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Rate of Adoption and Determinants of Climate Smart Agriculture Adoption among Small Holder Farmers: The Case of Welmera Woreda, Oromia Region, Ethiopia

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Abstract: Climate change is one of the main barriers for agricultural production and productivity globally. Hence, understanding farmers' adoption level of CSA practices and determinants is of highly important for policy decisions. Consequently, the study's purpose was to assess adoption level of multiple CSA practices and determinants of climate-smart agriculture practices in the study area. The study was conducted in Welmera Woreda, Oromia Region, Ethiopia. From the Woreda, three kebeles were identified, and 306 respondent farmers were selected. A cross-sectional household survey, focus group discussion, and key informant interviews were used. Multivariate probit model was used to examine adoption determinants of multiple climate-smart agriculture practices. According to the result, Conservation agriculture, integrated soil fertility management, and crop diversification are the most commonly practiced CSA techniques in the study area. Demographic factors result indicated that being male as compared with female farmers, has positive and significant effect on crop diversification and improved livestock feed and feeding practices. Age of farmers significantly and negatively affecting the probability of adoption of improved soil fertility management practices and crop diversification. However, it affects the adoption of agroforestry practices positively and significantly. Based on the result of economic factors, having relatively large farm land size significantly increases the adoption of conservation agriculture, improved soil fertility management, crop diversification, improved livestock feed and feeding practices, and postharvest technology practice. Better farm income increases the likelihood of uptake of improved livestock feed and feeding. Having a large number of livestock positively influences adoption of conservation agriculture and having access to credit services positively influences the implementation of agroforestry, crop diversification, and postharvest technology. In addition, institutional factors such as access to agricultural extension service and training found that significantly and positively influences the adoption of crop diversification; access to participation on farmers' field day similarly significantly and positively influence the adoption of both conservation agriculture and improved soil fertility management practice. Awareness creation for farmers and experts about climate change and including location specific CSA practices in to agricultural program is crucial.

Keywords: climate change; perception; climate smart agriculture; adoption; multivariate probit

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1. Introduction

The agricultural sector, which also forms the backbone of the Ethiopia's economy, continues to employ the majority of Ethiopians. However, the majority of farmers in the country are smallholders who mainly practice rain-fed and subsistence agriculture. According to Jirata et al. (2016) and Rahel et al. (2021), smallholder farmers produce more than 90% of the agricultural production in the nation. However, it is anticipated that climate change have significant effect on agricultural outputs in Africa, especially Ethiopia (Mekonnen et al., 2021; Rahel et al., 2021). Ethiopian agriculture is mostly rain-fed, therefore it responds to variations in precipitation (Conway and Schipper, 2011). This suggests that crop production may stop being a feasible means of subsistence if rainfall is insufficient in quantity or distribution over multiple growing seasons. This drastic reduction in crop production leads to food insecurity.

Erratic rainfall in some parts of the country, together with severe drought, land degradation, population growth, and climate change, greatly constrain the country's economic and social development, and again, its food security (Jirata et al., 2016). Recurring drought cause food scarcity and affects many people in Ethiopia. Particularly, the droughts of 1984 and 2003, which affected 7.5 and 12.6 million people, respectively, had a significant impact on farmers' livelihoods (CIAT; BFS/USAID, 2017). More recently, the El Nino event in 2015/16 caused Ethiopia to experience one of the worst droughts in decades, with over 10.2 million people estimated to be in need of food assistance (CIAT; BFS/USAID, 2017).

To overcome the mistrust of climate change impacts on agriculture, emphasis has been given to the development of means and methods of sustaining agricultural activities in sub-Saharan Africa (SSA) by promoting the use of climate smart agriculture (CSA) among smallholder farmers through empowerment and capacity building (Branca et al., 2013). Ethiopia also has policies and laws in place to address the effects of climate change on agriculture and the national economy, some of which are relevant to climate-smart agriculture (Eshete et al., 2020).

Various literature and field observations in many areas reveal that adoption of natural resource conservation practices in Ethiopia is low; however, traditional and improved practices are in operation. Although a multitude of agricultural development activities both traditionally and innovatively conducted in Ethiopia as part of livelihoods and food security improvement, they are also considered important in addressing issues related to climate change and are contributing to climate change adaptation and mitigation (Jirata et al., 2016). CSA is an approach that requires location-specific assessments to identify suitable agricultural production technologies and practices to address the complex, interrelated challenges of food security, development, and climate change (FAO, 2013). It indicate that, to facilitate the uptake of CSA practices, understanding the adaptive capacity of the farm community and the reaction of institutions requires the integration of the approach into research and development. Due to its disastrous repercussions, climate change is currently a top priority agenda in both wealthy and developing nations. The detrimental impact of climate change is obvious in underdeveloped nations where agriculture is directly reliant on natural elements like rainfall. Consequently, the intensions of the study is to assess level of climate-smart agricultural technologies' adoption, and explore demographic, socio-economic, and institutional factors affecting the adoption of climate-smart agricultural technologies.

2. Materials and methods

2.1. The study area

Walmara woreda is one of 11 woredas found in Finfine Surrounding Oromia special Zone. Welmera Woreda is located 29 kilometers west of the capital Addis Ababa on the main road to Ambo, bordered by Sebeta Hawas woreda, Ejere Woreda, Mulo Woreda, Sululta, and Addis Ababa on the south, on the west, on the north, on the northeast, and on the east, respectively. The district has 26 peasant associations. Its total land area is about 80,927 hectares, of which 37411 hectares are farmland or under cultivation. The altitude of the Woreda ranges from 2060 m a.s.l. to 3380 m a.s.l. The Woreda is located between $8^0 50'$ and 9^0 $15'$ N latitude and $38^0 25'$ and 39^0 $45'$ E longitude. The total population is estimated to be 104,143, with 52,403 men and 51,740 women.

Welmera woreda is classified into two agro-ecological zones: highland and midland. Highland accounts for 61% of the total, while the midlands account for approximately 39%. The average annual rainfall ranges from 834 mm to 1300 mm, and the average annual temperature ranges from 0 °C to 27 °C. The soil types are red (60%), black (37%), and mixed (3%). Agriculture is the primary source of income for the woreda's smallholder farmers.

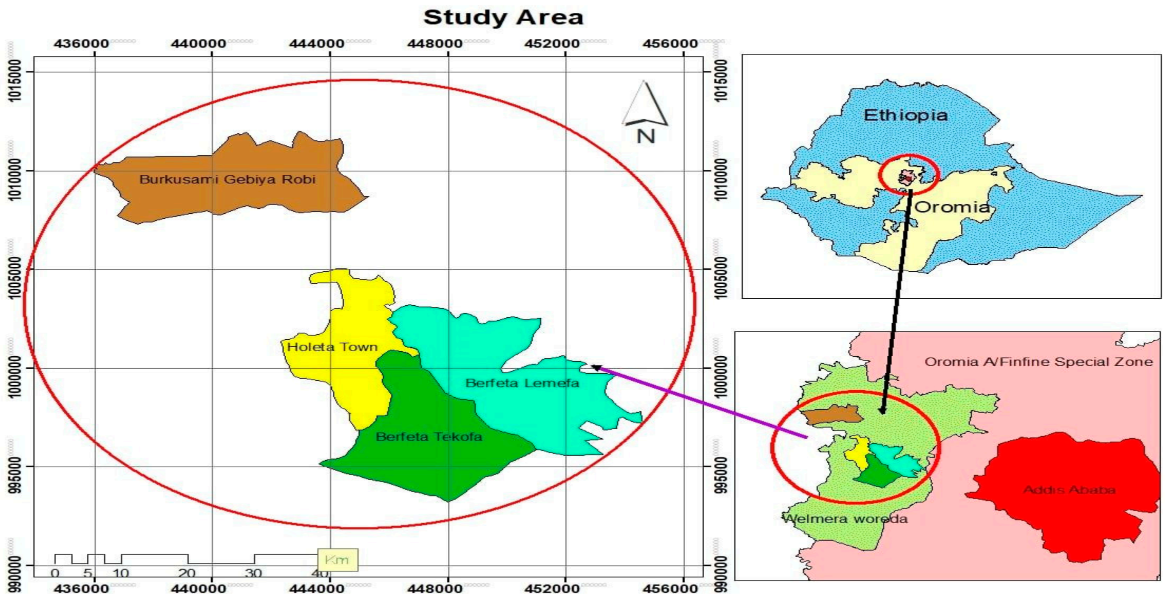

Figure 1. Map of the study area.

2.2. Sampling and data collection

A multistage sampling technique was used during woreda, kebele, and household selection. Purposive sampling methods were employed during Woreda and PAs/kebele selection. The woreda where the study takes place is selected purposively based on wheat and dairy production extent. Secondly, three Kebeles with high potential of crop production to see the trend of climate change and coping mechanism were selected after discussion made with the woreda agriculture experts. Finally, the respondents are randomly selected from the three kebeles. Structured questionnaire was prepared and used for data collection from randomly selected respondents. The sample size was determined based on Yamane's (1967) sample size formula to get a representative sample (Syed, 2016).

$$n = \frac{N}{1 + N(e)^2}$$

Where

n= sample size, **N**=population understudy, **e**=error term

The total farm households of the three kebeles are 1308/ sampling frame/ households. Based on the above formula the total sample size was 306 households.

2.3. Method of data analysis and econometric model

Respondent farmer's adoptions of CSA practices are correlated (Abyiot et al., 2023; Mebratu et al., 2022; Tamirat, 2022; Samuel et al. 2022). The correlation arises either from technological complementarity or from substitutability among the practices. Hence, the multivariate probit model, which is a generalization of the probit model, used to estimate several correlated binary outcomes jointly.

The farmer decides to use the Kth technology of CSA if

$$Y^*_{kj} = U^*_k - U_0 > 0.$$

Where U_k = benefit from one of the CSA practices, U_0 = benefit from traditional/unimproved practices.

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The net benefit (Y^*_{kj}) that the farmer derives from Kth CSA practice is a latent variable determined by observed sociodemographic, institutional economic factors and climate change perception level (X_{kj}) and unobserved characteristics (U_{kj}):

$$Y^*_{kj} = \beta_k x'_{kj} + U_{kj}, \text{ where } (k = CA, ISF, SSI, AF, CD, ILF, IWI, PH) \ldots\ldots\ldots\ldots\ldots\ldots \mathbf{1}$$

Translate the unobserved preference in the above equation (equation 1) into the observed binary outcome equation for each choice of the CSA practices as follows:

$$Y_{kj} = \begin{cases} 1 \; if \;\; Y^*_{kj} > 0 \\ 0 \; otherwise \end{cases} \quad (k = CA, ISF, SSI, AF, CD, ILF, IWI, PH) \ldots\ldots\ldots\ldots\ldots\ldots \mathbf{2}$$

Where CA=conservation agriculture, ISF=improved soil fertility management, SSI=small-scale irrigation, AF=Agroforestry, CD= Crop diversification, ILF=Improved livestock feed and feeding, IWI=improved weather information, and PH=Post-harvest technology.

k=1, 2,3, ……m indicates the types of CSA practices, and j=1….n implies sample size.

Initially in the equation (1), the assumption is that a rational jth farmer has a latent variable Y^*_{kj} which capture the unobserved characteristics associated with the *k*th choice of CSA practice. This latent variable is assumed to be a linear combination of observed characteristics x'_{kj}, factors that affect the adoption of *k*th CSA practice, as well as unobserved characteristics captured by the stochastic error term $\mathbf{U_{kj}}$. The vector of parameters to be estimated in this model is indicated by β_k. Given the latent nature of Y^*_{kj}, the estimations are based on observable binary discrete variables Y_{kj} which pointing whether or not a farmer adopt a particular CSA practices on his/her farm land or plot p. If a farmers decision to adopt one CSA practice is unrelated to whether or not adopt another practices, and if error terms are normally spread, in that case, equations (1) and (2) specify univariate probit models, where information on farmers' adoption of one CSA practice does not cause to change the prediction of the probability that they will adopt another CSA practice. In the case when several CSA practices adoption is possible, a more realistic specification is to assume that the error terms in equation (1) jointly follow a multivariate normal (MVN) distribution, with zero conditional mean and variance normalized to unity, $\mathbf{U_{kj}} \sim MVN(0, \Omega)$. This indicates that in the multivariate model, when adoption of several practices is possible, the error terms jointly follow a multivariate normal distribution with zero conditional mean and variance normalized to unity, suppose the CSA practices are CA, ISF, SSI, AF, CD, ILF, IWI AND PH, then ($\mu_{CA}, \mu_{ISF}, \mu_{SSI}, \mu_{AF}, \mu_{CD}, \mu_{ILF}, \mu_{IWI}, \mu_{PH}$) ~ **MVP** (0, Ω) and the symmetric [8x8] covariance matrix Ω is given:

$$\Omega = \begin{bmatrix} \mathbf{1} & PCAISF & PCASSI & PCAAF & PCACD & PCAILF & PCAIWI & PCAPH \\ PISFCA & \mathbf{1} & PISFSSI & PISFAF & PISFCD & PISFILF & PISFIWI & PISFPH \\ PSSICA & PSSIISF & \mathbf{1} & PSSIAF & PSSICD & PSSIILF & PSSIIWI & PSSIPH \\ PAFCA & PAFISF & PAFSSI & \mathbf{1} & PAFCD & PAFILF & PAFIWI & PAFPH \\ PCDCA & PCDISF & PCDSSI & PCDAF & \mathbf{1} & PCDILF & PCDIWI & PCDPH \\ PILFCA & PILFISF & PILFSSI & PILFAF & PILFCD & \mathbf{1} & PILFIWI & PILFPH \\ PIWICA & PIWIISF & PIWISSI & PIWIAF & PIWICD & PIWIILF & \mathbf{1} & PIWIPH \\ PPHCA & PPHISF & PPHSSI & PPHAF & PPHCD & PPHILF & PPHIWI & \mathbf{1} \end{bmatrix}$$

The pairwise correlation coefficient of the error terms of any two of the estimated adoption equation of CSA practices in the model represented by ***p***.

2.3.1. Descriptive statistics result

The analysis of the data employed descriptive statistic for analysis of mean deference of explanatory variables between adopters & non-adopters of identified CSA practices in the area. The study considers explanatory variables that could affect CSA practices adoption and it includes gender, age, educational

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status, family size, farming system, farmland size, livestock holding (TLU), farm income, access to credit, access to agricultural ext. & training, access to field day participation and climate change perception level. From the total randomly selected sample HHs, about 15.4% were female-headed HHs and 84.6% were male-headed HHs, and this result is almost similar to the national data by the CSA (2012), which indicated that about 16% of households were women-headed. Maximum and minimum age of the farmers is 25 and 82 years respectively with mean, age is 47years, which indicate on Table 1 that is 3.22 which indicated that the mean age lies in the third categories. About 34.3% of respondents have access to credit service; about 46.1% and 35.6% have access to agricultural training and agricultural field day participation.

Table 1. Description of the study variables.

Dependent Variables(CSA practices)	Description	Mean	Std. Dev.
Conservation Agriculture	Dummy=1 if farmers adopt the practice, 0 otherwise	0.418	0.494
Improved soil fertility	Dummy=1 if farmers adopt the practice, 0 otherwise	0.588	0.488
Small scale irrigation	Dummy=1 if farmers adopt the practice, 0 otherwise	0.382	0.487
Agroforestry	Dummy=1 if farmers adopt the practice, 0 otherwise	0.333	0.472
Improved crop varieties/crop diversification/	Dummy=1 if farmers adopt the practice, 0 otherwise	0.516	0.501
Improved Livestock feed and feeding	Dummy=1 if farmers adopt the practice, 0 otherwise	0.363	0.482
Improved weather information	Dummy=1 if farmers adopt the practice, 0 otherwise	0.353	0.479
Postharvest technology	Dummy=1 if farmers adopt the practice, 0 otherwise	0.386	0.488
Independent Variables			
Sex	Dummy=1 if farmers sex is male, 0 otherwise	0.846	0.361
Age	18-29 yrs.=1, 30-39yrs=2, 40-49yrs=3, 50-59yrs=4, >59yrs=5	3.229	1.056
Education	unable to read& write=1, grade1-4=2, grade5-8=3, grade9-12=4, >grade12=5	2.297	0.941
Perception level	very low=1,low=2,medium=3,High=4 and very high=5	3.892	0.912
Family size	2-4members=1, 5-10members=2, >10members=3	1.768	0.460
Farm land size	<0.51ha of land=1, 0.51-2ha of land=2, >2ha=3	2.173	0.600
Farming system	only crop=1, only livestock=2, Both=3	2.961	0.278
Farm income	Households Farm income Birr in thousand	23.830	19.530
Access to credit service	Dummy=1 if farmers access to credit, 0 otherwise	0.343	0.476
Livestock holding	Livestock holding in TLU	5.542	2.492
Access to Agri. Ext. services & agri. training	Dummy=1 if farmers access to agri.ext. and training, 0 otherwise	0.461	0.499
Farmers field day participation	Dummy=1 if farmers access to field day participation, 0 otherwise	0.356	0.480

The average household income is 23.8 birr in thousand. The average livestock holdings of the household is 5.54 (TLU).

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3. Results and discussion

3.1. CSA practices implementing in the study area

Climate change is influencing production and productivity negatively. According to the survey data, FGD and KII, farmers believed that the rise in temperature and the late onset of the main rainy season were indicators of climate change. Soil erosion, hailstorms, late onset, high temperatures, and frost are the main incidences reported by respondents in the study area. These incidences are affecting agricultural production and productivity, both directly and indirectly. In order to minimize the effects of climate change in the study areas, there are CSA practices implementing by farmers. Based on these incidences, farmers are implementing various coping strategies (Jirata et al., 2016; Keller, 2009; FAO, 2013). Adoption of practices such as nitrogen-efficient and heat-tolerant or resistance crop varieties, zero-tillage or minimum tillage, and integrated soil fertility management would improve productivity and farmers' incomes and help lower food prices (FAO, 2016).

Adoption of CSA practices is likely vary from place to place due to the diversity of agro ecology and agricultural practices in Ethiopia. CSA practices that have the potential to minimize climate change effects include zero tillage (minimum tillage) and integrated soil fertility management (Komarek et al., 2018). A study by Saguye (2017) proves that agroforestry, soil and water management, crop management, and livestock management practices are among the most commonly practiced CSA practices.

The adoption rate of CSA practices in the study area is low. Conservation agriculture, integrated soil fertility management, high yielding, disease resistance, and drought tolerance, short-season crop varieties (crop diversification) adopters' percentage indicate 42.5%, 61%, and 52%, respectively, while the other practices were adopted by less than 40% of respondents. The result shows, adoption rate of different CSA practices identified in the study area remains low.

The farmers are assume adopters of the practices for example conservation agriculture if the farmers adopt at list one of the component of the practice for example bund or reduced tillage or crop residue or crop rotation.

3.2. Interdependency of adopted CSA practices

The CSA techniques being used in the research area include; conservation agriculture, integrated soil fertility management, small-scale irrigation includes, agroforestry practice, Crop diversification, improved livestock feed and feeding, improved weather information, and post-harvest technologies.

The result of correlation coefficient error components result from MVP model estimate of eight CSA practices indicated correlation coefficients are jointly significant. This confirms that the null hypothesis that there is no significant relationship or correlation between the error terms in all eight equations is rejected. Table 2 shows the interdependently and jointly adopted CSA practices by farmers. Moreover, it indicates that those practices are complementary. The result is in line with the findings of (Abyiot et al., 2023; Mebratu et al., 2022; Tamirat, 2022; Samuel et al. 2022).

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Table 2. Multiple CSA practices implementing in the study area.

	Kebeles						**Total % N=306**	
	Berfeta lemefa **n=66**		B/ Gaba Robi **n=105**		Berfeta Tokkofa **n=135**			
CSA practices	Adopters	Non adopter	Adopters	Non adopter	Adopters	Non adopter	Adopter	Non Adopter
Conservation Agriculture	36.4	63.6	54.3	45.7	32.6	67.4	42.5	57.5
Integrated soil fertility management(Different types of compost, efficient fertilizer application)	78.8	21.2	75.2	24.8	43.7	56.3	61	39
Small Scale Irrigation	54.5	45.5	23.8	76.2	20.7	79.3	38	62
Agroforestry	18.2	81.8	20	80	16.3	83.7	38	62
Crop diversification (high yielding, disease resistance and short season improved varieties)	60.6	39.4	72.4	27.6	31.1	68.9	51.6	48.4
Improved Livestock feed and feeding practices	16.7	83.3	44.8	55.2	29.6	70.4	39	61
Improved weather information system	48.5	515	34.3	65.7	37.8	62.2	38.9	61.1
Post-Harvest technology	18.2	81.8	42.8	57.1	33.3	66.7	38.6	61.4

Table 3. covariance of correlation matrix of CSA practices.

CSA practices relation ship	*Corr. Coef.*
Improved soil fertility Management and Conservation Agriculture	**0.335***(0.074)**
Small Scale Irrigation and Conservation Agriculture	-0.056(0.080)
Agroforestry and Conservation Agriculture	-0.043(0.080)
Crop diversification and Conservation Agriculture	**0.204**(0.086)**
Improved Livestock feed& feeding and Conservation Agriculture	**0.192**(0.085)**
Improved weather information and Conservation Agriculture	-0.047(0.076)
Post-harvest technology and Conservation Agriculture	**0.898***(0.023)**
Small scale irrigation and Improved soil fertility	-0.110(0.079)
Agroforestry and Improved soil fertility	0.046(0.078)
Crop diversification and Improved soil fertility	**0.221**(0.084)**
Improved livestock feed & feeding and Improved soil fertility	**0.219**(0.087)**
Improved weather information and Improved soil fertility	0.051(0.077)
Post-harvest technology and Improved soil fertility	**0.398***(0.087)**
Agroforestry and small scale irrigation	**0.367***(0.062)**
Crop diversification and small scale irrigation	-0.036(0.082)
Improved livestock feed & feeding and small scale irrigation	0.006(0.088)

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Improved weather information and small scale irrigation	0.081(0.069)
Post-harvest technology and small scale irrigation	0.018(0.089)
Crop diversification and Agroforestry	-0.103(0.085)
Improved livestock feed & feeding and Agroforestry	-0.021(0.093)
Improved weather information Agroforestry	0.067(0.075)
Postharvest technology and Agroforestry	0.022(0.095)
Improved livestock feed & feeding Crop diversification	0.102(0.099)
Improved weather information and Crop diversification	0.111(0.081)
Post-harvest technology and Crop diversification	**0.210**(0.096)**
Improved weather information and Improved livestock feed &feeding	-0.061(0.082)
Post-harvest technology and Improved livestock feed& feeding	**0.351***(0.097)**
Post-harvest technology and Improved weather information	-0.074(0.090)

Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho61 = rho71 = rho81 = rho32 = rho42 = rho52 = rho62 = rho72 = rho82 = rho43 = rho53 = rho63 = rho73 = rho83 = rho54 = rho64 = rho74 = rho84 = rho65 = rho75 = rho85 = rho76 = rho86 = rho87 = 0: chi2 (28) = 251.988 Prob > chi2 = 0.0000 **Stand.er. in parenthesis ***p<0.01, **p<0.05, *p<0.1.**

3.3. Adoption determinants of Climate Smart Agriculture practices

Adoption determinants of climate-smart agriculture practices were analyzed using a multivariate probit model. Institutional, socioeconomic, and demographic factors are identified explanatory variables in the analysis result. Response variables are conservation agriculture, improved soil fertility management, small-scale irrigation, agroforestry practices, crop diversification, improved livestock feed & feeding, improved weather information, and post-harvest technology suppose 1 if the practice adopted by farmers 0 otherwise (**Table 4**).

The coefficient result of multivariate probit is shown in **Table 4** below. Independent variables are household head sex, age, family size, education level, climate change perception, land/farm size, livestock holding (TLU), farm income, household farming system, access to credit service, access to agricultural extension & agricultural training and farmer field day participation.

Demographic factors

Sex

Site and agro ecology specific improved crop varieties including drought and disease resistance, high yielding crop varieties are highly recommended to cultivate in the situation when climate change is affecting production and productivity in order to overcome the devastating effects of climate change on the agriculture. The study indicate that household sex or being male as compared to female significantly **(p<0.01)** increased the likelihood of adoption of improved crop varieties.

Livestock production is one of the agriculture sector which contributing for greenhouse gas emission specifically methane gas, hence working on livestock feed and breed improvement is crucial in this case. Household sex or being male as compared to female significantly **(p<0.1)** increased the likelihood of adoption of improved livestock feed and feeding practice.

Age

The level of soil fertility is one of the determining factors that can affect the output per plot of land in agriculture that is why many farmers add fertilizer to their farmland. However, if farmland is failed to be managed in well-mannered, soil fertility is decreasing, possibly because of climate change and unwise use. In this study, the result indicated household head age significantly (p<0.05) and negatively influenced the likelihood of improved soil fertility practice adoption. This suggests that younger people are more motivated to implement improved soil fertility practices than the older. Possible explanation is that improved soil fertility practices for example compost and manure applications are laborious that more easily applicable for youngster than older. Likewise the age of household significantly ($p<0.05$) and negatively affecting crop diversification. This result is in line with the findings of (Mebratu et al. 2022).

Household head age is positively and significantly ($p<0.05$) influenced agroforestry adoption. The result is consistence with Abyiot et al. (2023), which indicated age is significantly and positively affected agroforestry practice adoption.

Education level

Agroforestry practices, such as tree-based conservation agriculture can help lessen the impacts of climate change. Trees and other plants can reduce erosion. The study result indicated education level of household heads significantly ($p<0.1$) and positively affecting adoption of agroforestry practice. The result is in agreement with Abyiot et al. (2023).

Climate change Perception

Climate change perception believed to have significant and positive contribution for CSA adoption in this study. It has significantly ($p<0.05$) increased improved weather information adoption. This implies that as perception of climate change increases, the decision to uptake and use improved weather information increases.

Economic factors

Land holding (Farm Land size)

Households land holding size significantly ($p<0.01$) increased adoption decision of agroforestry practices. The findings are in line with those of Samuel et al. (2022), who found that adoption of minimum tillage (a conservation agriculture technique) was substantially and favorably influenced by total land holding and Tamirat (2022), who found that adoption of conservation tillage significantly and positively influenced by cultivated land size owned by households.

Improved soil fertility management practice is significantly ($P<0.01$) and positively influenced by size of land holding. Likewise, crop diversification significantly and positively influenced by land holding size. This could mean that farmers who have larger farms are more apt to allocate farmland to various improved crop varieties than farmers who have smaller farms.

Improved livestock feed and feeding practice is significantly ($p<0.01$) and positively influenced by households land holding size. This implies households relatively with large farmland sizes more likely to adopt improved livestock feed and different forages for livestock feed compared with households relatively small land holdings. Post-harvest technologies are a measure taken after harvest of a product for conserving, protecting or processing. The study result indicated that land holding size significantly ($p<0.01$) increased the probability of adopting post-harvest technology practice.

Farm income

Households farm income which helps the farmers to cover household expenses significantly ($P<0.01$) and positively affected improved livestock feed and feeding practice adoption. This indicated that as farmers' income increases the likelihood of adopting improved livestock feed and feeding practices.

Table 4. Adoption determinants of CSA practices.

Variables	Conservation Agriculture	Improved soil fertility	Small scale irrigation	Agroforestry practices	Improved crop/Crop diversification	Improved Livestock feed and feeding	Improved weather information	Post-harvest technology
Sex	0.035	0.154	-0.018	-0.141	0.887***	0.553*	-0.156	0.27
	(0.277)	(0.226)	(0.235)	(0.226)	(0.273)	(0.311)	(0.222)	(0.252)
Age	-0.206	-0.264**	0.152	0.282**	-0.316**	-0.018	0.149	-0.180
	(0.155)	(0.125)	(0.118)	(0.119)	(0.140)	(0.130)	(0.119)	(0.123)
Education Level	-0.155	-0.083	0.057	0.208*	-0.273	0.121	0.010	-0.19
	(0.135)	(0.108)	(0.109)	(0.107)	(0.133)	(0.122)	(0.107)	(0.111)
CC Perception level	-0.043	0.084	0.027	0.0014	0.192	0.267	0.36**	0.005
	(0.194)	(0.147)	(0.143)	(0.143)	(0.167)	(0.174)	(0.144)	(0.167)
Family size	-0.038	0.049	-0.094	0.064	-0.028	-0.001	0.103	-0.056
	(0.266)	(0.206)	(0.207)	(0.206)	(0.23)	(0.260)	(0.200)	(0.254)
Farm land size	1.919***	0.578***	0.221	-0.064	0.840***	1.120***	-0.080	1.611***
	(0.234)	(0.162)	(0.154)	(0.153)	(0.18)	(0.204)	(0.151)	(0.193)
Farming system	-0.167	0.389	-2.383	-0.278	0.174	1.916	-0.021	-0.39
	(0.364)	(0.296)	(50.206)	(0.348)	(0.319)	(74.25)	(0.299)	(0.283)
Farm income	-0.0052	-0.0009	0.00062	0.0011	-0.0021	0.034***	0.005	-0.009
	(0.0057)	(0.004)	(0.0049)	(0.005)	(0.005)	(0.0061)	(0.0045)	(0.005)
Access to credit	0.158	-0.253	0.221	0.417**	0.67**	-0.018	-0.046	0.43**
	(0.235)	(0.186)	(0.176)	(0.175)	(0.215)	(0.218)	(0.179)	(0.213)
Livestock Holding (TLU)	0.121**	0.004	-0.147***	-0.073*	-0.016	-0.072	0.014	0.13
	(0.047)	(0.038)	(0.040)	(0.038)	(0.041)	(0.044)	(0.037)	(0.040)
Access to Agri. Ext. services & agri. training	-0.029	-0.037	-0.0221	-0.367	1.212***	-0.241	0.067	0.0755
	(0.292)	(0.230)	(0.235)	(0.237)	(0.258)	(0.29)	(0.225)	(0.248)
Field day Participation	0.504*	0.664***	0.256	0.24	0.405	-0.146	-0.263	0.296
	(0.265)	(0.128)	(0.123)	(0.23)	(0.236)	(0.254)	(0.213)	(0.134)
Cont.	-2.517	-1.429	6.497	0.449	-2.64	-10.79	0.67	-2.00
	(1.256)	(1.056)	(150.62)	(1.192)	(1.146)	(222.7)	(1.07)	(1.043)

Log likelihood = -1144.4475, Wald chi2(112) = 385.56, Prob > chi2 = 0.0000. Stand.er. in parenthesis ***p<0.01, **p<0.05, *p<0.1.

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Access to credit service

The result indicated that farmers who have access to credit services which helps farmer to solve their financial deficit more likely to adopt agroforestry practices than farmers who have no access to credit services. The possible explanation perhaps agroforestry practices requires getting different seedlings of trees that have dual advantages both for conserving the soil and for producing fruit. Such tree seedlings may be expensive to purchase, but many people lack financial resources, and in this case, access to credit services helps to secure the gap. The result also indicated that, improved crop varieties adoption significantly ($p<0.05$) and positively affected by access to credit services. The possible explanation is that seed of improved crop varieties and inputs related with the seed requires cash, which may not all smallholder farmers not have at hand. Thus, access to credit services probably helps farmers to secure this gap.

Likewise post-harvest technology adoption significantly and positively ($p<0.05$) related with access to credit service. This implies that farmer who have access to credit service more likely to adopt post-harvest technology than farmers who have no access to credit service.

Livestock holding (TLU)

Livestock is the important asset in rural parts of Ethiopia and helps the smallholder farmers for many including as a source of income and use the livestock product for household consumption. The result indicated livestock holding size which is the source of income for farmers significantly and positively ($P<0.05$) influenced adoption of conservation agriculture. The result is in line with the findings of Tazeze et al. (2012); Samuel et al. (2022), which confirms that an increase in livestock holding increases the probability of adoption of soil and water conservation techniques. To the contrary, livestock holding significantly and negatively ($P<0.01$) affected the likelihood of adoption of small-scale irrigation practice. The result is in line with the study result of Titay et al. (2022), which found that livestock and small-scale irrigation could compete for water. Likewise, we found that significant and negative effect of livestock holding on adoption of agroforestry practices.

Institutional factors

Access to Agriculture extension services& trainings

Agricultural extension services and agricultural trainings, the methods and means through which farmers' access different agricultural information positively and significantly ($p< 0.01$) affect the adoption of crop diversification. The study result is in line with the findings of (Abyiot et al., 2023; Mebratu et al., 2022).

Farmers' field day participation

Field days are a standard element of the farmer's field school approach, which takes place at the end after trainings are carried out to explain the demonstration and share information with a wider set of farmers and it is an approach being practiced in more than 90 countries (Emerick and Dar 2021). The study result indicated that farmers field day participation significantly and positively ($p<0.1$) affected adoption of conservation agriculture practices. This implies that farmers access to participate in the field day occasion more likely to adopt agroforestry practices compared with the farmers have no access to participate on field day. Similarly, farmers who have access to participate in field day more likely to adopt improved soil fertility practices.

3.4. Climate smart agriculture adoption barriers

Farmers who participated in the poll said that a number of obstacles make the adoption process difficult. Figure 2 depicts Climate smart agriculture practices adoption main challenges identified by farmers in the study area. Lack of technical knowledge for the CSA practices, lack of access to irrigation water, shortage of labor peculiarly for laborious practices, lack of full information, and lack of financial resources were the major barriers to CSA practice adoption.

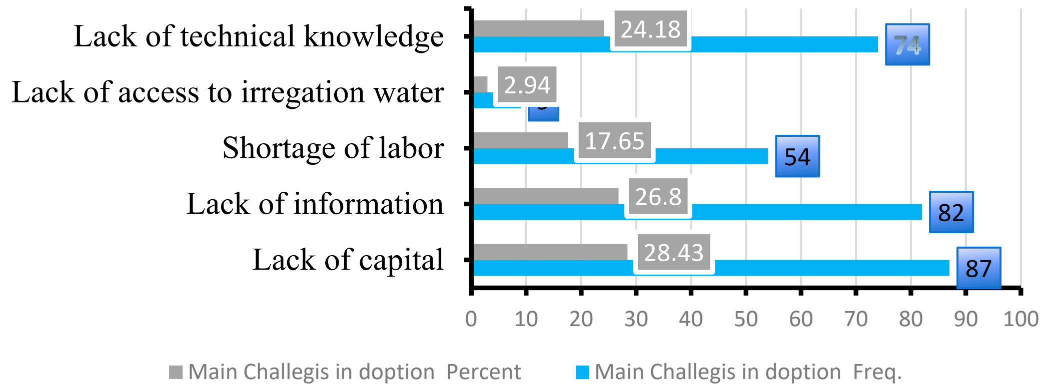

Figure 2. CSA adoption barriers. Source: Survey data (May, 2022).

According to a study by Titay et al. (2022) conducted in the East Hararghe Zone, poor access to information and limited financial resources are among the challenges confronting farmers and impeding the implementation of climate change adaptation strategies.

4. Conclusion and recommendation

Many studies focus only on factors affecting adoption of some selected CSA practices. However, there are limited empirical studies found on what type of CSA practices that the farmers are using in their area and factors affecting the adoption of the practices. There is an implication message for why farmers are implementing some CSA practices. In the study area CSA practices identified that implementing by farmers include conservation agriculture, integrated soil fertility management, small-scale irrigation includes, agroforestry practice, crop diversification, improved livestock feed and feeding, improved weather information, and post-harvest technologies. The study's findings indicate that a number of factors influencing adoption of CSA practices. Demographic factors result indicated that being male as compared with female farmers, increases the adoption of crop diversification and improved livestock feed and feeding practices significantly. Age of farmers significantly and negatively affecting the probability of adoption of improved soil fertility management practices and crop diversification. However, it affects the adoption of agroforestry practices positively and significantly. The economic factors result indicated, having relatively large farmland size significantly increases the adoption of conservation agriculture, improved soil fertility management, crop diversification, improved livestock feed and feeding practices, and postharvest technology practice. Better farm income increases the likelihood of uptake of improved livestock feed and feeding. Having a large number of livestock which helps the farmers as a source of income positively influences adoption of conservation agriculture and having access to credit services positively influences the implementation of agroforestry, crop diversification, and postharvest technology. We again found that positive and significant effect of climate change perception level on adoption of improved weather information. In addition, institutional factors result indicated access to agricultural extension service and training positively influences the adoption of crop diversification, access to participation on farmers' field day similarly positively influence the adoption of both conservation agriculture and improved soil fertility management practice. This indicated that agricultural extension services have an important role to create awareness about agricultural technologies. Policy makers and concerned bodies should give due attention on the area of factors affecting agricultural extension and training system since this is an important factors. Researchers, decision-makers, and stakeholders must consider site-specific CSA practices to lessen the detrimental effects of climate change on agriculture.

Further investigation is recommended in order to gauge the economic impact of CSA practices in the study areas as well as the adoption intensity of these practices.

Annex

Pictorial presentation of some of CSA techniques being used by farmers in the research area (taken during survey data collection).

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