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# Factors Influencing Farmers' Adoption of Climate Smart Agriculture Practices in the Case of Ilu Aba Bora Zone, South West Ethiopia

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## Abstract

To overcome the challenges of climate change, this study was intended to identify factors that affect the farmers' adoption of CSA in the Ilu Aba Bora Zone of Southwest Ethiopia across varying agro-ecological zones. A mixed research design was used for this study. During this study, representative districts (Bure, Hurumu, and Nono Sale) were selected purposely based on their differences in agro-ecology, while rural kebeles and respondents were selected randomly from the districts to minimize the biases of the data. Data collection tools employed were a questionnaire, KKI, FGD, and field observations. A binomial logistic regression model was used to identify the interaction of response and explanatory variables and to draw a conclusion. The findings of this study revealed the majority (63.1%) of farmers did not have an understanding of the meaning, function, and goals of CSA practices. Existing CSA options in the study area were conservation agriculture, crop diversification, agro-forestry, early warning system, livelihood diversification, and improved livestock feed, which were practiced at different levels and by a few households. In particular, the early warning system and improved livestock feed were the least implemented CSA options, whereas livelihood diversification, conservation agriculture, and agro-forestry were the highly adopted practices in the area. Independent variables including on-farm income, farming experience, weather information, agro-ecology, farm land size, age, extension service, marital status, and off-farm income were the factors significantly affecting the adoption of CSA practices in the study area. Experts, governments, and nongovernmental organizations should improve farmers' awareness of the benefits of CSA practices in ensuring food security, climate mitigation and adaptation through training and capacity building. The result of this study will show the direction for farmers, policy makers, planners, and other stakeholders to set up a solution in order to promote CSA practices and technologies based on agro-ecology.

## Keywords

Adoption, Awareness, Climate Smart Agriculture, Practices

## 1. Introduction

In Ethiopia, agriculture is the fundamental economic sector, and most of the population relies on its social and economic development [1]. Its contribution was 46.3% of the national GDP and 90% of the foreign exchange earnings of the country [2]. However, climate variability, change, and related extreme events are adversely affecting agricultural production. Climate

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changes are likely to result in increased variability in precipitation and an increase in temperature [3]. The variability in precipitation and temperature increase is due to increases in greenhouse gas (GHG) emissions into the atmosphere.

Human activities like agriculture have caused climate change; mainly, small-scale farming contributes to greenhouse gas (GHG) emissions and is a victim of climate change [4]. It is estimated that agriculture and associated land-use changes account for 24% of total global emissions. However, excluding forestry and other land uses, agriculture contributes approximately 12% of global GHG emissions [5]. Methane ($CH_4$) and nitrous oxide ($N_2O$) are the primary GHGs produced by agricultural activities, comprising about 55% and 45% of emissions from agriculture, respectively. In Ethiopia, annual GHG emissions were estimated at 150 Mt $CO_2$e in 2010, with 50% and 37% of these emissions resulting from the agricultural and forestry sectors, respectively. In addition, livestock production accounted for more than 40% of the emissions in agriculture [6].

Climate-smart agriculture (CSA), as an approach to agricultural development, re-orients agricultural production systems to ensure food security in the face of climate change by building climate resilience and adapting to climate change, and if possible, reducing or removing greenhouse gas (GHG) emissions [7]. CSA innovations are agricultural innovations that enable farmers to achieve at least two of the three pillars of CSA: food security, climate change adaptation, and mitigation [8].

In the past three decades, research efforts in CSA have been targeted at the development and promotion of low-cost technologies suitable for the smallholder farming sector [9]. These technologies include but are not limited to green manure, composting, mulching systems, farm yard manure combined with other fertilizers, crop diversification, cereal-legume intercrops, agro-forestry, conservation agriculture, and stress-tolerant crop varieties such as drought-tolerant maize.

The government of Ethiopia has developed policies and strategies that are pertinent to ensure food security, as well as address climate change. It has also ratified international climate change-related conventions. The country has developed a comprehensive green growth strategy that encompasses agriculture in the form of the Climate Resilient Green Economy (CRGE) strategy. However, the adoption of climate-smart agricultural (CSA) practices is affected by different factors. These could be due to farming factors (farm size), technology inaccessibility, environmental factors, policy design and social expertise, negative attitudes and motivations of farmers, farmers' socio-demographic factors, and farmers' socioeconomic factors [10]. The education status of the farmers and access to extension and weather information can also influence the likelihood of adopting these practices [11].

To ensure future generations live in a better and sustainable world, it is essential that we change our understanding and the way we use and manage our resources today. There is a lot of knowledge about how to grow our food sustainably. However, this knowledge is not used by most agricultural producers, consumers, entrepreneurs, policy-makers, researchers, and other stakeholders in most countries in the world. Therefore, the aim of this study was to assess the factors that influence farmers' the adoption of climate-smart agricultural practices to attain the three pillars of CSA, which are food security, climate change mitigation, and adaptation.

## 2. Materials and Methods

### 2.1. Description of the Study Area

The study was conducted in Ilu Aba Bora zone of the Oromia National Regional State, South West Ethiopia. Representative districts for this study were Bure, Hurumu, and Nono Sale districts. Geographically, Ilu Aba Bora zone is located between latitude 8.12 °-8.53 ° and longitude 35.76 °-35.94 °.

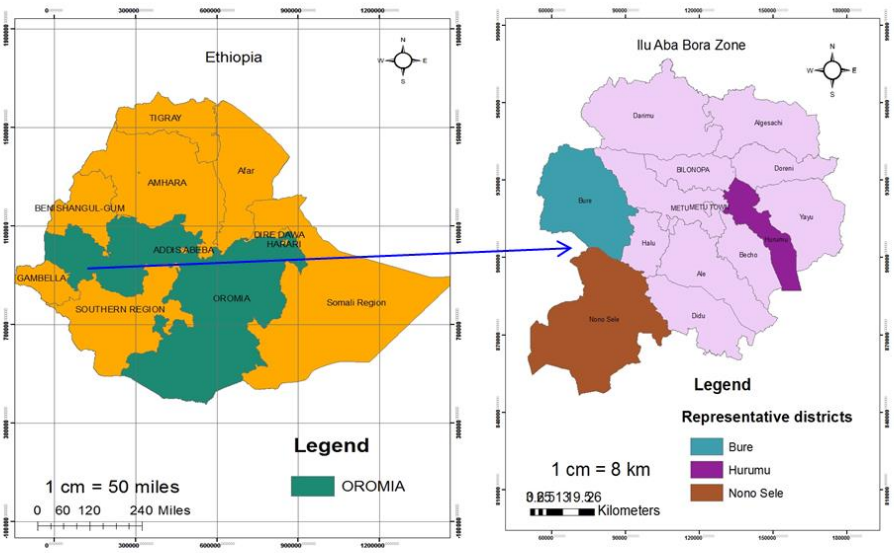


***Figure 1.*** *Location map of the study area.*

## 2.2. Research Design

Research design is important, because it provides a structure or framework for collecting and analyzing information for research. To achieve the objectives of the study, descriptive and explanatory research designs were employed. Descriptive research was used to describe the results in frequencies and percentage. Explanatory research was used to explore the significance effects of independent variables on dependent variables. Binomial logistic regression model as an explanatory research design was used to determine the magnitude of relationships between the dependent and independent variables under study. Both qualitative and quantitative research approaches were employed in order to analyze the data obtained from primary and secondary sources.

## 2.3. Sample Size and Sampling Procedure

For this study, a reconnaissance survey was conducted to be familiar and to get preliminary data which have helped for the validity of the study. The study was used purposive sampling technique to select districts based on the agro ecology of the zone. Accordingly, Bure district from lowland, Hurumu district from mid high land, and Nono Sale district from high land agro ecology was selected. A simple random sampling technique was used to select kebeles and households for this study. From each representative district, three rural kebeles were selected randomly to overcome the biasness of data.

Simplified formula to calculate sample sizes. This formula is used to calculate the sample size in this study. A 95% confidence level and P=0.05 was used to determine the required sample size from the total population [12].

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

Where:
n = Number of samples
N = total number of households;
e = maximum variability or margin of error 5%;
1 probability of the event occurring.

$$n = \frac{3919}{1+3919(0.05)^{(2)}} = \frac{3919}{1+3919(0.0025)} = 363$$

The total households of the selected three districts' *kebeles* (villages) were 3919 and 363 households heads were chosen for this study.

$$ni = \frac{n}{N} * 363$$

Where ni is the sample size for the *kebele* (villages), n- is the total number of farmers in the ward, and N-is the total number of farmers in the study area.

***Table 1***. *Distribution of sample households by kebeles.*

| S/N | District | *Kebele* (village) | No. of Households | Sample Size | Remark |
|---|---|---|---|---|---|
| | | Magarsa | 450 | 42 | |
| 1 | Bure | Lalisa | 320 | 29 | |
| | | Toli Korase | 550 | 51 | |
| | | Gaba | 435 | 40 | |
| 2 | Hurumu | Cabare | 389 | 36 | |
| | | Sonta | 405 | 38 | |
| | | Gamachisa | 360 | 33 | |
| 3 | Nono Sale | Nono Berbirsa | 580 | 54 | |
| | | Haro | 430 | 40 | |
| | | Total | 3919 | 363 | |

Source: Household survey (2023)

## 2.4. Data Sources and Collection Tools

In order to achieve the objective of the study, both primary and secondary data sources were employed. While collecting the data, ethical considerations were seriously taken into account to ensure the protection of concern, integrity, anonymity, consent, and other human elements of the informants.

The research used household survey questionnaire, FGD, KIIs, and field observation as tools.

### 2.5. Data Analysis

Raw data collected from primary sources was arranged and organized using Microsoft Excel 2007. Descriptive and inferential statistical data analysis was carried out for this study using SPSS version 24 software. Descriptive statistics which included frequency distribution and percentage were used to summarize and present demographic, socio-economic, and institutional factors. While inferential analysis was carried out to examine the effects of independent variables on the dependent variables.

## 3. Results and Discussion

### 3.1. Farmers' Awareness on Climate Smart Agriculture Practices

*Table 2. CSA Awareness.*

| CSA Awareness | | Frequency | Percent |
|---|---|---|---|
| Have you awareness about CSA Practices in climate change mitigation and adaptation? | Yes | 134 | 36.9 |
| | No | 229 | 63.1 |
| | Total | 363 | 100 |

Table 2 shows farmers' awareness of CSA practices in the study area. Awareness of the farmers has a direct impact on the adoption of CSA practices. Accordingly, out of the total 363 sampled households, only 36.9% had awareness of CSA practices while 63.1 households were not awarded for climate smart agriculture practices and its role. This reveals that the majority of the farmers in the study area had not detailed knowledge of CSA practices and its impact in realizing the goal of CSA pillars.

### 3.2. Climate Smart Agriculture Practices

In Ethiopia, various CSA technologies have been adopted under the broader framework of integrated watershed management [13]. Therefore, different biophysical and socioeconomic measures such as physical soil and water conservation structures, afforestation, enclosure, cut and carry feeding practices, destocking, beekeeping, dairy farming, agro-forestry, application of organic fertilizers, access to financial sources, access to weather information, and awareness creation intervention were among integrated watershed management practices meet the CSA criteria [6]. Accordingly, a range of CSA technologies were practiced by sample households in the study area as shown in Table 3.

The table shows all selected climate-smart agriculture practices have been adopted in the study area. But, the adoption level of each practice was not the same. According to the results shown in Table 3, livelihood diversification, conservation agriculture, and agro-forestry CSA practices were more adopted in the study area with 64.5%, 56.5%, and 51.2% respectively. Contrary, the least adopted among the eight CSA practices were early warning systems and improved livestock feed with 13.2% and 21.8%, respectively. This result indicated that the identified climate-smart agriculture practices in the study area were not equally adopted. Moreover, this revealed that all CSA practices, including relatively highly adopted technologies, need stakeholders' contribution to improve farmers' implementation on their farmland.

*Table 3. Climate smart agriculture practices.*

| CSA Practices | | Frequency. | Percent | CSA Practices | | Frequency. | Percent |
|---|---|---|---|---|---|---|---|
| Conservation Agriculture | Yes | 205 | 56.5 | Crop diversification | Yes | 164 | 45.2 |
| | No | 158 | 43.5 | | No | 199 | 54.8 |
| | Total | 363 | 100 | | Total | 363 | 100 |
| Integrated Soil Fertility Management | Yes | 144 | 39.7 | Improved livestock feed | Yes | 79 | 21.8 |
| | No | 219 | 60.3 | | No | 284 | 78.2 |
| | Total | 363 | 100 | | Total | 363 | 100 |
| Irrigation | Yes | 176 | 48.5 | Early Warning System | Yes | 48 | 13.2 |
| | No | 187 | 51.5 | | No | 315 | 86.8 |
| | Total | 363 | 100 | | Total | 363 | 100 |
| Agro-forestry | Yes | 186 | 51.2 | Livelihood diversification | Yes | 235 | 64.7 |
| | No | 177 | 48.8 | | No | 128 | 35.3 |

| CSA Practices | | Frequency. | Percent | CSA Practices | | Frequency. | Percent |
|---|---|---|---|---|---|---|---|
| | Total | 363 | 100 | | Total | 363 | 100 |

Source: Field survey data (February 2023)

### 3.3. Factors Influencing Farmers' Adoption of Climate Smart Agriculture Practices

Table 4 shows the factors influencing the adoption of each CSA practice. The result shows the impact of demographic, socioeconomic, and institutional factors on the adoption of conservation agriculture and integrated soil fertility management.

Accordingly, on-farm income (P=0.015), farming experience (P=0.001), and weather information (P=0.036) had a positive significant effect on the adoption of conservation agriculture while agro-ecology (P=0.028) and weather information (P=0.037) had a significant effect on the adoption of integrated soil fertility management.

A sample household with higher on-farm income and off-farm income was more likely to practice conservational agriculture by 70% than the one with low on-farm income. The likelihood of conservation agriculture adoption in sample households who had farming experience was higher by 60.2% and those who had weather information were higher in adopting conservation agriculture by 50.22%.

The possibility of conservation agriculture adoption by respondents who had weather information and mid-high land agro-ecology was higher by 73% and 20.37%, respectively. When the income of the farmers is better from agricultural activities, they can be motivated to modernize their agriculture by compost and verm compost preparation, and the use of soil and water conservation structures to improve the production and productivity of the soil. Farming experience is a golden asset to overcoming different challenges that might be raised by climate variability and change. So, the experience of farmers might help them to have weather information. SWC practices and compost-making might be affected by the weather conditions of the area. The results of FGD and KII also confirm the previous conclusion. Farmers who have been farming for a long time, had on-farm income and access to weather information were more practiced than conservation agriculture. Consistent with these results, previous studies have shown that farmers with higher on-farm income were more likely to adopt conservation CSA than others [14].

***Table 4****. Factors influencing the adoption of conservation agriculture and integrated soil fertility management.*

| Dependent variable: adoption of conservation agriculture | | | | | | | |
|---|---|---|---|---|---|---|---|
| Independent variables | B | S.E. | Wald | P-Value | Exp(B) | 95%C.I.for EXP(B) | |
| | | | | | | Lower | Upper |
| Sex | 0.368 | 0.352 | 1.096 | 0.295 | 1.445 | 0.725 | 2.881 |
| Age | 0.263 | 0.176 | 2.220 | 0.136 | 1.301 | 0.920 | 1.838 |
| Marital Status | -0.356 | 0.353 | 1.021 | 0.312 | 0.700 | 0.351 | 1.397 |
| Family Size | 0.110 | 0.158 | 0.483 | 0.487 | 1.116 | 0.819 | 1.522 |
| Educational Level | 0.671 | 0.371 | 3.264 | 0.071 | 0.511 | 0.247 | 1.059 |
| Agro-Ecology | -0.161 | 0.146 | 1.222 | 0.269 | 0.851 | 0.639 | 1.133 |
| Land Size | 0.119 | 0.166 | 0.519 | 0.471 | 1.127 | 0.814 | 1.559 |
| On-farm Income | 0.357 | 0.147 | 5.925 | 0.015** | 0.700 | 0.525 | 0.933 |
| Farming Experience | 0.508 | 0.149 | 11.66 | 0.001*** | 0.602 | 0.450 | 0.805 |
| Off-farm income | 0.233 | 0.167 | 1.953 | 0.162 | 1.262 | 0.911 | 1.749 |
| Credit Service | 0.012 | 0.229 | 0.003 | 0.957 | 0.988 | 0.631 | 1.546 |
| Extension Service | 0.114 | 0.254 | 0.204 | 0.652 | 1.121 | 0.682 | 1.843 |

| **Dependent variable: adoption of conservation agriculture** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Independent variables** | **B** | **S.E.** | **Wald** | **P-Value** | **Exp(B)** | **95%C.I.for EXP(B)** | |
| | | | | | | **Lower** | **Upper** |
| Weather Information | 1.614 | 0.770 | 4.393 | 0.036** | 5.022 | 1.110 | 22.70 |
| Constant | -1.026 | 2.26 | 0.206 | 0.650 | 0.359 | | |
| Dependent variable: adoption of integrated soil fertility management | | | | | | | |
| Sex | 0.021 | 0.343 | 0.004 | 0.952 | 1.021 | 0.521 | 1.998 |
| Age | -0.057 | 0.174 | 0.106 | 0.745 | 0.945 | 0.672 | 1.329 |
| Marital Status | 0.551 | 0.369 | 2.231 | 0.135 | 1.734 | 0.842 | 3.573 |
| Family Size | 0.080 | 0.154 | 0.268 | 0.604 | 0.923 | 0.682 | 1.249 |
| Educational Level | 0.458 | 0.362 | 1.600 | 0.206 | 0.633 | 0.311 | 1.286 |
| Agro-Ecology | -0.315 | 0.143 | 4.833 | 0.028** | 0.730 | 0.552 | 0.966 |
| Land Size | 0.131 | 0.159 | 0.682 | 0.409 | 0.877 | 0.643 | 1.197 |
| On-farm Income | 0.121 | 0.138 | 0.764 | 0.382 | 0.886 | 0.676 | 1.162 |
| Farming Experience | 0.144 | 0.141 | 1.042 | 0.307 | 0.866 | 0.657 | 1.142 |
| Off-farm income | 0.061 | 0.160 | 0.147 | 0.702 | 1.063 | 0.777 | 1.455 |
| Credit Service | 0.063 | 0.224 | 0.080 | 0.778 | 1.065 | 0.686 | 1.654 |
| Extension Service | 0.011 | 0.247 | 0.002 | 0.965 | 0.989 | 0.610 | 1.605 |
| Weather Information | 1.438 | 0.687 | 4.383 | 0.037** | 0.237 | 0.062 | 0.912 |
| Constant | 4.509 | 2.202 | 4.195 | .041 | 90.867 | | |

Note: *** and ** represent significance level at less than 1% and 5% respectively
NB: b=Beta coefficient, S.E=Standard Error, Exp (B)= Exponential Beta

Source: Field survey data (February 2023)

Table 5 shows that agro-ecology (P=0.007), farmland size (P = 0.000), and farming experience (P = 0.042) significantly influenced the implementation of irrigation. Thus, representative households who are living in mid-high land agro-ecology, have large farm sizes and hoarded long periods of time farming experience, were more likely to implement irrigation than sample households who are living in low land and high land, have small farmland sizes, and had a short period of time farming experience.

Table 5 also illustrates that agro-ecology (p =0.000) has significantly influenced the implementation of agro-forestry CSA practices. The likelihood of agroforestry adoption by sample households who have been living in low-land agro-ecology has negatively affected the practice of agro-forestry. Among the 3 agro-ecologies, agro-forestry was more adopted at mid-high land. This might be due to favorable conditions like temperature and rainfall to produce crops and livestock with trees especially home garden agroforestry and coffee with trees. On the contrary, agroforestry, irrigation is more practiced in low land agro-ecology. This might be due to the landscape of the area and the short months of the rainy season. Farmers with substantial farming experience should be willing to use small-scale irrigation after learning about the benefits of different irrigation technologies [15]. This outcome is in line with that of a study which suggested that farmers with larger farmlands adopted more CSA adoption techniques, indicating encouraging farmers to adopt CSA practices [16].

***Table 5.** Factors influencing adoption of irrigation and agro-forestry.*

| **Dependent variable: adoption of Irrigation** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Independent variables** | **B** | **S.E.** | **Wald** | **P-Value** | **Exp(B)** | **95%C.I.for EXP(B)** | |
| | | | | | | **Lower** | **Upper** |
| Sex | 0.163 | 0.366 | 0.199 | 0.656 | 1.177 | 0.575 | 2.413 |
| Age | -0.029 | 0.182 | 0.025 | 0.874 | 0.971 | 0.679 | 1.389 |
| Marital Status | 0.504 | 0.390 | 1.664 | 0.197 | 1.655 | 0.770 | 3.556 |
| Family Size | 0.022 | 0.163 | 0.019 | 0.892 | 0.978 | 0.711 | 1.346 |
| Educational Level | 0.601 | 0.374 | 2.580 | 0.108 | 0.548 | 0.263 | 1.141 |
| Agro-Ecology | -0.412 | 0.153 | 7.216 | 0.007*** | 0.662 | 0.490 | 0.895 |
| Land Size | 1.225 | 0.198 | 38.198 | 0.000*** | 0.294 | 0.199 | 0.433 |
| On-farm Income | 0.239 | 0.151 | 2.517 | 0.113 | 0.788 | 0.586 | 1.058 |
| Farming Experience | 0.306 | 0.150 | 4.143 | 0.042** | 0.736 | 0.549 | 0.989 |
| Off-farm income | 0.158 | 0.171 | 0.852 | 0.356 | 1.171 | 0.838 | 1.636 |
| Credit Service | 0.099 | 0.237 | 0.174 | 0.677 | 1.104 | 0.694 | 1.756 |
| Extension Service | 0.480 | 0.263 | 3.330 | 0.068 | 1.615 | 0.965 | 2.704 |
| Weather Information | 0.957 | 0.663 | 2.079 | 0.149 | 0.384 | 0.105 | 1.410 |
| Constant | 4.399 | 2.214 | 3.949 | 0.047 | 81.36 | | |
| Dependent variable: adoption of agro-forestry | | | | | | | |
| Sex | -0.160 | 0.359 | 0.198 | 0.656 | 0.852 | 0.422 | 1.721 |
| Age | -0.046 | 0.182 | 0.065 | 0.799 | 0.955 | 0.668 | 1.363 |
| Marital Status | 0.300 | 0.363 | 0.684 | 0.408 | 1.350 | 0.663 | 2.749 |
| Family Size | -0.116 | 0.162 | 0.508 | 0.476 | 0.891 | 0.648 | 1.224 |
| Educational Level | 0.396 | 0.370 | 1.145 | 0.285 | 0.673 | 0.326 | 1.390 |
| Agro-Ecology | -1.082 | 0.158 | 47.066 | 0.000*** | 0.339 | 0.249 | 0.462 |
| Land Size | 0.033 | 0.166 | 0.039 | 0.842 | 1.034 | 0.746 | 1.432 |
| On-farm Income | 0.019 | 0.148 | 0.017 | 0.896 | 1.020 | 0.763 | 1.362 |
| Farming Experience | -0.136 | 0.151 | 0.804 | 0.370 | 0.873 | 0.649 | 1.175 |
| Off-farm income | 0.162 | 0.172 | 0.893 | 0.345 | 1.176 | 0.840 | 1.646 |
| Credit Service | 0.186 | 0.238 | 0.608 | 0.435 | 1.204 | 0.755 | 1.920 |
| Extension Service | 0.394 | 0.263 | 2.232 | 0.135 | 1.482 | 0.885 | 2.484 |
| Weather Information | 1.079 | 0.666 | 2.625 | 0.105 | 0.340 | 0.092 | 1.254 |
| Constant | 3.943 | 2.198 | 3.217 | 0.073 | 51.55 | | |

Note: *** and ** represent significance level at 1% and 5% respectively
NB: b=Beta coefficient, S.E=Standard Error, Exp (B)= Exponential Beta

Source: Field survey data (February 2023)

As shown in Table 6 below, another important factor that significantly influenced the use of CSA practices (crop diversification) was the age of households, farming experience, extension services, and weather information on p-values of

0.027, 0.039, 0.000 and 0.029 respectively. This Result indicated that, households with higher age group were positively more likely to practice diversification of crops than households with lower age groups. Likewise, farmers with higher farming experience were more expected to undertake their farming with diversified crops than farmers with lower farming experience by 73.9%. The Possibility of farmers with accessible to extension services and weather information to adopt crop diversification was positively higher than that of households with inaccessible to extension service and weather information.

Table 6 illustrates that marital status (p=0.001) and off-farm income (p=0.000) of households were negatively and significantly affected the degree of improved livestock feed CSA technique adoption in the study area. This shows that divorced and widow household heads were less expected to carry out improved livestock feed as climate smart agriculture practice. The results revealed that respondents with high off-farm income were also less likely to implement improved livestock feed to realize CSA practices. This result has confirmed with the FGD, KII, and field observation. As observed from the field, farmers have been producing different crops to overcome the probability of crop failure due to pests, disease, and moisture stress. Moreover, there were cowpea, *lablab*, and elephant grass cultivated to improve livestock feed.

*Table 6. Factors influencing the adoption of crop diversification and improved livestock feed.*

| **Dependent variable: adoption of crop diversification** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Independent variables** | **B** | **S.E.** | **Wald** | **P-Value** | **Exp(B)** | **95%C.I.for EXP(B)** | |
| | | | | | | **Lower** | **Upper** |
| Sex | -0.030 | 0.350 | 0.007 | 0.931 | 0.970 | 0.488 | 1.928 |
| Age | 0.398 | 0.180 | 4.900 | 0.027** | 1.489 | 1.047 | 2.119 |
| Marital Status | 0.578 | 0.361 | 2.566 | 0.109 | 1.782 | 0.879 | 3.612 |
| Family Size | -0.100 | 0.159 | 0.395 | 0.530 | 0.905 | 0.663 | 1.235 |
| Educational Level | -0.031 | 0.364 | 0.007 | 0.932 | 0.969 | 0.475 | 1.980 |
| Agro-Ecology | 0.000 | 0.146 | 0.000 | 0.999 | 1.000 | 0.751 | 1.330 |
| Land Size | 0.215 | 0.167 | 1.655 | 0.198 | 1.240 | 0.893 | 1.721 |
| On-farm Income | -0.091 | 0.143 | 0.406 | 0.524 | 0.913 | 0.690 | 1.208 |
| Farming Experience | -0.302 | 0.147 | 4.252 | 0.039** | 0.739 | 0.555 | 0.985 |
| Off-farm income | 0.160 | 0.167 | 0.925 | 0.336 | 1.174 | 0.847 | 1.628 |
| Credit Service | 0.137 | 0.230 | 0.353 | 0.553 | 0.872 | 0.555 | 1.370 |
| Extension Service | 1.357 | 0.260 | 27.283 | 0.000*** | 3.883 | 2.334 | 6.460 |
| Weather Information | 1.563 | 0.714 | 4.789 | 0.029** | 0.209 | 0.052 | 0.849 |
| Constant | -0.289 | 2.155 | 0.018 | 0.893 | 0.749 | | |
| Dependent variable: adoption of improved livestock feed | | | | | | | |
| Sex | -0.390 | 0.469 | 0.692 | 0.406 | 0.677 | 0.270 | 1.698 |
| Age | 0.037 | 0.250 | 0.022 | 0.882 | 1.038 | 0.636 | 1.693 |
| Marital Status | -1.440 | 0.425 | 11.495 | 0.001*** | 0.237 | 0.103 | 0.545 |
| Family Size | -0.013 | 0.226 | 0.003 | 0.955 | 0.987 | 0.634 | 1.537 |
| Educational Level | 0.195 | 0.490 | 0.159 | 0.690 | 1.215 | 0.465 | 3.174 |
| Agro-Ecology | 0.150 | 0.205 | 0.532 | 0.466 | 1.161 | 0.777 | 1.736 |
| Land Size | 0.334 | 0.253 | 1.744 | 0.187 | 1.396 | 0.851 | 2.291 |
| On-farm Income | 0.057 | 0.219 | 0.068 | 0.794 | 0.944 | 0.614 | 1.451 |
| Farming Experience | -0.049 | 0.205 | 0.058 | 0.809 | 0.952 | 0.637 | 1.421 |

| Dependent variable: adoption of crop diversification | | | | | | | |
|---|---|---|---|---|---|---|---|
| Independent variables | B | S.E. | Wald | P-Value | Exp(B) | 95%C.I.for EXP(B) | |
| | | | | | | Lower | Upper |
| Off-farm income | -1.904 | 0.250 | 57.819 | 0.000*** | 0.149 | 0.091 | 0.243 |
| Credit Service | 0.129 | 0.330 | 0.153 | 0.695 | 0.879 | 0.460 | 1.678 |
| Extension Service | 0.876 | 0.347 | 6.368 | 0.012** | 2.401 | 1.216 | 4.739 |
| Weather Information | 0.493 | 0.889 | 0.308 | 0.579 | 1.638 | 0.287 | 9.359 |
| Constant | 4.839 | 2.781 | 3.029 | 0.082 | 126.3 | | |

Note: *** and ** represent significance level at 1% and 5% respectively

NB: b=Beta coefficient, S.E=Standard Error, Exp (B)= Exponential Beta

Source: Field survey data (February 2023)

Table 7 shows that the agro-ecological variation of the household head had significantly and negatively influenced the level of adoption of early warning system in the study area. Those who were from low land agro-ecology were less practiced early warning system than households from mid-high land and high-land agro-ecology with the p-value of 0.000. This might be due to the population density of the area and the accessibility of weather and climate information.

As shown in Table 7 below, most of the explanatory variables in the model were statistically significantly affected by adoption of the early warning system. Hence, sex (p=0.042), farming experience (p=0.038), and off-farm income (p=0.011) of respondents had positively and significantly affected the practice of livelihood diversification. The likelihood of male households was positively higher by 43.1% than female households to diversify livelihood. The possibility of practicing livelihood diversification CSA practices by households that had longer farming experience was higher by 69.6% than that of the household who had shorter farming experience. Similarly, households who had off-farm income were higher in adoption of livelihood diversification by 1.594 than households who had not off-farm income. Age (p= 0.000) and agro-ecology (p=0.000) appeared to be negatively and significantly affected the implementation level of livelihood diversification. The results of FGD and KII also confirm the respondents' perceptions and views.

***Table 7.*** *Factors influencing adoption of Early warning system and livelihood diversification.*

| Dependent variable: adoption of early warning system | | | | | | | |
|---|---|---|---|---|---|---|---|
| Independent variables | B | S.E. | Wald | P-Value | Exp(B) | 95%C.I.for EXP(B) | |
| | | | | | | Lower | Upper |
| Sex | 1.159 | 0.892 | 1.689 | 0.194 | 3.187 | 0.555 | 18.30 |
| Age | -0.056 | 0.360 | 0.024 | 0.876 | 0.945 | 0.467 | 1.915 |
| Marital Status | 0.407 | 0.625 | 0.425 | 0.515 | 1.502 | 0.442 | 5.110 |
| Family Size | 0.099 | 0.322 | 0.095 | 0.759 | 1.104 | 0.587 | 2.078 |
| Educational Level | -0.077 | 0.595 | 0.017 | 0.897 | 0.926 | 0.288 | 2.972 |
| Agro-Ecology | -1.453 | 0.400 | 13.20 | 0.000*** | 4.277 | 1.953 | 9.367 |
| Land Size | -0.241 | 0.368 | 0.430 | 0.512 | 0.786 | 0.382 | 1.615 |
| On-farm Income | -0.007 | 0.278 | 0.001 | 0.981 | 0.993 | 0.576 | 1.713 |
| Farming Experience | -0.038 | 0.285 | 0.018 | 0.894 | 0.963 | 0.550 | 1.684 |
| Off-farm income | -0.104 | 0.303 | 0.118 | 0.732 | 0.901 | 0.498 | 1.632 |

| Dependent variable: adoption of early warning system | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Independent variables** | **B** | **S.E.** | **Wald** | **P-Value** | **Exp(B)** | **95%C.I.for EXP(B)** | |
| | | | | | | **Lower** | **Upper** |
| Credit Service | 0.261 | 0.460 | 0.321 | 0.571 | 1.298 | 0.527 | 3.196 |
| Extension Service | -0.612 | 0.606 | 1.020 | 0.312 | 0.542 | 0.165 | 1.778 |
| Weather Information | 6.054 | 1.211 | 24.99 | 0.000*** | 425.65 | 39.66 | 4567. |
| Constant | -12.48 | 4.059 | 9.458 | 0.002 | 0.000 | | |
| Dependent variable: adoption of livelihood diversification | | | | | | | |
| Sex | 0.841 | 0.413 | 4.152 | 0.042** | 0.431 | 0.192 | 0.968 |
| Age | -1.191 | 0.208 | 32.79 | 0.000*** | 0.304 | 0.202 | 0.457 |
| Marital Status | 0.115 | 0.374 | 0.095 | 0.758 | 1.122 | 0.539 | 2.335 |
| Family Size | 0.109 | 0.176 | 0.382 | 0.536 | 1.115 | 0.789 | 1.576 |
| Educational Level | 0.225 | 0.368 | 0.372 | .542 | 1.252 | 0.608 | 2.577 |
| Agro-Ecology | -0.667 | 0.170 | 15.44 | 0.000*** | 0.513 | 0.368 | 0.716 |
| Land Size | -0.003 | 0.176 | 0.000 | 0.986 | 0.997 | 0.706 | 1.407 |
| On-farm Income | 0.005 | 0.165 | 0.001 | 0.974 | 1.005 | 0.728 | 1.389 |
| Farming Experience | 0.362 | 0.175 | 4.288 | 0.038** | 0.696 | 0.494 | 0.981 |
| Off-farm income | 0.466 | 0.184 | 6.429 | 0.011** | 1.594 | 1.112 | 2.287 |
| Credit Service | 0.510 | 0.261 | 3.824 | 0.051 | 0.600 | 0.360 | 1.001 |
| Extension Service | 0.030 | 0.287 | 0.011 | 0.916 | 0.970 | 0.553 | 1.702 |
| Weather Information | 0.398 | 0.663 | 0.360 | 0.549 | 0.672 | 0.183 | 2.465 |
| Constant | 5.136 | 2.276 | 5.091 | 0.024 | 169.95 | | |

Note: *** and ** represent significance level at 1% and 5% respectively

NB: b=Beta coefficient, S.E=Standard Error, Exp (B)= Exponential Beta

Source: Field survey data (February 2023)

## 4. Conclusion

Climate Smart Agriculture determines the sustainability of agricultural development in the economic, environmental, and social spheres. Therefore, an understanding of factors that may hamper farmers' adoption of CSA is an essential question for stakeholders and policymakers and requires consideration at the policy, research, and practice levels. This study has examined several determinants of farmers' adoption of CSA, including age and sex of households, educational level, farmland size, and access to credit, access to extension, off and on-farm income in selected districts of Ilu Aba Bora Zone. The adoption of CSA options such as conservation agriculture, irrigation, agro-forestry, and improved livestock feed, crop diversification, livelihood diversification, and early warning system have been adopted by a small number farmer in the study area. Even though they were adopting CSA practices on their farm land, the majority of farmers in the study area had not have detailed awareness about CSA practices and its role in realizing the sustainability of food security, climate mitigation and adaptation.

Adoption of CSA by sample households was affected by several interrelated factors like institutional, socio-economic, and demographic factors. Statistically, among the identified independent variables, on-farm income, farming experience, weather information, agro-ecology, farm land size, age, extension service, marital status, and off-farm income were significantly affected the implementation of CSA practices in the study area. To overcome the challenges of CSA adoption and enhance the benefits of farmers from CSA, different institutions and stakeholders should work together on capacity building, awareness creation, and support of financial and extension services.

## Abbreviations

| | |
|---|---|
| CRGE | Climate Resilient Green Economy |
| CSA | Climate Smart Agriculture |
| FGD | Focus Group Discussion |
| GDP | Growth Domestic Product |
| GHGs | Greenhouse Gases |
| Ha | Hectare |
| KII | Key Informant Interview |

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## Data Availability Statement

Data used to support the findings of this study are available from the corresponding author upon request.

## Conflicts of Interest

The authors declare no conflicts of interest.

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