

Determinants of climate-smart agriculture practices adoption among smallholder farmers in Guagusa Shikudad Woreda, Northwestern Ethiopia

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Abstract. Climate variability has become a major challenge affecting the agricultural sector. Smallholder farmers, particularly in developing countries, are highly vulnerable to climate-related risks because of their limited adaptive capacity. Climate-Smart Agriculture (CSA) provides an approach to improve agricultural productivity while supporting climate adaptation and mitigation. However, the adoption and diffusion of CSA practices remain slow and vary across locations. Therefore, this study examined the determinants of CSA practice adoption among smallholder farmers in Guagusa Shikudad Woreda, Northwestern Ethiopia. A cross-sectional survey design was employed, and data were collected from 143 sample households using a structured questionnaire. Descriptive statistics and logistic regression analysis were used to identify factors associated with CSA adoption. The results indicate that education level, family size, farm size, access to extension services, and access to credit significantly influence CSA adoption, while household age is negatively associated with adoption. The findings highlight the need to strengthen extension services, improve access to credit and education, and promote locally appropriate CSA practices to enhance agricultural productivity, food security, and smallholder farmers' resilience to climate variability.

Keywords: adoption, climate-smart agriculture, climate variability, food security, structured questionnaires analysis.

1. Introduction

Recently, the issue of climate change is one of the major environmental problems that have been accepted as a threat of the 21st century at global level. It is the main cause of food insecurity and poverty for countries (Erekalo & Yadda, 2023; Kiros Getachew Belachew et al., 2026). Ensuring human food security and mitigating the impact of climate change are dual challenges facing the global society today (Tilahun, 2022). In the face of climate change, addressing food insecurity and malnutrition is a major challenge for agricultural and food systems. Variability of rainfall in terms of its patterns, distribution and quantity; increasing temperature; frequency and intensity of

extreme events all have profound effects on agriculture (FAO, 2013). Maintaining sustained and steady growth in agricultural productivity is the inevitable way to reduce poverty and ensure food security. However, climate change has already impacted global agriculture in various ways (Jarraud & Steiner, 2012). Agriculture faces unique challenges such as the increased frequency of extreme weather events that threaten global food security and the overall well-being of humans and the ecosystem (Gondwe et al., 2022). Climate change is posing challenges to agriculture. It continues putting immense stress on agricultural production systems as they seek to meet the food requirements of a growing population (Tilahun, 2022) Ethiopia is one of many developing countries in Sub-Saharan Africa (SSA) particularly vulnerable to impacts of climate change. The country already experiencing associated shocks such as droughts, floods (Abdissa & Gameda, 2025; Tariku & Kebede, 2024).

Climate change has intensified the challenges faced by rain-fed agricultural systems. As a result, there is growing recognition of the need to harmonize natural environment, agriculture and improving food production and productivity through reducing carbon emissions and vulnerability to the impacts of climate change (Collins-Sowah Peron A., 2018). In recent decades, many countries and institutions have issued a series of policies to deal with climate change, increase yield and grower incomes, and promote agricultural sustainable development. Hence, effective methods are needed to improve agricultural production and ultimately achieve the mandated goals of ensuring food security and climate change mitigation (Abdulkadir Ibrahim, 2023). For agriculture to successfully address the issues of food security, substantial changes must be made. Climate-Smart Agriculture (CSA) is a possible option for the adoption of accessible farming methods to adapt to a changing climate and to achieve improved productivity and revenue. It also helps contribute to the mitigation of greenhouse gas (GHG) emissions (Tariku & Kebede, 2024). Climate-smartness refers to mitigation, adaptation and productivity priorities which strongly depend on the context and temporal-spatial configurations under consideration (Collins-Sowah Peron A., 2018). CSA is a comprehensive, cross-disciplinary approach that aims to address the challenges posed by climate change on agricultural systems, particularly focus promoting sustainable crop production through improve resource utilization efficiency; diversify production systems; and manage agro-ecosystems, ecosystem services, and biodiversity (Collins-Sowah Peron A., 2018; Gemtou et al., 2024). Climate-smart agriculture indicates a holistic approach that can strengthen food and agricultural production systems by focusing on ecosystem health, resilience, and sustainability (Tariku & Kebede, 2024). Climate-

Smart Agriculture focus on the transformation of agriculture into sustainable, food secure and climate-resilient systems by the achievement of its three principles: increasing of sustainable productivity and food security, building climate resilience, and reducing Greenhouse Gas (GHG) emissions (Hatfield-Dodds et al., 2007; Gemtou et al., 2024). CSA is a context-specific concept outlined by multi-dimensions (agronomic, social, political, economic) in which mitigation, adaptation, and productivity interact and generate multiple responses (Arenas-Calle, 2022).

CSA emphasizes the possibility of increasing agricultural productivity, contributing to poverty eradication and making agriculture more adaptable to climate change. In addition, it is effective to reduce greenhouse gas emissions and increase the carbon fixation capacity of crop production systems (FAO, 2013). CSA is an integrated system of technologies, policies, and investments to achieve sustainable agricultural development and food security under climate change; it aims to respond the challenges of food security and climate change better by integrating three important aspects of sustainable development: economy, society, and environment (Leta et al., 2023). CSA should integrate economic, social, and environmental factors to ensure food security. Sustainably increasing agricultural productivity and growers' incomes mainly guarantee food security in two ways: increased productivity increases the food supply for household and local markets; improved incomes further secure the food supply (Agustini, 2021; Mahashin, 2019). CSA pays great attention to the livelihoods and food security of smallholder farmers and emphasizes the use of appropriate methods and technologies to produce, process, and sell agricultural products by improving the management and utilization of natural resources (Aune, 2014; Leta et al., 2023; Gemtou et al., 2024). While there is evidence that climate-smart agriculture supports and enhance resilience of smallholders' to climate change, the status of climate-smart agriculture practices adoption remains low, particularly in sub-Saharan Africa (Kangogo et al., 2021; Nyirenda, 2024; Ali et al., 2023; Nkumulwa & Pauline, 2021). The Ethiopian government has implemented number of policies, strategies, and laws focused strengthening climate change mitigation and adaptation, as well as that promote sustainable development and enhance livelihood of smallholder farmers (Tewodros, 2018; Ali et al., 2023). From these policies one is establishment of ministry of environmental protection, forestry, and climate change from national level to Woreda level to address effects of climate change and other environmental related issues (Kassa & Abdi, 2022). Nevertheless, in order to strengthen and make the existing CSA practices be effective, identification of the identification of the bottlenecks to invest on CSA is required to scale up the practices. Knowing key factors

that determine practice of climate-smart agriculture adoption by small farmers help to strengthen the adaptive and mitigation potentials of farmers. Belayneh Y. (2021) affirmed there is limit of research findings on climate-smart agriculture practices and determinant in Ethiopia for the various agro-ecology and socioeconomic setup. Zeleke et al. (2024), Alemayehu et al. (2024), Diro et al. (2022), Tilahun (2022), and Abdissa & Gemed (2025) also confirmed that there different natural, bio-physical, socioeconomic, institutional and development situation of the local area determines the context with in which the climate smartness is evaluated and recommended. So with this research gap, the aim of this study is examine determinants of climate-smart agriculture adoption among smallholder farmers in the case of Guagusa Shikudad Woreda.

Objective of the study: To examine the determinants of Climate-Smart Agriculture (CSA) practice adoption among smallholder farmers in Guagusa Shikudad Woreda, Northwestern Ethiopia.

2. Materials and Methods

2.1. Description of Study Area

Guagusa Shikudad District is one of tenth Districts of Awi Zone in Amhara Regional State. Geographically the District located between 10° 44'0"N to 10° 48'0" N and 37° 0'30" E to 37°3'30"E. It is located at distance of Regional capital city Bahir dar at distance of 129 km and 550 km from Addis Ababa. The District bordered with on the West by Ankesha District, on the North by Banja District on the East and South by West Gojjam Administration Zone. The altitude of the District ranges from 1800 to 3100 meter above sea level with an average altitude of 2300 m.a.s.l. The total area of the District is 296.04 km². Its annual average temperature varies between maximum of 27°C to minimum of 17°C with annual average rainfall is 1750 mm rainfall that ranges from 1200-2000 mm. The short and long rainy season falls in February to March and June to September, respectively, followed by an extended dry season from October to February. The District has a total population of 83,930, of whom 41,427 are men and 42,503 women. Guagusa Shikudad District is characterized by a predominantly smallholder-based mixed farming system in which crop production and livestock rearing are closely interconnected. Crop production constitutes an important component of household livelihoods, while livestock provides food, income, draught power, manure, and other household benefits. Farmers combine crop and livestock production with various soil and water management practices, including crop diversification, crop rotation, soil-fertility management, water harvesting, agroforestry, and other

climate-smart agricultural practices. The farming system is strongly influenced by local agroecological conditions, seasonal rainfall variability, land availability, household labour, access to agricultural inputs, and farmers' knowledge and experience. Consequently, households differ in their capacity to manage climate-related risks and adopt agricultural practices that improve productivity and resilience.

The socioeconomic conditions of households in Guagusa Shikudad District play an important role in shaping agricultural decision-making and land-use practices. Household characteristics such as age, sex, education level, family size, farming experience, and labour availability influence farmers' ability to obtain and use agricultural information and technologies. Economic conditions, including farm size, livestock ownership, household income, off-farm income, access to credit, and access to markets, also determine the resources available for agricultural investment. Institutional factors, particularly access to agricultural extension services, climate and weather information, farmer organizations, cooperatives, and improved agricultural inputs, further influence farmers' production decisions and their capacity to respond to climate variability. Differences in these socioeconomic conditions can therefore contribute to variations in farming practices, land-use decisions, and adoption of climate-smart agriculture among households.

The land-use system of Guagusa Shikudad District reflects the interaction between agricultural production, natural resources, settlement expansion, and household livelihood requirements. Cultivated land represents a major component of the landscape and supports crop production, while grazing and pasture areas provide resources for livestock production. Forests, woodlands, shrublands, wetlands, and other natural or semi-natural areas contribute to soil conservation, biodiversity, water regulation, fuelwood supply, and other ecosystem services. Settlement and homestead areas are also important components of the local land-use system, with some households integrating trees and agricultural production around homesteads.

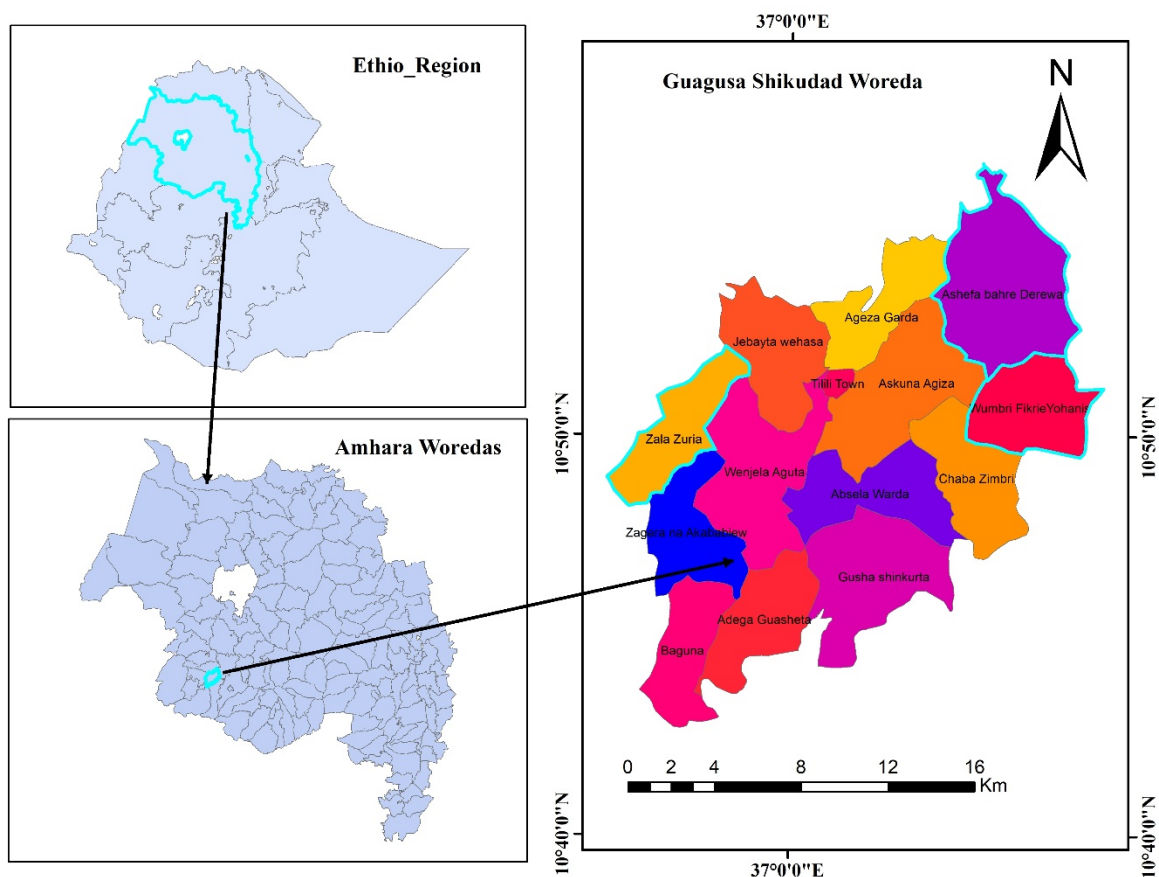


Figure 1. Map of study area

Research design

This study adopted survey research design. Mixed research approaches particularly concurrent design by merging both quantitative and qualitative research approaches were used in this study. The purpose of a convergent (concurrent) mixed methods design enables to collect both quantitative and qualitative data, merge the data, and use the results to understand a research problem simultaneously.

Sample size and sampling procedures

Guagusa Shikudad woreda was selected purposively as a target area because of the researcher's personal experience of the area; ineffective adoption of climate-smart agriculture practices. Since Guagusa Shikudad woreda is clustered in 14 kebeles, 3 of these kebeles (Zala Zuria, Ashifa Bahra Derewa and Wombri Fikir Yohannes) were selected by using simple random sampling techniques. The target population of the study includes households from each kebele Development Agents (DAs) and woreda agricultural office experts. The total household heads of

sample kebele is 12,606 (Zala Zuria=2345, Ashifa Bahra Derewa =3210 and Wombri Fikre Yohannes =3242). Because of its appropriateness and manageability, the following sample sizes decided and selected by using different mechanisms (formulas). The researchers determined the size of sample kebele households by using the following formula in Equation 1:

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2(N-1) + z^2 p \cdot q} \quad \text{Equation 1}$$

where, n = sample size

z = value standard variation at 95% confidence level (1.96)

p = sample proportion or result of plot study (0.03)

q = 1 – p

N = number of total household population

e = the estimated true value.

Based on this formula 143 sample respondents were selected.

The proportional sample size from each kebele was identified by using the proportional sampling of Equation 2:

$$P = \frac{t}{T} \quad \text{Equation 2}$$

where, P = common multiple t = number of sample size

T = total number of household heads of the selected *kebele*

$$P = \frac{143}{8797} = 0.016 = 1.62\%$$

Based on this from the total 143 sample HH heads, 39 sample HH heads *from Zala Zuria kebele*; 52 sample HH heads *from Ashifa Bahara Derewa kebele* and 52 HH heads from *Wumbri Fike Yohannes* were selected.

Simple random sampling techniques were used to select sample households head respondents. Because of their responsibility and their understanding about the issue, Kebele DAs; and woreda agricultural office experts were selected purposively.

Data types, sources, and methods of collections

Primary and secondary data were used for this study. Primary data were collected by enumerators. A semi- structured questionnaire was used to gather the primary data that was prepared after conducting a pre-test to enhance some of the questions based on the feedback found from pre- test. Additionally, secondary data were collected from published and unpublished reports Guagusa Shikuda Woreda offices of agriculture.

Data analysis

Data were analyzed by using both qualitative and quantitative techniques. The quantitative data mainly collected by questionnaires were coded and analysis using SPSS where the generated results were presented in the form of tables' graphs, and charts. Qualitative data from key informants interview and focus group discussion analysis qualitatively to support the finding of quantitative information's.

Model specification

In this study to analysis the factors that influence the adoption of climate-smart agriculture regression analysis (logit model) used. The model is popular statistical techniques in which the probability of dichotomous outcomes was related to explanatory variables that are expected influence the outcome. Logistic regression also referred to as logit model has no assumption about the independent variable the do not have to be normally distributed, linearly related with each group .Due to its computational simplicity and other statistical advantage logit MNL model will be employed in this study. The model can be specified as:

$$\begin{aligned} P_i &= E(Y_i) = \frac{1}{X_i} = F(\beta_0 + \beta_i X_i) = \frac{1}{1 + e^{-(\beta_0 + \beta_i X_i)}} & \text{Equation 3} \\ &= \frac{1}{1 + e^{-(z)}} , \text{ where } z_i = \beta_0 + \beta_i X_i \\ &= \frac{e^{-(z)}}{1 + e^{-(z)}} \text{ is cumulative logistic regression function} \end{aligned}$$

where; $p_i = p(Y=1)$ is the probability that the farmer adopt CSA practices

X_i = are different explanatory factors that affect farmers adoption decision

β_0 = the constant term

β_i = are the coefficient of parameter.

In the estimation of the model the probability of non-adoption on practices is given by

$$1 - P_i = \frac{1}{1 + e^{-(z)}} \quad \text{Equation 4}$$

The odd ratio which tells the ratio of probability the farmer will adopt climate-smart agriculture practices to the probability of the farmer will not adopt the practices can be written as:

$$\frac{p_i}{1 + p_i} = \frac{1 + e^{z_i}}{1 + e^{-z}} \quad \text{Equation 5}$$

Hence,

$$L_i = \ln \left[\frac{p_i}{1 + p_i} \right] = Z_i + \beta + \beta x \text{ where, } L_i \text{ the log of odd ratio}$$

$$\text{Also } Z_i = \beta_0 + \beta_i X_i + \beta_i X_i + \dots + \beta_i X_i + e_i$$

Taking the natural algorithm of odd ratio of the logit model indicated below

$$Li = \ln \left[\frac{pi}{1+pi} \right] = \ln \left[e^{\beta_0} \prod_{i=0}^n \beta X_i \right] = Zi = \beta_0 + \sum \beta x + e \quad \text{Equation 6}$$

E is the error term in this study the logical function of (--) applied to model the explanatory variables. Where, Zi= denote the probability of the farmer to adopt climate-smart agriculture. β predicts the log odds of dependent variable.

Table 1. The hypothesized sign of explanatory variables in this study.

variables	Description of variables	Variable type	Expected sign
sex	1,if household head is male, otherwise 0	dummy	+
educa	1,if household is literate (read and write, otherwise 0	dummy	+
age	Age of household heads in years	continuous	+
Farm_size	Amount of plot measured in hectare	continuous	+
Fam_size	member family in the household in number	continuous	+
Ext_service	Extension service experience of household head	dummy	+
Cred_acess	1,if access credit ,otherwise 0	dummy	+
wea-info	1,if access weather information, otherwise 0	dummy	+
Off-in	Off farm income sources	continuous	+
Loc.as.mem	1,if they are membership , other wise 0	dummy	+

3. Results and discussion

The status of climate variability in the District

In this study the status of climate variability focused on parameter of temperature and rainfall climate were analyzed to evaluate the trends in terms of annual maximum and minimum as discussed below.

Temperature trend

Rainfall and temperature variability are the most significant components of climate. These two climates variables determine the socio economic conditions and livelihoods status of geographical area (Arenas-Calle et al., 2019). The mean annual maximum temperature of the study areas from 1981-2021 was found to be 28.663°C with standard deviation of 0.782°C, while

maximum temperatures were found 32.63°C which recorded in spring season 2002. The result also shows annual maximum coefficient of variation is 2.728 (Fig. 2). On other hand, annual mean and standard deviation of minimum temperature of the study area is 20.51°C and 0.678°C respectively with that of coefficients of variation is 13.905 minimum temperature recorded in winter season with temperature of 10.293°C (Fig. 3).

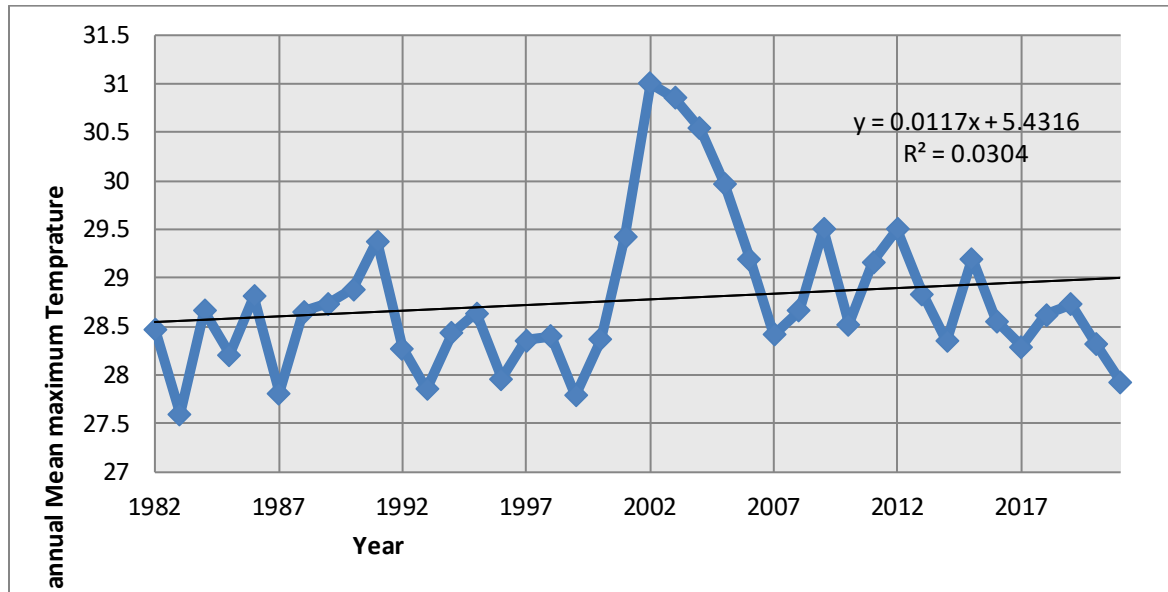


Figure 4. Annual average maximum temperature of the study area

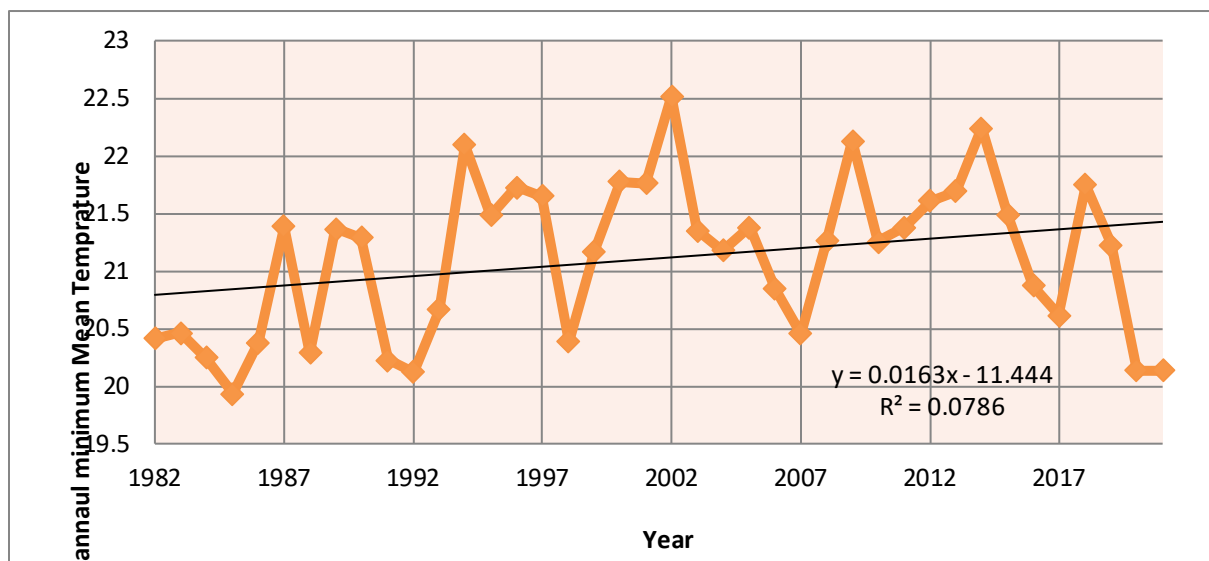


Figure 5. Annual average minimum temperature of the study area

Rainfall trends

The pattern of annual rainfall showed that the average total rainfall from 1981-2021 was 2257.69 mm in the study area, while the minimum and maximum annual average rainfall during the observation time period were 1091.590 mm and 3160.150 mm respectively with coefficient of variation of 22.708% (Fig. 6).

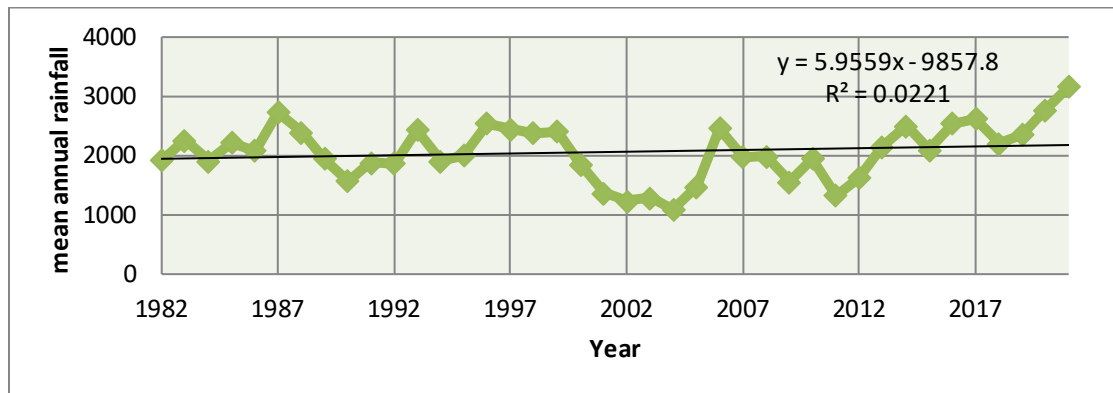


Figure 7. Annual average rainfall of the study area

Demographic and Socioeconomic characteristics

Demographic and socio economic status of household's head in the study kebele were presented in (Table 2 and Table 3). In this study out of 143 sample household heads in selected kebeles were 116 (81.12%) are male headed households and 27 (18.88%) female headed.

The age distribution of the respondents from 24-67 and the average age was 43 years. on other hand, the average household sizes of respondents are 4 and the absolute family size of respondents ranges from 2-9 family members. The marital status of the household heads shows that over 83% of respondent is married and interims of religious all of the respondents are the followers of orthodox Christianity. The educational level of the respondent shows that 46.5% the respondents have never attended any level of education; whereas 53.5% of respondents have attended formal education at different academic level. As the data indicated that collected from sample respondents the average farm land size is 1.02 ha and the average farming experiences is 25.53 year with range of 3-42 years.

Table 2. Continuous variables statistics of respondents

Variables	Average	maximum	minimum
Age of households	43	67	24
Family size	4	9	2
Farm size	1.02	0.5	4.25
Off farm income in Birr	2578	2125	13570

Table 3. Categorical variables statistics of respondents

Variables	frequency	percent
Education		
literate	77	53.5
illiterate	66	46.5
Sex		
male	116	81.12
female	27	18.88
Extension services		
yes	103	72.02
no	40	27.98
Credit access		
yes	82	57.34
no	62	42.66
Weather information		
yes	57	39.86
no	86	60.14
member of local organization		
yes	107	74.82
no	36	25.18

Sources: survey results

Small holder farmer perception on climate variability and CSA practices

Perception of smallholder farmers on climate variability

Based on the household survey result, households perceived that there is climate variability in their local area from total surveyed sample respondents (65%) of households agreed that they had observed climate variability in their local environment; on other hand (35%) of households strongly agree the existence of climate variability. Farmers' responds on the nature of temperature change that occurred in their locality, based on this 73% of respondents said that there is the increment of temperature which enhances the number of hot season, while other 21% of respondents reported that there is the fluctuation on temperature conditions and the remaining

(6%) responds there is decreasing condition of temperature. Focus group discussants also indicate that there is increment of temperature and variability of rainfall with high intensity and seasonal fluctuation. Regarding to rainfall pattern, highest proportion of farmers (87% households) perceived change of rainfall patterns in the last decades in their locality and the remaining 13% of the households did not observe any change in change of rain fall patterns (Table 4).

Table 5. Perception smallholder farmers on climate variability's

Perception on climate variability's		percentage
Degree of agreement on climate variability on farmers local area	Strongly agree	33
	agree	67
	neither agree or disagree	-
	disagree	-
	Strongly disagree	-
	total	100
have you notice temperature change in last decades years	yes	93
	no	7
	total	100
nature of temperature change	increased	73
	fluctuated	21
	decreased	6
	total	100
change of rain fall patters in 5-10 years	yes	87
	no	13
	Total	100

Source: survey results

Climate smart practices adopted by smallholder farmers

Smallholder farmers forced to adopt climate-smart agricultural practices that increase their agricultural productivities, increase food security, enhance livelihood and diversify their sources of income to overcome from the negative impact of climate related risks. As indicated (Figs 5, 6) smallholder farmer practice different types of climate-smart agricultural practices(crop diversification and rotation, soil fertility conservation water harvesting and management, change growing season, use of heat tolerant crops, agroforestry, irrigation).

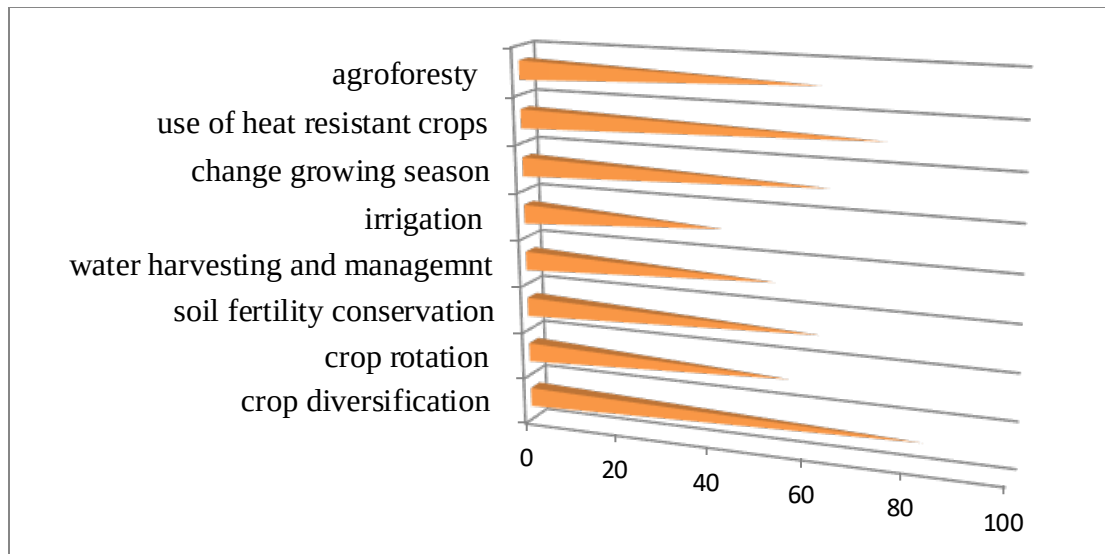


Figure 5. Adopted climate-smart agricultural practices

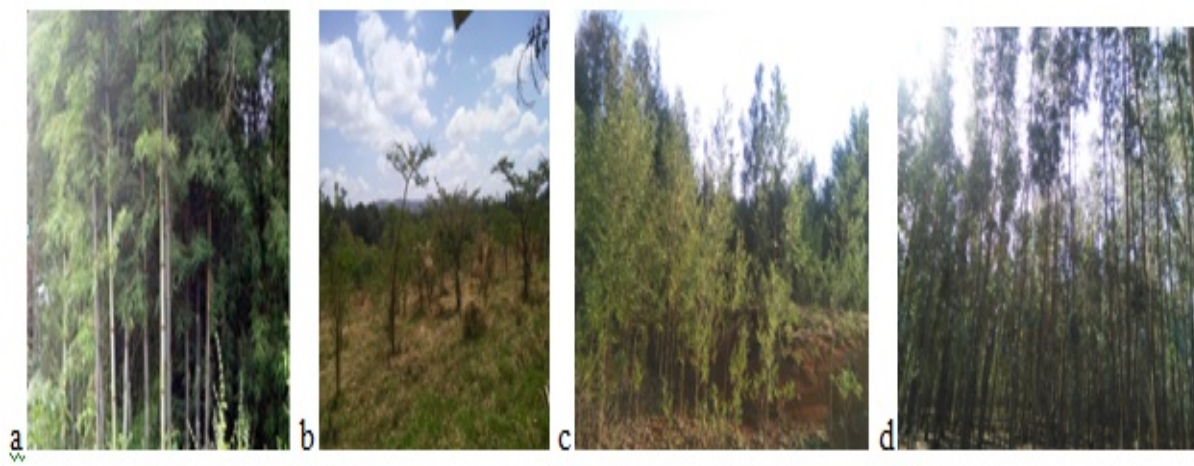


Figure 8. Climate smart agriculture practice in the study area (a=afforestation practice, b=agroforestry= gully rehabilitation and d= reforestation)

Determinants for adoption of climate-smart agriculture practices

In this study, to analysis the determinants of climate-smart agriculture practice adoption by using multinomial logit model different determinant influencing factors can be considered like household demographic and socioeconomic characteristics (age, education, sex, income, member of local organization), farm characteristics (farm size), institutional factors (access to credit, extension services, weather information) considered. The results of model indicated that there are different factors that affect the adoption of climate-smart agriculture practice at smallholder farmers' level as shown (Table 5).

Age of households: the result of multinomial logit shows that the ages of household heads were negatively associated with the adoption of climate-smart agriculture practices at 5% level of significances, which indicated that an increase in age of the house hold by one year, the likelihood of adopting climate-smart agriculture is reduced by -1.1% (Table 5). This shows that as the age of farmer's increases the use of different innovates climate-smart agriculture technology's decline because of elder farmers are not aware of this innovations. The finding of the study consistent with the finding of Francis et al. (2017), who report that an increase in age of the household head reduces the probability of adoption of more than two CSA practices by 4.5% due to, as ages of farmers become older, they tend to minimize activities that needs intensive labor. Muriithi et al. (2021) also assured that increase in the age of the household head was found to significantly reduce ability of smallholders to adopt innovate farm practices that increased chances of adopting crop diversification

Household family size: household family size is supposed the most determinant factors tor the implementation of labor intensive farming activities. Based on the coefficient of the model result shows that family size was positively correlated with the adoption of climate-smart agriculture at 5% significance level. Accordingly, a unit increase in family size increased the probability of household adoption of climate-smart agriculture by 2.6% (Table 5). This because of implementation of climate-smart agriculture practices needs intensive labor activities and integration of different local agro ecological based activities as well as indigenous knowledge. The result of the study similar with (Belay et al., 2023) who stated that the presence of a large active labor force in the household leads to the implementation of climate-smart agricultural practices while the presence of a less active labor force in the household did not enforce the use of more climate-smart agricultural practices.

Educational level: according to model result level of education is positively correlated with the adoption of climate-smart agricultural practices (Table 5). The coefficient indicated that one more years of education increased the probability of practicing climate-smart agriculture will have increased by 4.1% at 5% of significance level. This due to that educated farmers can be easily aware about the importance of climate-smart agricultural practices that increase their food security and enhance livelihoods with in the risk of climate variability's. In consistent with research Kassa & Abdi (2022) stated that farmers are more contented using current climate-smart agriculture practices as they become more educated.

Asaye et al. (2022) also stated that educated farm household's heads easily aware to adopt innovative agricultural technologies to enhance productivities of their farm lands. Similarly Amare and Simane (2017) stated that educated farmers are estimated to have awareness and understanding about impacts of climate change and adaptation practices that they can use in response. Education is believed to improve an individual's analytical capacity as well as increasing awareness of feasible technologies to be adopted. Therefore, this result implies that the probabilities of households with better formal education adopting appropriate climate smart technologies is higher than non- educated households (Muriithi et al., 2021). Thus this denotes that education allows a farmer to make decision and recognize farm related occasions for enhancement of production.

Household farm size: The sizes of agricultural farm lands also have significant effect on the adoption of climate-smart agricultural practices. this implies that an increase one-unit hectare of farm land the probability of applying climate-smart agriculture increased by 5.2% of coefficient. the model result revealed that, the availability of land provides opportunities for farmers to adopt and implement different innovate climate-smart agricultural practices and technologies. The result is consistent with the finding of Negera et al. (2022) who reported that farmers with larger landholdings are more likely to produce more and, hence, have more financial resources which enable them to purchase these modern agricultural inputs. Therefore, farm size to have a positive role in the decision to climate-smart agriculture technologies and it also negatively affects the use of different livelihood diversification activities.

Access to credit: Credit access has the advantage to solve financial restraints to meet their need to change their practices to reduce the impacts of climate change. Thus, it is hypothesized that access to credit has a positive effect on the adoption of climate smart agriculture practices (Amare & Simane, 2017). The model result shows that access to credit has a positive and significance impact on the adoption of climate-smart agricultural practices. The result shows that the farmers who get credit were 4.2% more likely to adopt climate-smart agricultural practices compare to who do not access credit (Table 5). This due to that credit access enables farmers to by different technologies as well as it diversifies sources of income for farmers to implement agricultural technologies that increase productivity.

Access to extension services: Access to extension refers to services delivered to farmers about climate-smart agricultural practices by development agent(s). It plays a crucial role in rising

awareness about climate-smart agriculture practices (Belay et al., 2023). The model result shows access to extension services positively influences the adoption of climate-smart agriculture practices. Based on the coefficient of the result, as their contact with extension agents increased the probability of adopting climate-smart agriculture by 7.1%. The result reveals that, extension services play a significant role on the implementation of technology by smallholder farmers. This also due to that information disseminated through extension services enhance the awareness of farmers about the impact of climate variability as well as the roles of implementing climate-smart agricultural practices. Leta et al. (2023) indicated that lack of information and inadequate extension services are the most critical barriers to the implementation of climate change adaptation strategies. Geda et al. (2024), who identified extension services as a key driver of the adoption of various CSA techniques through providing technical assistance, input access, awareness rising. It implies that farmers with more access to information and technical support about significance of climate-smart agricultural practices to reduce the negative impacts of climate change implement it.

Table 5. Determinant influencing adoption of climate-smart agriculture practices

Variables	Coef.	Std.Er.	p-Value	Marginal effect
Sex	1.125	0.717	0.052	0.041
Education	0.0415	0.141	0.002	0.053
Age of household heads	-0.0112	0.021	0.004	0.021
Farm size	0.0521	0.015	0.001	0.031
Family size	0.0264	0.035	0.000	0.067
Extension service	0.0715	0.601	0.000	0.073
Access to credit	0.0412	0.032	0.003	0.037
Access weather information	0.093	0.072	0.051	0.054
Off farm income	0.087	0.069	0.057	0.043
Member of local organization	0.057	0.059	0.060	0.830

Note: *significance at 5%, coef= coefficient, Std.Er= standard of error

4. Conclusion

Climate change and variability are the main environmental problem which affects the livelihoods of smallholder farmers in the study area. Most of respondents were aware the prevalence of

climate variability in the study area that manifested in terms of increment of temperature and variability of rainfall patterns. As agriculture is the main sources of livelihood and income, now it is challenged by variability of climate elements.to reduce the negative impacts of climate variability on agriculture smallholder farmers practiced different climate-smart agriculture practices. The main climate agriculture practices crop diversification and rotation, soil fertility conservation water harvesting and management, change growing season, use of heat tolerant crops, agroforestry, irrigation. In the study area different socioeconomic and demographic factors affect the implementation of climate-smart agricultural practices .those determinant factors are level of education, farm size, and age of household heads, family size, access to credit and access to extension services. The finding of this study has critical significance to the concerned bodies in Ethiopia by providing significant inputs on the factors of climate-smart agriculture at local level. Farmers must be encouraged to implement climate-smart agriculture which reduces the negative impacts of climate change and variability on the agricultural sectors. Supportive policy and regulation focus bottom-up approach which integrate local knowledge with science of climate-smart agriculture should be strengthen and encourage.

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