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FARMERS' PARTICIPATION IN CLIMATE SMART AGRICULTURE INITIATIVES AND ADOPTION DECISIONS IN THE ARSI AND EAST SHEWA ZONES OF OROMIA REGION, ETHIOPIA

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ABSTRACT

Climate change is a major challenge to sustainable agricultural production in the world. The intricacy of the problem requires farmers' compliance with regenerative agricultural practices that can facilitate conservation of fragile productive systems, while sustaining their productivity. Accordingly, various climate change management strategies have been promoted in Ethiopia. This paper analyzed farmers' participation in CSA practices and the determinants of adoption in the Oromia region of Ethiopia. The data were collected during the 2020 cropping season from 420 randomly selected farmers in the Arsi (highland) and East Shewa (lowland) zones of the Oromia region. The data was analyzed with descriptive and Logit regression. The results showed that of the total thirteen climate smart agricultural practices that were assessed, about 6 and 4 were adopted by more than 50% of the farmers in the highland and lowland, respectively. Also, 21.0% and 42.4% of respondents from highland and lowland respectively participated in CSA programs or projects. Moreover, 35.5% and 34.8% of the highland and lowland agroecology farmers respectively adopted some CSA after project participation. In the highland agroecology, crop rotation, crop residual management, crop diversification and intercropping were the mostly used practices, while crop rotation, adjustment of planting time, minimum tillage and planning of drought resistant varieties were mostly used by lowland agroecology farmers. Moreover, logistic regression results reveal that CSA adoption is influenced by age, education, gender, family size, credit support, experience, extension support, non-agricultural income, and livestock holding. It was concluded that adoption of CSA was low, and promotion of extension support and CSA participation experiences will facilitate adoption of some CSA practices. More importantly, extension support should focus on CSA practices that were widely used by the farmers.

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INTRODUCTION

In many developing countries, the agricultural sector contributes significantly to economic growth and development. The immense share of the agricultural sector in the economies of developing nations is highly recognized, particularly for its functional share in nationwide economic development and improvement of rural livelihoods. In Ethiopia, the agricultural sector is a vital sector due to its significant supports to national and regional economies, besides its role as the source of livelihoods for rural population. The agricultural sector provides employment opportunities for 80 percent of the labour force, in addition to generation of about 90 percent of export revenues (Mulatu et al., 2016). Likewise, the sector supplies 70 percent of raw materials for domestic agro-industries, besides contributing about 43 percent to the Gross Domestic Product (GDP) (Mulatu et al., 2016). In addition, the Ministry of Agriculture and Natural Resource (MoANR) (2017) divulged that over 83 percent of the Ethiopian population lives in rural parts of the country and largely depends on subsistence agriculture to support their livelihoods.

Furthermore, there are evidences in support of the fact that a substantial proportion of the farming sector is managed by small-scale farmers in rural areas. However, the impact of climate change, coupled with associated hazards has been identified as remarkable constraint to farm productivity in many developing countries. Therefore, the effectiveness of small-scale farmers is dependent on environmental sustainability, including favorable climate, for sustainable agricultural production and development. More importantly, given that some climate associated variables are direct inputs to agricultural production, changes in climatic parameters are bound to have some obvious impacts on farmers' resource use productivity (Asha et al., 2012). It is equally apparent that sustainable agriculture is about climate resilient cropping system, coupled with water supply systems, which decrease climate change linked hazards in the context of small-scale farm households and improved natural resource endowments of the farming systems (Getahun, 2017).

However, it has been documented that changes in some climate parameters and weather variability are critical problems confronting agricultural productivity in Ethiopia, thereby undermining natural resource sustainability (Temesgen, 2014). Climate change affects the livelihood of the farming communities, particularly those living in the dry regions of the country (Temesgen, 2014). Likewise, on a global scale, climate change is currently identified as the most important challenge confronting the scientific communities as well as policy makers, while its impacts are primarily felt in the agricultural sector. The reason is that the agricultural production system is overly sensitive to climate change and its effects, even though the consequence on the other natural resources may vary across different agro-ecologies (Getahun, 2017). It has also been observed that rain-fed agriculture experiences a greater climate related negative impact. Among the consequences of climate change are biophysical damages, ecological degradation, and economic constraints (Mendelssohn, 2009).

In this regard, National Meteorology Agency (NMA) (2007) of Ethiopia, in its National Adaptation Program for Action (NAPA) document asserted that developing countries like Ethiopia are more susceptible to unfavorable shocks resulting from changes in some climatic parameters, and effective adaptation methods are urgently required. Developing countries are more vulnerable to variability and changes in climate because of inadequate adaptive capacity and sensitivity of the socio-economic systems to seasonal weather and climatic shocks. Therefore, understanding the adoption of climate smart agricultural practices is essential for some reasons. First, the Ethiopian agricultural sector's productivity is required to double to ensure national food supplies that contributes a significant share to national food security with less dependence on food importation and aid. Second, without sufficient adaptation, the current state of farm productivity decline will cumulate into climate change induced environmental degradation with irreversible consequences on the food supply systems. Therefore, given that agricultural farmland in Ethiopia had been subjected to continuous environmental degradation in the past few decades, with severe climate change induced degradation being promoted by improper management practice, it is necessary to ensure the extension of intervention to promote environmentally suitable agricultural technologies and appropriate natural resources management to mitigate and adapt climate change impacts. To this end, Ethiopian government has adopted and established Climate Smart Agriculture (CSA) strategic practices to manage climate change with the support of international organizations in addition to national efforts. However, experiences of the programs and/or project over the past years have not made adequate progress with respect to bringing major impacts on the adoption of modern technologies including the climate change management options (Wagayehu, 2003).

On the other hands, despite widespread of environmental degradation and low level of technology adoption, limited efforts that have been made to identify the nature of climate change management options adoption were not sufficient to summarize distinct conclusion. Therefore, this study examines the adoption of CSA strategic practices and determines the influencing factors in the study community. Contextually, the paper is organized to explain and presents adoption of climate smart agricultural practices based on social, demographic and economic characteristics and profiles of smallholder farmers from the Arsi and East Shewa zones, representing highland and lowland agro-ecologies, respectively.

MATERIALS AND METHODS

Study Areas

The study was conducted in the catchment of great African Central Rift Valley (CRV). This region crosses the central part of the Oromia regional state, where environmental degradation has manifested for many years. Climate change is affecting the livelihoods of the farming communities. Mixed farming and agro-pastoral farming system are commonly practiced in the highlands, mid and lowlands of the study areas. Regarding this study, Bosati and Dudga districts were selected from East Shewa, and Hetossa and Tiyo districts were selected from the Arsi Zone. These districts were selected because they are in the catchment of the great Awash River catchment, where the negative influence of climate change is very severe. Topographically, the altitude of these two zones ranges from 500-3200 meters above sea level (masl), but the study was conducted in the lowland part of the east Shewa and relatively midland districts of Arsi zones to see some topographical variations.

Sampling Procedures

This study involved the use of structured interview schedules with questionnaires being the main instrument for data collection. The target population of the study comprises of rural communities in the catchment of Central Rift valley (CRV) of the Oromia region. The households in the catchment of the CRV were selected to participate in the study. Two zones were selected purposively to represent highland and lowland agro-ecologies in the region. In this regard, respondents of Arsi were selected to represent highland agro-ecology, while respondents of East Shewa were to represent lowland agro-ecological zones of study areas. Within the zones, the districts were sub-categorized into two major categories based on prevailing altitudes which are mid-highland and extreme highland in the case of highland ecological zone and dry and semi dry in the case of lowland ecological zones. Given the differences in agro-ecology of the study areas within the districts, the stratified random sampling method was used for sampling. Two districts were selected from each ecological zone using random sampling. Selected districts were sub-divided into three sub-categories based on the similar criterion established for districts selection, but emphasizing on farming practices. The sampling frame comprises of all households enlisted with the Peasant Associations. Therefore, the sample size was calculated with the formula presented in Equation 1 by following Singh and Masuku (2014).

$$n = \frac{N}{1+N(e)2} \qquad \text{............1}$$

where, N is the total population of the Peasant Association, which is 10,156 households, n is the desired sample size and e is level of precision required which was set as 5 percent. The required minimum sample size is estimated to be 385. Specifically, three Peasant Associations (PAs) were randomly selected from each of the study's districts. A sample size of between 420 was targeted to cater for expected non-response from some respondents. However, 410 households were successfully interviewed with 210 from the Arsi zone and 200 from East Shewa zone.

Logistic Regression to Analyze the Determinants of CSA Practices Adoption

Based on Gujarati and Porter (2016), logit model was employed to examine the association of CSA practices adoption with its determinants because the dependent variable (Y) has only two categories which are 1 for adopters and 0 for non-adopters. Thus, general derivation of the working equation is presented as.

$$Ln\left[\frac{p}{1-p}\right] = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \cdots + \beta_k\chi_k + e_i \qquad \text{.................2}$$

In the above equation, P is defined as the probability that Y=1, where Xs are the independent variables that influence the dependent variable or P is the probability of the dependent variable in this case adoption decision. The Logit is a function (a transformation) of a parameter, and it is the logarithm of the odds of the event - which is the probability of an event divided by the probability of the event not occurring. The estimated model is presented as:

$$L_i = Ln\left[\frac{p}{1-p}\right] = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \cdots + \beta_k\chi_k + e_i \quad \ldots\ldots\ldots\ldots 3$$

Based on the above equation, the logit (L_i) is the multiple regression model (logistic distribution) containing predictors (binary and continuous variable) specified and regressed against dependent dummy variable of CSA adoption. To estimate the probability of adoption of selected practices in relation to CSA, equation 3 was estimated separately for respondents from the highland and lowland agro-ecologies. The independent variables are socio-economic variables are respondents' age, educational level, respondent gender, family farm size, livestock holding, non-agriculture income, farming Experience, family size, extension support, FTC Distance, credit support and project experience.

RESULTS AND DISCUSSION

Farmers' Participation in CSA Initiatives

Table 1 shows farmers' participation in initiatives for the promotion of CSA. It reveals that 21.0% and 42.4% of the farmers from highland and lowland respectively participated in programs or projects on CSA. On the other hand, among the selected respondents, 39% of highland farmers and about 58% of lowland farmers were never introduced any kind of CSA practices or innovation. This can explain the reason behind inadequate adoption of CSA practices. More importantly, a significant proportion (about 58% in highland and 59% lowland respondents) perceived inadequate success in managing the intended and expected benefit from introduced CSA practices. This may be due to inadequacy in services provision, policy and strategic level limitation and/or incompatibility (socially and environmentally) of innovation. Table 1 further reveals that after being introduced to the CSA practices, only 35.5% and 34.8% of farmers in the highland and lowland respectively decided to adopt the initiatives.

Table 1. Participation of respondents in CSA program or project (N=410)

CSA Programme	**Highland agro-ecology**				**Lowland agro-ecology**			
	Yes		No		Yes		No	
	Freq	%	Freq	%	Freq	%	Freq	%
Program or projects participation	42	21.0	158	79.0	89	42.4	121	57.6
Introduction of CSA innovations	120	60.0	78	39.0	88	41.9	122	58.1
CSA Achieved Intended Goal	85	42.5	115	57.5	86	41.0	124	59.0
CSA practices adopted	71	35.5	129	64.5	73	34.8	137	65.2

Source: Compiled from Survey data (2020)

Table 2. Farmers' years of project or program participation (N=410)

Participation Years	**Highland agroecology**		**Lowland agroecology**	
	Frequency	%	Frequency	%
No participation	140	70.00	104	49.50
1-3 years	42	21.00	40	19.00
4-6 years	14	7.00	49	23.30
7-10 years	4	2.00	17	8.10
Total	200	100.00	210	100.00

Source: Compiled from survey data (2020)

Table 2 shows the year of farmers' participation in the CSA programs or projects. It reveals that among those from the highland zone, 21% had between 1-3 years of experiences in CSA projects, as compared to 19% for the lowland zone. In addition, 4-6 years CSA programs/project experiences were had by 7% and 23.3% of the farmers in the highland and lowland zones, respectively.

Demographic Characteristics of Adopters and Non-Adopters

The results in Table 3 show the distribution of adoption of CSA based on the age with majority from the highland (40.85%) and lowland 49.32% being 41-50 years and 31-40 years age groups, respectively. Moreover, majority of the non-adopters in the highland (35.66%) and lowland 40.88% were from the 41-50 years age group. Bayard et al. (2007) confirmed that age has a positive correlation with adoption of climate smart agricultural practices with expectation that older farmers possess more farming experiences that can positively influence adoption of improved technologies for enhanced productivity.

Table 3. Respondents' Demographic Variables in Relation to Adoption of CSA Practices

Age category	Highland Agro-ecology					Lowland Agro-ecology				
	Total	**Adopters**		**Non-adopters**		**Total**	**Adopters**		**Non-adopters**	
	(200)	Freq	%	Freq	%	**(210)**	Freq	%	Freq	%
20-30 years	13	1	1.41	12	9.30	25	9	12.33	16	11.68
31-40 years	53	16	22.54	37	28.68	91	36	49.32	55	40.15
41-50 years	75	29	40.85	46	35.66	73	17	23.29	56	40.88
51-60 years	40	17	23.94	23	17.83	19	10	13.70	9	6.57
Above 60	19	8	11.27	11	8.53	2	1	1.37	1	0.73
Total	200	71	100.00	129	100.00	210	73	100.00	137	100.00
Household size										
Less 5	47	18	25.35	29	22.48	34	13	17.81	21	15.33
5-10	149	50	70.42	99	76.74	167	52	71.23	115	83.94
11-15	2	2	2.82	0	0.00	8	7	9.59	1	0.73
Above 15	1	0	0.00	1	0.78	1	1	1.37	0	0.00
Gender										
Female	24	11	15.49	13	10.08	19	10	13.70	9	6.57
Male	176	60	84.51	116	89.92	191	63	86.30	128	93.43
Marital status										
Married	179	65	91.55	114	88.37	205	70	95.89	135	98.54
Single	21	6	8.45	15	11.63	5	3	4.11	2	1.46
Education										
No formal	12	5	7.04	7	5.43	62	12	16.44	50	36.50
Adult	13	6	8.45	7	5.43	54	21	28.77	33	24.09
Primary	79	28	39.44	51	39.53	57	23	31.51	34	24.82
Junior-secondary	48	20	28.17	28	21.71	25	9	12.33	16	11.68
Secondary	48	12	16.90	36	27.91	12	8	10.96	4	2.92
Farming experience										
<10 years	12	0	0.00	12	9.30	39	13	17.81	26	18.98
11-20 years	50	12	16.90	38	29.46	91	25	34.25	66	48.18
21-30 years	73	33	46.48	40	31.01	68	29	39.73	39	28.47
31-40 years	47	16	22.54	31	24.03	12	6	8.22	6	4.38
> 40 years	18	10	14.08	8	6.20	0	0	0.00	0	0.00
Total	200	71	100.00	129	64.5	210	73	100.00	137	100.00

The Table shows that the majority of the households had 5-10 members. In addition, 70.42% of the adopters and 76.74% of the non-adopters were from households with 5-10 members in the highland agro-ecology, while 71.23% of adopters and 83.94% of non-adopters were from households with 5-10 members in the lowland agro-ecology. The average household size was 6.1 for the highland and 5.9 for the lowland agro-ecologies, while average family size for both agro-ecology is 6.0. These results imply that household sizes were relatively higher in the study area than the national average family size of 4.9 (CSA,2011b). Large family size in the survey community indicates that the population in the study area is quite high and this could negatively affect natural environment preservation. Ntsabane and Moteele (2008) affirmed that human population in Africa and globally posed the greatest threat to the environment than ever before, threatening the sustainability of natural and social environment. Bradshaw (2014) avowed that to realize a sustainable development in social and economic context, efforts should be directed towards reducing the impact of population growth on the environment through technological and social innovation in an environmentally friendly manner. According to Mugula and Mkuna (2016), household with large members may require more farm outputs thereby motivating adaptation to climate change through CSA.

Table 3 again further shows that 88% of the respondents in highland area are males, as compared to 90.95% for those on the lowland. The results indicate that farming households are largely headed by males and in line with those Arega **(**2013) who revealed that out of the total sample households, about 14 percent was female-headed. Ajala (2017) confirmed similar results and argued that the reason for having higher number of male farmers may be due to the drudgery nature of agricultural farm practices, which require extended efforts and time to perform. Oduniyi (2013) and Coster and Adeoti (2015) asserted that female farmers cannot be as active as their male counterparts. Besides, female farmers often have limited access to critical farm inputs. Likewise, an overwhelming 84.51% and 86.3% of the CSA adopters in the highland and lowland were respectively males. Similar trend was found among the non-adopters with 89.92% and 93.43% of them in the highland and lowland respectively being males. Arega **(**2013) submitted that female-headed households are usually differentiated by having small farm holdings, severe labor force shortage, inadequate financial resources and insufficient assets to operate farm business. Besides, female farmers shoulder greater responsibility to take care of family members due to the need to gather fuel wood and fetch water for domestic purposes.

The marital status of the respondents in the highland agro-ecology also reveals that 91.55% of the adopters were married, while 88.37% of the non-adopters were married. In lowland agro-ecology, 95.89% and 98.54% of the adopters and non-adopters were married. The Table further shows that 39.44% and 28.19% of the adopters in the highland attained primary and junior secondary education, respectively. However, majority of the non-adopters had primary and secondary education with 39.53% and 27.91%, respectively. In the lowland agro-ecology, 28.77% and 31.51% of the adopters had adult and primary education, respectively. In addition, among the non-adopters, 36.50% and 24.82% had no formal education and primary education, respectively. Promotion of knowledge, innovation, and education are essential in building a culture of safety and resilience to climate change at all levels (Gebrie, 2015). Additionally, Harris (2012) stated that as individual's knowledge on environment increases, the community will be more aware of the potential consequences of the negative impacts and risks. Consequently, an educated farmer can have a realistic perception of natural disasters, its causes and impacts which consequently facilitate the adoption of the climate change adaptation measures in the community (ibid). All these necessitate the need of relevant assessment related to the impact of education on Technology adoption and thus, emphasized in this study. Accordingly, examination of the educational background of the respondents reveals that only 6% and 29.5% of them have not attended any kind of formal education in the highland and lowland agro-ecology respectively (Table 3), While 6.5% of the respondents attended the least adult education schooling in highland, 25.7% are found in lowland farming community. Thus, this result indicates, better schooling profile of the study community than what is reported at the national level, which confirms that in Ethiopia 58% of women and 44% of men are illiterate (Gebrie, 2015). Generally, out of the overall total of the surveyed respondents located in the highland and lowland areas of the study, about 65.6% of them attended and completed primary school education, and above during the survey period. As indicated in Table 3, most of the farmers who participated in this study are semi-literate, having attained high school education. Specifically, 17.8% attended junior secondary, while 14.6% had secondary level education, respectively when the aggregate of highland and lowland is considered. However, the proportion of the respondent with junior secondary and secondary level education is significantly lower at lowland agro-ecology compared with the ratio of participants from highland areas of the study.

Several studies significantly supported the role of education and knowledge in enhancing technology adoption decision. In line with this, Ajala, (2017) suggested the role of education based on relevant sources, like Asfaw and Admassie (2004) and Bamire *et al.* (2002), that education facilitates agricultural production by enhancing farmer's expertise to produce more output from given farmland resources, in addition to strengthening farmer's ability to acquire and analyze relevant information in accordance with the community's situation. Furthermore, this author asserted that experienced and educated farmers have more skills and knowledge regarding climate change and coping measures which ultimately can positively influence the adoption decision of the farmers. Furthermore, Ibrahim *et al.* (2015) and Maddison (2007) affirmed that farmers' literacy level impact on adaptation, as it affects producers' awareness, as well as perception regarding climate change and importance of adaptation options, as educated farmers could be proactive or reactive to climate change risks by making appropriate options toward adaptation. On the other hand, although there is limitation to verify direct association between lack of formal education and household food insecurity, lack of education might limit household heads' capacity to read and understand written information related to regulation, markets systems, technology, technical training, financial management and infrastructures that could improve their awareness and perception to adopt the recommended innovations required to attain food security (Bunana, 2014).

In the case of this survey research, the respondents' educational profile is on average, and better than the national average of the country, which further indicates enhanced awareness of farmers about natural resource degradation, contributing knowledge regarding climate change, which particularly requires building adaptation skills and resilience at community level. This finding is in conformity with several other study results, like Gebrie (2015), who confirmed educated communities' responsiveness to adapt to climate changes and manage disaster better than uneducated community members. However, the survey result presented in Table 3, shows no significant difference among the educational level of the respondent in respective to adoption decision makings. In the study area, a ratio of 66.7 are adopters, with secondary educational level, all the remaining educational level including the non-formal education was found less than average (below 50%) rate of CSA practices adoption decision in both highland and lowland farming community. Therefore, the impact of education on CSA adoption decision is less, it seems that the education strategies need to be designed in a way that accommodate the environmental aspect of knowledge which require further revisiting of strategies including education policy.

The farming experience of the respondent is presented in Table 3, and it shows that the majority of the farmers (53.2%) had farming experience of 21 years and above, while 46.8% had farming experience of less than 20 years. Meanwhile, the proportion of farmers who have farm experience of more than 30 years is high (32.5%) at highland agro-ecology compared with lowland (5.7%) during survey period. Similarly, farmers with less farming experience (within the range of 10 years) account for 6% and 18.6% for highland and lowland, respectively, and almost the same proportion is observed with those who have between 11- and 15-years farming experience amongst the respondents. The farmers with less than two years of farming experience constitute only 7.1 percent. Thus, the distinction made is a pointer that there are more experienced farmers who had adequate knowledge about the farming sector in the study community. According to Ajala (2017), who explained referring to Ibrahim *et al.* (2015) and Madisson (2007, the farming experience of respondents would impact positively on farmers' productivity as the result of fact it helps to identify the climate change situation earlier and respond earlier to related impacts compared with less experienced farmers.

With regard to farming experience of the household heads, the results of the survey (Table 3), illustrate that a high proportion of farmers in each farming experience category are non-adopters of CSA practice, while just a few are adopters (below 50%). This is significantly low as compared to information garnered from literature, which indicates high impact of farming experience on technology adoption including climate change adaption and mitigation practices. In the meantime, inter agro-ecological variation concerning the rate of adoption decision of CSA practices is minimal, contrary to prior expectation. For instance, it was expected that there would be a better rate of adoption in the lowland farming community considering the significant impact of climate change on the national economy in general and livelihoods of the farming community in particular. Debatably, these findings adequately indicate that farming experience of individual farmers without integrating the CSA practices in Technology packaging and ultimately in the farming system has nothing to do with climate change management aspect in the farming system which clearly indicates limitation of Technology and innovation packaging in extension service delivery system. Furthermore, Table 3 enounces livestock farming experience in the context of CSA practices adoption decision of the respondents. Regarding livestock farming experience, two extreme situations were observed from the survey data. Majority (27%) of the respondents had more than 30 years of experience in the highland farming community, as compared to about 2 percent of the lowland, while majority of the lowland respondents (33.3%) had less than 10 years (including 10) experience in the field of livestock husbandry, which was relatively higher as compared to highland (9.5%) situation. In summary, the result shows that there is a high variability between the two agro-ecology, indicating a significantly pronounced experience in the lowland farming community when compared with its counterpart, the highlanders of the study community.

In relation to CSA strategic practice adoption, the highlanders in almost all the categories concerning livestock farming experience are better adopters in comparison to the lowland respondents. However, with exception of those with less than 10 years' experience, the lowland farmers are better adopters (about 37%), contrasting the highlanders' rate of adoption (about 15%) in the same range of livestock farming experiences. It is however surprising, as depicted in Table 3, that no farmer had above 40 years of livestock farming experience among the survey sample selected from the lowland agro-ecology, unlike the highland respondents where there are farmers with more than 40 years of experience, and also better adopters of the CSA practices. The study observed that majority of the respondents (50.6%) with 11 - 20 years of livestock farming experience are notable better adopter of the CSA practices in the highland agro-ecology, followed by 41-50, then 31-40 years of experiences as 2nd (50%) and 3rd (40%) respectively in the same farming system, indicating about an average rate of adoption. On the other hand, the rate of CSA practice adoption in respective to livestock farming experience were found below average in all the range of years of experiences, showing comparatively that the farmers within the livestock farming experience of less than 10 are (about 37%) better adopters, whereas 11-20 and 21-30 years of experiences are ranked 2nd (36.5%) and 3rd (27.5%) respectively. In general, the low rate of CSA practices adoption observed in this study indicates that the extension service delivery system and traditional farming systems are not integrating the environmentally friendly practices like that of climate smart agricultural practices. This is a threat to environmental sustainability and requires special managerial and technical attention in order to put maximum effort that will enable the integration of CSA practices into farming systems.

Table 4a. Parameter estimate for adoption of two top CSA practices at highland agro-ecology

Explanatory variables	**Crops Rotation (1st)**				**Crops residue management (2nd)**			
	Coefficient	Wald stat	Exp (B)	P-Value	Coefficient	Wald stat	Exp (B)	P-Value
Respondent age	-0.08	2.87	0.93	0.09*	0.01	0.02	1.01	0.88
Educational level	-0.52	5.15	0.59	0.02**	0.11	0.43	1.12	0.51
Respondent gender	-0.60	1.04	0.55	0.31	-0.63	1.73	0.53	0.19
Family farm size	-0.13	0.33	0.88	0.56	-0.15	0.66	0.86	0.42
Livestock holding	0.01	1.46	1.01	0.23	-0.021	1.37	0.98	0.24
Non-agriculture income	0.000	1.67	1.00	0.19	0.00	2.05	1.00	0.15
Farming Experience	0.04	0.87	1.04	0.35	-0.03	0.78	0.97	0.38
Family size	-0.12	1.49	0.89	0.223	0.02	0.04	1.02	0.84
Extension support	0.21	0.46	1.23	0.49	0.09	0.17	1.10	0.68
FTC Distance	-0.41	5.34	0.66	0.02**	-0.12	1.63	0.89	0.20
Credit support	0.57	1.65	1.77	0.19	0.11	0.09	1.11	0.76
Project Experience	0.83	3.09	2.29	0.08**	0.04	0.01	1.04	0.93
Constant	**2.19**	**1.267**	**8.936**	**0.260**	**-0.05**	**0.00**	**0.95**	**0.97**
-2 Log likelihood				154.38				228.33
Hosmer & Lemshew test (Chi-square(X^2))				18.62***				14.01*
Test of model coefficient (Chi-square (X^2))				35.94***				18.59*

Table 4b. Parameter estimate for adoption of two immediate top CSA practices at highland agro-ecology

Explanatory variables	**Crops varieties diversification (3rd)**				**Intercropping (4th)**			
	Coefficient	Wald stat	Exp (B)	P-Value	Coefficient	Wald stat	Exp (B)	P-Value
Age of respondents	0.05	2.08	1.05	0.15	0.02	0.58	1.02	0.45
Educational level	0.03	.033	1.03	0.86	0.02	0.02	1.02	0.89
Gender of respondents	0-.05	.014	0.95	0.91	0.76	3.24	2.13	0.07*
Family Farm size	-0.29	2.57	0.75	0.11	0.26	2.42	1.29	0.12
Live stockholding	-0.03	1.83	0.98	0.18	-0.01	0.04	0.99	0.83
Non agriculture income	0.00	4.39	1.00	0.03**	0.00	1.00	1.00	0.32
Farming experience	-0.03	.941	0.97	0.33	-0.03	0.74	0.98	0.39
Family size	0.04	.327	1.04	0.57	-0.20	7.71	0.82	0.01**
Extension support	-0.33	1.87	0.72	0.17	-0.20	0.82	0.82	0.37
FTC Distance	-0.13	2.11	0.88	0.15	0.03	0.17	1.04	0.68
Credit support	0.04	.014	1.04	0.91	0.08	0.05	1.08	0.82
Project experience	-0.65	1.48	0.52	0.22	0.51	1.58	1.67	0.21
Constant	0.44	.08	1.55	0.77	-0.59	0.17	0.55	0.68
-2 Log likelihood				231.96[a]				243.93[a]
Hosmer & Lemshew test (Chi-square (X^2))				10.29**				13.25
Test of model coefficient (Chi-square (X^2))				24.41**				19.71*

Binary Logistic Regression Results of the Determinants of Adoption

Tables 4a and b shows the results of the logistic regression analyses for the determinants of adoption of selected CSA practices in the highland agro-ecology, while Tables 5a and 5b present those for lowland agro-ecology. The four most adopted CSA practices were analyzed. Multicollinearity test using the variance inflation factor indicated non-existence of perfect correlation (Menard, 1995). Furthermore, log likelihood ratio and Hosmer-Lemeshow test techniques were selected to determine the goodness of fit of the models. Additionally, to tests the unique contribution of each predictor, Wald statistics (Chi-square) was selected to describe magnitude of each effect, whereas the coefficient of each variable was used to verify and interpret the direction of effect (whether negative or positive) on dependent variables.

Table 4a and b show that age, educational level, distance of FTCs and experience in project on crop rotation adoption found statistically significant at 10% for age and at 5% for the remaining other variables, while the effect of none agriculture income on crop variety diversification is significant at 5% significance level. The effect of gender on inter-cropping found significant at 10% significance level, while family farm size on inter-cropping adoption found statistically significant at 5% significance level. On the other hand, the remaining majority of socio-economic variables found statistically none significant, without denying customarily recognized potential effects and influences on technology adoption.

In the case of lowland Table 5a and b, presents the summary of the results, where the model chi-square appeared statistically significant indicating the reduced log likelihood ratio of the model as compared to model without independent variables and a significant Hosmer-Lemeshow test, indicates that the available data fit the model well in contrary to null hypothesis. Particularly, credit found leading in contributing to odds ratio of CSA practices adoption, in which odds ratio found 2.842 for crops rotation, 1.91 for planting time and 1.87 for adaptable crop varieties, indicating the higher odds of approval (those mentioned CSA practices adoption) for each one-point increase in accessibility to credit sources as compared to other predictors. Furthermore, extension support found 2nd level in the context of crops rotation and adjusting planting time, and comes 3rd level in the case of minimum tillage and adaptable crop varieties, while educational level and project experiences are 2nd in respect of these last two CSA practices. On the other hand, the odds of farm size, project years, gender and educational level found to be the smallest of all against crops rotation, crops planting time, minimum tillage and adaptable crop varieties adoption, in the context of lowland community.

Table 5a. Parameter estimate for adoption of two top CSA practices at Lowland agro-ecology

Explanatory variables	Crops Rotation (1st)				Adjust crop planting time (2nd)			
	Coefficient	Wald stat	Exp (B)	P-Value	Coefficient	Wald stat	Exp (B)	P-Value
Respondent age	0.050	0.63	1.051	0.426	-0.107	6.76	0.899	0.009***
Educational level	-0.065	0.08	0.937	0.775	-0.166	1.05	0.847	0.305
Gender of household head	0.527	0.39	1.694	0.530	-0.514	0.53	0.598	0.465
Family size	0.184	1.43	1.202	0.232	0.024	0.06	1.024	0.808
Farm experience	-0.045	0.75	0.956	0.387	0.074	4.16	1.077	0.041**
Family farm size	-0.431	3.19	0.650	0.074*	-0.165	2.47	0.848	0.116
Livestock Holding	-0.002	0.02	0.998	0.876	0.018	4.08	1.018	0.043**
Non-agriculture income	0.000	1.66	1.000	0.197	0.000	1.42	1.000	0.234
Project experience year	0.286	0.22	1.330	0.642	-0.610	2.04	0.543	0.153
FTC Distance	0.145	2.48	1.156	0.115	-0.026	0.14	0.974	0.706
Credit support	1.045	2.928	2.842	0.087*	0.647	3.014	1.910	0.083*
Extension support	0.778	3.961	2.177	0.047**	0.457	3.269	1.579	0.071*
Constant	-7.837	6.133	0.000	0.013***	1.828	0.824	6.219	0.364
-2 Log likelihood				113.544[a]				220.078[a]
Hosmer & Lemshew test (Chi-square(X^2))				9.004				12.607
Test of model coefficient (Chi-square (X^2))				19.932*				23.795**
Overall correct prediction				79.6%				67.0%
Sensitivity prediction				98.9%				94.9%
Specificity prediction				13.6%				10.8%

On the other hand, in respective of effect directions, different results identified, among which some are different from initial assumption and experiences of the research findings. For instance, the coefficient of farm size against crop rotation is smallest of all and negative, indicating that with a unit increase on farm size scale the odds of disapproving (non-adoption) of the crop's rotation would increase by a multiplicative factor of 0.65 point, whereas the effect of this variable found to be positive in some of the study findings. Additionally, the probability of disapproval of minimum tillage adoption would increase by 1.694 factors as binary dummy gender variable changed.

In summarized manner, when coefficient of the variables considered, the majority such as education level, FTCs distance, farm size, farm experience, livestock holding, gender, age, project experience and family size have identified with different unique contribution to expanded model which vary in the range of less than one with positive or negative, while only the credit accessibility as a variable contributing more than point to the probability of approval (by a factor of 1.045) in the context of crops rotation. With regard to odds ratio, some explanatory variables such as extension supports, none-agriculture income and credit accessibility, in all cases influence the odds of CSA practices adoption by more than one factor with positive factors in most (extension support and non-agriculture income source), while only negative influence identified in the case of credit accessibility on minimum tillage in lowland agro-ecology.

In general term, more than half of explanatory variables, about 67% for crops rotation, 50% planting time, 58% minimum tillage and adaptable crops varieties adoption, provided positive association with included independent variables, among these, extension support and none agriculture related incomes found as predicted in the model specification section, while others provided as predicted in some cases and different in other cases, showing inconsistent association with independent variables. For instance, finding of FTCs distance indicated opposite in the case of crop rotation and minimum tillage to hypothetical proposal which suggested negative association with technology adoption, but consistent in the case of planting time and adaptable crop variety adoption.

Table 5b. Parameter estimate for adoption of two immediate top CSA practices at lowland agro-ecology

Explanatory variables	Minimum Tillage (3rd)				Climate change adaptable varieties (4th)			
	Coefficient	Wald stat	Exp (B)	P-Value	Coefficient	Wald stat	Exp (B)	P-Value
Respondent age	0.025	0.351	1.02	0.554	-0.037	1.01	0.96	0.314
Educational level	0.393	5.567	1.48	0.018***	-0.080	0.28	0.92	0.599
Gender of household heads	0.478	0.346	0.62	0.557	-0.058	0.01	0.94	0.924
Family size	-0.128	1.349	0.88	0.246	-0.034	0.14	0.97	0.707
Farm experience	0.001	0.001	1.00	0.980	0.014	0.20	1.01	0.657
Family farm size	0.520	17.68	1.68	0.000***	0.089	1.10	1.09	0.294
Livestock holding	-0.001	0.006	0.99	0.939	0.025	6.74	1.03	0.009***
Non-agriculture income	0.000	4.987	1.00	0.026***	0.000	3.34	1.00	0.068*
Project experience year	-0.247	0.333	0.78	0.564	0.396	1.09	1.49	0.296
FTC distance	0.022	0.094	1.02	0.760	-0.019	0.08	0.98	0.773
Credit support	-0.161	0.181	0.85	0.671	0.628	3.32	1.87	0.068*
Extension support	0.384	1.690	1.47	0.194	0.076	0.10	1.08	0.753
Constant	-2.056	0.793	0.13	0.373	-0.594	0.11	0.55	0.744
-2 Log likelihood				201.295[a]				245.751[a]
Hosmer & Lemshew -test (Chi-square(X^2))				16.141**				22.523***
Test of model coefficient (Chi-square (X^2))				61.348***				20.715**
Overall -correct prediction				89.6%				70.1%
Sensitivity prediction				88.6%				89.8%
Specificity prediction				65.4%				42.2%

Note: ***, ** and * significant at p< 1%, p<5% and P<10%, respectively

On the other hand, of selected twelve explanatory variables, almost all were found statistically insignificant at any of customarily accepted probability levels. For instance, the effect of age was found positive on crop rotation and minimum tillage, while negative in the case of planting time and adaptable crop variety adoption, but the identified effects are statistically insignificant. Similarly, association of two explanatory predictors (gender and distance of FTCs) was found positive with crops rotation and minimum tillage, whereas negative association observed in respective of planting time and adaptable crop variety adoption which are statistically insignificant. The remaining explanatory predictors, such as educational and family farm size also found statistically insignificant with almost all negative association of educational level to three CSA practices (Crops rotation, adjusting planting time and adaptable crop variety) adoption, while only minimum tillage practice found positive with education. According to the model result, an increase in educational scale of farmers are more likely to disapprove CSA practices adoption (decrease the odds of adoption) as compared to those who did not attain formal education, but this finding by far different from initial assumption and most previous findings which suggest the positive association with Technology adoption due to the fact that educated farmers are more likely to access information and to be aware of problem severity which enhance them to seek for appropriate innovation. For example, Mulugeta (2000) and Haji (2002) who conducted research on soil conservation practices and cross breed dairy cows' adoption in Ethiopia, respectively, asserted positive association of technology adoption with educational level. In general term, as one can realize from above Tables, the effect of a majority of predictors found insignificant in proposed models, however, it is obvious that there is important association between independent variables and dependent as indicated by model parameter estimates which in frequency sense statistically insignificant.

CONCLUSION AND RECOMMENDATION

Generally, rate of adoption identified very low for almost all CSA practices selected among introduced strategies and surprisingly, in the case of some practices which are very important for climate change management found discouragingly below expectation and required level. For instance, of aggregated total respondents, 88%, 80% and about 73% found non-adopters of small-scale irrigation, improved range land management and water harvesting, respectively. On the other hand, a range of variables have considered and accessed to identify level of impact they exerted on adoption of introduced technologies and result confirmed that farmers with more resources are more likely to participate in the program and then adopt the introduced technologies than resources poor farmers. Accordingly, households within low income categories found more none adopters as compared to high- and medium-income categories where the majority found adopters of the introduced CSA practices. On the other hand, the several study findings and literatures showed that adoption rate of other disciplines technologies (crops and livestock) are by far better than natural resource conservation strategies adoption, indicating that poor attention and promotion of natural resource conservation related technologies which ultimately positively influence the climate change impact related risk management.

The evidence from this study suggests that much policy related aspects need to be considered to promote economically and environmentally sustainable development approaches emphasizing on the climate change managements. Specifically, extension policy of the country in general and study region in particular need redesigning to attain intended environmentally sustainable development goals without compromising the climate change management practices. In this regard, there should be well designed locally fitted rural extension policy and strategies using integrated grass root practical knowledge to foster sustainable rural development approaches with adequate integration of climate change management policy and strategies. Accordingly, land use and environmental policy with appropriated strategies should be in place and mainstreamed in all sectors which adequately emphasize the climate change scenario to supplement technical and local efforts, which addressing the natural resources degradation problem including the climate change negative impacts and consequences.

Along with resource availability and work environment suitability, Technical capacity of human resource is critical factors of success in extension service delivery level. However, it has realized from the findings of the study that the in adequate technical capacity of extension field staff (DAs) in relation to climate change management which is adversely affecting the effectiveness and efficiency of the extension field workers. Therefore, it is worth to well train extension field agents and technical back stopping must be in place to fill the technical capacity gap. The result of the study also suggested several limitations in respective of coping strategies availability, promotion and community awareness on nationally adopted strategies. Hence, it's worthwhile to make available a menu of coping strategies with required amount to farmers according to real demand. Specifically, none agriculture livelihood based coping strategies such credits, none agriculture employment opportunities and petty business must be strategically emphasized to help the community during natural disasters.

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CONFLICT OF INTEREST

The authors declare that there are no identified and acknowledged competing interests that could have appeared to influence the work reported in this paper.

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