.051)	(0.170)	(0.052)	(0.052)	(0.066)	(0.066)
Water Harvesting (Dams, Ditch,	0.002	0.203	0.043	0.21	0.053	0.126**	0.065	0.142**
Water Pans)	(0.047)	(0.145)	(0.051)	(0.169)	(0.053)	(0.053)	(0.065)	(0.065)
Use of Irrigation	0.001	0.151	0.021	0.22	0.002	0.182***	0.069	0.329***
	(0.038)	(0.116)	(0.042)	(0.140)	(0.042)	(0.048)	(0.051)	(0.056)
Zai Pits/Planting Pits	0.003	-0.027	-0.053	0.194	-0.335*	-0.202	0.067	-0.113
	(0.061)	(0.193)	(0.067)	(0.221)	(0.170)	(0.168)	(0.169)	(0.179)
Leaving Crop Residue	0.005	0.680***	-0.057	0.685***	-0.013	0.145***	-0.068	0.089
	(0.036)	(0.110)	(0.040)	(0.131)	(0.037)	(0.053)	(0.047)	(0.064)
Composting	-0.042	0.213	-0.05	0.412**	-0.068	0.139*	0.022	0.222***
	(0.052)	(0.158)	(0.053)	(0.178)	(0.072)	(0.072)	(0.078)	(0.079)
Livestock manure management	-0.108***	0.704***	-0.074*	0.950***	-0.091**	0.222***	-0.076	0.346***
	(0.036)	(0.114)	(0.041)	(0.138)	(0.036)	(0.052)	(0.047)	(0.066)
More efficient use of fertilizer	0.058	0.657***	0.018	0.594***	0.078	0.322***	0.008	0.344***
	(0.047)	(0.149)	(0.051)	(0.167)	(0.049)	(0.058)	(0.059)	(0.063)
Use of improved, high yielding	-0.056**	0.879***	0.012	0.620***	-0.056**	0.171***	0.027	0.087*
varieties	(0.028)	(0.086)	(0.030)	(0.101)	(0.027)	(0.045)	(0.036)	(0.052)
No till/Minimum tillage	0.001	0.657***	0.007	0.649***	-0.026	0.105	0.001	0.063
	(0.049)	(0.143)	(0.053)	(0.180)	(0.075)	(0.076)	(0.088)	(0.088)
Improved grain storage	0.02	0.404**	-0.015	0.503***	-0.032	0.024	-0.098	0.141*
	(0.050)	(0.161)	(0.055)	(0.190)	(0.066)	(0.066)	(0.081)	(0.081)
Improved Stoves (wood or	-0.025	0.295**	-0.055	0.239	-0.052	0.114**	-0.077	0.063
charcoal burning)	(0.046)	(0.141)	(0.054)	(0.176)	(0.056)	(0.056)	(0.079)	(0.079)
Improved feed management	-0.071	0.547***	0.031	0.504**	-0.072	0.081	0.065	0.252***
(livestock)	(0.056)	(0.171)	(0.060)	(0.206)	(0.076)	(0.081)	(0.087)	(0.091)
Destocking/Restocking	-0.004	0.420***	0.014	0.482***	0.132*	0.197**	0.075	0.171*
	(0.049)	(0.150)	(0.052)	(0.173)	(0.079)	(0.091)	(0.086)	(0.094)
Cover Cropping	-0.006	0.621***	-0.064	0.551***	-0.049	0.116*	-0.026	0.07
	(0.046)	(0.142)	(0.052)	(0.174)	(0.057)	(0.066)	(0.073)	(0.082)
Switching to drought and pest	0.046	0.046	-0.046	0.567***	0.009	-0.138	-0.16	-0.102
tolerant species or breeds	(0.062)	(0.198)	(0.063)	(0.216)	(0.105)	(0.105)	(0.116)	(0.116)
Grazing, Pasture, Rangeland	-0.139**	0.396**	-0.138**	1.052***	-0.131*	0.194**	-0.11	0.154*
Management	(0.054)	(0.176)	(0.058)	(0.204)	(0.069)	(0.079)	(0.086)	(0.092)
Periodic fallowing	0.008	0.366***	0.001	0.367**	0.015	0.209***	0.066	0.165**
	(0.045)	(0.138)	(0.050)	(0.168)	(0.058)	(0.058)	(0.074)	(0.074)
Integrated Pest Management	-0.04	0.649***	-0.02	0.434**	-0.099	-0.006	0.09	0.256**
	(0.059)	(0.188)	(0.064)	(0.213)	(0.086)	(0.101)	(0.096)	(0.120)
Composited chicken manure	0.152	0.081	-0.185**	0.671***				
	(0.134)	(0.664)	(0.073)	(0.251)				
Coating seeds with fertilizer	0.155	0.303	0.026	0.841**				
	(0.210)	(0.839)	(0.110)	(0.352)				
Fluorescent crops that show	0.043	-0.092	-0.004	0.582**				
water stress	(0.074)	(0.226)	(0.082)	(0.268)				
Use of drought and pest tolerant	0.168	0.181	0.057	0.622**				
varieties	(0.150)	(0.749)	(0.072)	(0.246)				
Integrated soil fertility management	0.171	-0.141	0.023	1.073***				
	(0.129)	(0.576)	(0.059)	(0.198)				

Annex table 4: Practice/adoption LATE

	LATE SMD				Late ANCOVA					
	Female		Male		Female			Male		
VARIABLES	Coeff	Constant	Coeff	Constant	Coeff	Y-lag	Constant	Coeff	Y-lag	Constant
Agroforestry	-0.178**	0.463***	-0.189*	0.428***	-0.183**	0.084*	0.747***	-0.154*	0.196***	0.703***
	(0.083)	(0.127)	(0.101)	(0.135)	(0.091)	(0.043)	(0.041)	(0.092)	(0.047)	(0.041)
Terraces, Bunds	-0.007	0.335**	-0.06	0.452***	0.004	0.136***	0.496***	0.062	0.138**	0.489***
	(0.093)	(0.141)	(0.119)	(0.167)	(0.107)	(0.053)	(0.049)	(0.120)	(0.066)	(0.058)
Water Harvesting (Dams, Ditch, Water Pans)	0.004	0.202	0.102	0.223	0.113	0.126**	0.370***	0.114	0.139**	0.413***
	(0.096)	(0.149)	(0.120)	(0.167)	(0.112)	(0.053)	(0.052)	(0.114)	(0.065)	(0.056)
Use of Irrigation	0.002	0.15	0.054	0.225	0.005	0.182***	0.240***	0.135	0.325***	0.162***
	(0.077)	(0.118)	(0.106)	(0.137)	(0.090)	(0.048)	(0.035)	(0.100)	(0.056)	(0.040)
Zai Pits/Planting Pits	0.006	-0.029	-0.125	0.214	-0.558*	-0.266	0.682***	0.105	-0.104	0.411***
	(0.103)	(0.197)	(0.155)	(0.224)	(0.326)	(0.200)	(0.195)	(0.258)	(0.173)	(0.122)
Leaving Crop Residue	0.01	0.677***	-0.139	0.675***	-0.028	0.146***	0.646***	-0.137	0.084	0.737***
	(0.073)	(0.114)	(0.098)	(0.130)	(0.077)	(0.053)	(0.051)	(0.094)	(0.064)	(0.066)
Composting	-0.081	0.236	-0.124	0.413**	-0.129	0.143**	0.370***	0.045	0.220***	0.310***
	(0.099)	(0.164)	(0.132)	(0.178)	(0.135)	(0.072)	(0.062)	(0.158)	(0.078)	(0.065)
Livestock manure management	-0.218***	0.743***	-0.191*	0.921***	-0.191**	0.210***	0.717***	-0.163	0.350***	0.568***
	(0.076)	(0.121)	(0.106)	(0.138)	(0.078)	(0.054)	(0.058)	(0.102)	(0.066)	(0.066)
More efficient use of fertilizer	0.12	0.630***	0.049	0.598***	0.171	0.336***	0.425***	0.018	0.344***	0.467***
	(0.097)	(0.154)	(0.137)	(0.164)	(0.108)	(0.060)	(0.064)	(0.130)	(0.063)	(0.059)
Use of improved, high yielding varieties	-0.116**	0.896***	0.031	0.624***	-0.120**	0.172***	0.769***	0.052	0.083	0.801***
	(0.057)	(0.088)	(0.077)	(0.099)	(0.058)	(0.046)	(0.045)	(0.069)	(0.052)	(0.051)
No till/Minimum tillage	-0.001	0.657***	0.017	0.652***	-0.053	0.103	0.654***	0.003	0.062	0.639***
	(0.094)	(0.147)	(0.126)	(0.176)	(0.150)	(0.075)	(0.071)	(0.161)	(0.087)	(0.075)
Improved grain storage	0.041	0.397**	-0.038	0.492***	-0.07	0.025	0.627***	-0.194	0.141*	0.586***
	(0.103)	(0.164)	(0.142)	(0.186)	(0.143)	(0.066)	(0.062)	(0.159)	(0.080)	(0.075)
Improved Stoves (wood or charcoal burning)	-0.049	0.304**	-0.137	0.227	-0.115	0.109*	0.396***	-0.157	0.06	0.520***
	(0.091)	(0.144)	(0.132)	(0.172)	(0.124)	(0.057)	(0.054)	(0.159)	(0.078)	(0.076)
Improved feed management (livestock)	-0.151	0.573***	0.091	0.527***	-0.18	0.094	0.586***	0.145	0.252***	0.401***
	(0.118)	(0.174)	(0.170)	(0.203)	(0.192)	(0.083)	(0.074)	(0.192)	(0.090)	(0.090)
Destocking/Restocking	-0.008	0.422***	0.035	0.488***	0.333	0.202**	0.345***	0.139	0.185**	0.347***
	(0.098)	(0.152)	(0.127)	(0.170)	(0.206)	(0.094)	(0.067)	(0.156)	(0.093)	(0.069)
Cover Cropping	-0.011	0.623***	-0.154	0.517***	-0.09	0.115*	0.669***	-0.049	0.072	0.648***
	(0.087)	(0.144)	(0.122)	(0.172)	(0.105)	(0.067)	(0.071)	(0.136)	(0.081)	(0.076)
Switching to drought and pest tolerant species or breeds	0.091	0.023	-0.114	0.545**	0.022	-0.136	0.659***	-0.32	-0.092	0.715***
	(0.120)	(0.202)	(0.152)	(0.213)	(0.243)	(0.107)	(0.117)	(0.223)	(0.113)	(0.105)
Grazing, Pasture, Rangeland Management	-0.302**	0.465**	-0.335**	0.976***	-0.278*	0.189**	0.513***	-0.264	0.144	0.498***
	(0.119)	(0.182)	(0.144)	(0.210)	(0.150)	(0.080)	(0.082)	(0.210)	(0.094)	(0.095)
Periodic fallowing	0.018	0.362**	0	0.367**	0.033	0.210***	0.263***	0.137	0.162**	0.313***
	(0.096)	(0.141)	(0.124)	(0.164)	(0.128)	(0.057)	(0.051)	(0.153)	(0.073)	(0.068)
Integrated Pest Management	-0.086	0.670***	-0.054	0.418**	-0.217	-0.028	0.792***	0.203	0.278**	0.421***
	(0.127)	(0.194)	(0.173)	(0.210)	(0.192)	(0.107)	(0.120)	(0.220)	(0.127)	(0.138)
Composited chicken manure	0.471	0.124	-0.548**	0.572**						
	(0.382)	(0.602)	(0.223)	(0.254)						
Coating seeds with fertilizer	0.76	0.383	0.065	0.847**						
	(0.934)	(0.730)	(0.262)	(0.336)						
Fluorescent crops that show water stress	0.069	-0.125	-0.01	0.583**						
	(0.115)	(0.234)	(0.194)	(0.264)						
Use of drought and pest tolerant varieties	0.51	0.4	0.152	0.637***						
	(0.424)	(0.685)	(0.187)	(0.240)						
Integrated soil fertility management	0.675	0.027	0.059	1.073***						
	(0.515)	(0.579)	(0.153)	(0.194)						