Research



# Determinants of adoption of small-scale irrigation practices as adaptation strategies to climate change stresses in Kersa District, Eastern Oromia, Ethiopia

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# Abstract

This study was conducted to assess the factors influencing farmers' decisions to adopt small-scale irrigation practices as an adaptation strategy to climate change in Kersa district, East Hararghe Zone, Oromia. The data were collected from a sample of 288 farm households (130 adopter and 158 non-adopters). Both qualitative and quantitative data were obtained from primary and secondary sources. A binary logistics regression model was used to identify the determinants of irrigation scheme adoption. The results indicate that the adoption of small-scale irrigation scheme was influenced by the age of the household head, dependency ratio, distance from water source, household size, frequency of extension contact, access to credit, livestock holding, off/nonfarm activities, membership in an agricultural cooperative, access to climate information, and perception of climate change, which had significant positive effects. Small-scale irrigation practices are a practical solution to lessen the effects of climate change stresses. Therefore, to improve rural farm productivity and lessen the effects of climate change stresses, the agricultural and natural resources office should focus scientific attention on the key factors that influence the adoption of small-scale irrigation.

Keywords Adoption · Climate change · Logistic regression · Kersa · Small-scale irrigation · Oromia · Ethiopia

# 1 Introduction

Climate change is rapidly emerging as the most challenging environmental problem affecting many sectors, particularly in agricultural-dependent countries [1]. Sub-Saharan Africa (SSA) is highly vulnerable to climate change due to the overdependence of economies on climate-sensitive sectors [2]. The majority of smallholders rely on rain-fed agriculture, which is climate-sensitive, and the sector is more vulnerable to climate change impacts than any other sector [3]. The adverse effects of climate change on the agricultural sector are clear, as its consequences affect the livelihoods of smallholder farmers within the tropics [4].

The adoption of climate-smart agriculture (CSA) practices has been widely recognized as a promising and successful alternative to lessen the adverse influences of climate change [5]. The interventions may help to meet household demands for improved productivity, adaptation, and mitigation, as well as attain sustainable development goals (SDGs) [6]. The adoption of CSA practices plays a vital role in enhancing smallholder farmers' resilience to climate change [7]

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in Gerar Jarso Woreda of Oromia. Moreover, activities to make agriculture more sustainable are among the most effective ways to help countries adapt to and reduce global climate change and to improve resilience and adaptability to achieve the SDGs. To address recurrent droughts and ensure food security in an ever-growing population, production and productivity-improving agricultural technologies such as small-scale irrigation are promoted [8] in the Abay Chomen district and other studies in the Sibu Sire district in Western Oromia [9].

Adopting CSA practices such as small-scale irrigation and agricultural water management holds significant potential to improve production and reduce vulnerability to climactic instability [10] in the Lume district, central rift valley of Ethiopia. The decisions about adopting CSA practices depend on their local resources, contexts, and agro-ecology [6, 11]. Small-scale irrigation (SSI) schemes are becoming a practice by smallholder farmers as climate variability and climate change adaptation improve livelihoods [12], increase productivity by stabilizing agricultural production [13], enhance farmers' resilience and lessen the adverse effects of climate change [9].

The Ethiopian government also promotes small-scale irrigation practices as an adaptation strategy to address the adverse effects of climate change to increase the production and productivity of smallholder farmers. In Ethiopia, the irrigation potential is projected to reach approximately 5,536,457 hectares of land, 4,256,457 hectares are irrigated [14], and the Oromia region is endowed with ample amounts of irrigation water and irrigable land resources. Out of the total of 1.7 million hectares of irrigable land, only 1,350,000 hectares were irrigated in both traditional and modern irrigation schemes. Similarly, according to data by KDANRO [15], the Kersa district has different rivers and streams that are suitable for small-scale irrigation activities. The total irrigable land potential in the district is more than 5071 hectares, out of which 2704 hectares were cultivated under different types of irrigation schemes. The total number of households that benefited from small-scale irrigation was 5834 households.

However, the impacts of climate change stresses and adaptation strategies are locally specific. Kersa district is the focus area for this study. Despite the potential of small-scale irrigation practices to reduce poverty and ensure food security, few empirical studies have been conducted in Ethiopia in general and in the East Hararghe zone in particular. These include determinants of the adoption of water harvesting technology [16], effects of small-scale irrigation on household income [17–19], the role of small-scale irrigation on food security [20], and factors influencing the adoption of small-scale irrigation [21], which did not address the analysis of factors that influence smallholder farmers' decisions to adopt small-scale irrigation practice as an adaptation strategy to climate change. Moreover, the adoption of small-scale irrigation in improving farmers' resilience to climate change was not emphasized by previous studies.

Despite the significance and potential of small-scale irrigation schemes in the Kersa district, little empirical research has been done to identify the pertinent demographic, socioeconomic, institutional, and psychological characteristics, and the primary factors influencing the adoption of small-scale irrigation to mitigate the effects of climate change in the study area are few. Hence, there is a need for a better understanding of the factors that influence farmers' decisions to adopt small-scale irrigation schemes as an adaptation strategy to withstand the impacts of climate variability and climate change on smallholder farmers in Kersa district. Therefore, this study was developed to address these research gaps. Such empirical evidence is of paramount importance to inform development interventions and increase farmers' resilience to climate change.

# 2 Research methodology

# 2.1 Study area

The study was conducted in the Kersa district of the East Hararghe Zone, Oromia National Regional State, Ethiopia. The district is located 478 km east of Addis Ababa and 42 km west of Harar town, which is the capital city of both the East Hararghe zone and Harari Regional State. The total population of the district is estimated to be 199,601, and the majority (93.8%) of them are rural residents, while urban residents constitute only 6.2% [15]. The sex ratio is 101 males for every 100 females. From the total population of the district, 101,796 are male, and the remaining 97,805 are female. Mixed crop-livestock farming is the dominant activity in the area to generate income and improve livelihood. The agro-ecology of the district is midland (74%), highland (20%), and lowland (6%). The annual rainfall ranges from 830 to 1658 mm, and the temperature ranges from 10 °C to 30 °C. The main economic activities are food crop, cash crop (khat) and livestock production. Land size, livestock and other assets determine wealth status. The climate-smart agriculture practices that are common in the Kersa district are intercropping, crop rotation, soil and water conservation, drought-resistant crop varieties, and small-scale irrigation, such as water harvesting [22].

#### 2.2 Data types, sources and methods of data collection

Both primary and secondary data were collected for this study. The data collected for the study were quantitative and gualitative in nature. The guantitative data were collected from the sample households by using a semi-structured guestionnaire. The data were collected on various socioeconomic, demographic, institutional and related factors. For qualitative data, Focused Group Discussions and Key Informants Interviews were applied to generate general and specific information regarding the factors that influence the adoption of small-scale irrigation practices and the constraints that hinder the adoption of small-scale irrigation schemes. Focus group discussion and key informants' interviews were used to supplement and triangulate the data collected through structured interviews. Secondary data were collected from different records of the Kersa District Office of Agriculture and Natural Resources, kebele administration offices, journals, websites and other relevant sources to review the published data or articles and reports.

#### 2.3 Sampling procedures and sample size determination

For this study, a three-stage sampling method was used. In the first stage, Kersa district was selected purposively from the East Hararghe zone because the district is one of the areas that is visible regarding problems concerning high vulnerability to climate variability and climate change, such as rainfall variability, increased temperature, crop yield and livestock production declines, and drought [23, 24]. Moreover, the district has extensive experience in adopting CSA practices, specifically small-scale irrigation schemes [22]. In the second stage, among the total 35 rural kebeles of the district, four kebeles were selected randomly from 12 potential small-scale irrigation practice kebeles. In the third stage, from the selected kebeles, the households were stratified into irrigation adopters and non-adopters, and then simple random sampling was used to select 288 sample households based on probability proportional to size. Gerar Jarso Woreda Of the total sample households, 158 were non-adopters, whereas 130 were adopters of small-scale irrigation (Table 1).

Samples from each kebele were proportional to the population (Table 1) and were determined using the following [25] formula:

$$\mathbf{n}_i = \frac{(N_i)(n)}{\sum N_i} \tag{1}$$

where,  $\mathbf{n}_i$  is the sample to be selected from the ith kebele;  $N_i$ —The total population living in i<sup>h</sup> kebele;  $\sum N_i$ —The summation of the population in the four selected kebeles; n-Total sample size for the district.

### 2.4 Methods of data analysis

#### 2.4.1 Descriptive statistical analysis

Descriptive statistics such as the mean, standard deviation, minimum, maximum, percentage, and frequency distribution were used to summarize, present, and interpret survey results such as demographic, socioeconomic, and institutional factors.

Table 1 Population and sample distributions over the selected kebeles	Name of Kebeles	Total house- holds	Sample selected	Adopters	Non-adopters	Proportion (%)
	Mada Oda	1200	77	35	42	26.74
	Burka Watar	867	55	25	30	19.10
	Handhura Kosum	1500	96	43	53	33.33
	Burka Jalala	944	60	27	33	20.83
	Total	4511	288	130	158	100

Source: Computed based on data obtained from Kersa district, 2022

Inferential statistics such as the chi-square test and t-test were applied to check the statistical significance for dummy and continuous variables, respectively. For the analyses, STATA software version 17 was used.

#### 2.4.2 Binary logit econometric model

Binary choice models are discrete choice models that deal with binary replies. The binary logit econometric model was used to analyze the factors that influence small-scale irrigation practice adoption. The use of linear regression is limited when the dependent variables are not continuous in nature. The underlying assumption of binary choice is that individuals express their preference between two alternatives; that is, there is a chance of choosing one over the other. As a result, the estimate using the ordinary least squares parameter will be inconsistent and biased. In this case, the linear probability model, logistic model, and probit regression model are proposed as the best solutions to overcome the constraint [26]. In the probit model, the error term in the equation is normally distributed, with a mean of zero and a standard deviation of one. However, in logistic regression, the error term is expected to have a logistic distribution and a standard deviation greater than one. Although the logit and probit models are nearly identical and the model selection is arbitrary, the logit model has a number of advantages.

Because it is easier to work with and provides a close approximation to the cumulative normal distribution, the logistic function is used. Furthermore, as Train [27] noted, a logistic distribution (logit) has an advantage over others in the analysis of dichotomous outcome variables because it is a mathematically extremely flexible and easily used function (model) that lends itself to a meaningful interpretation and is relatively easy to estimate. Moreover, binary logistic regression is a common statistical procedure that has been widely used in adoption studies to relate the probability of a dichotomous outcome (adoption or non-adoption) to a set of explanatory variables [28]. Thus, the adoption of small-scale irrigation was used as a dummy dependent variable to assess factors affecting household participation decisions in small-scale irrigation practices. Because the dependent variable in this study is dichotomous, we assign a value of 0 to non-adopters and a value of 1 to adopters. Functionally, the logit regression model can be specified as:

$$P_i = \text{Prob}(y_i = 1 | x_i) = \frac{1}{1 + e^{-(\beta_0 + \beta_i x_i)}}$$
(2)

Equation (2) can be simplified as

$$P_i = \text{Prob}(y_i = 1 | x_i) = \frac{1}{1 + e^{-z_i}}$$
(3)

where,  $P_i$  is the probability that the *i*th household participated in small-scale irrigation and ranges from 0 to 1;  $L_i$  is a function of *n* explanatory variables (*x*) expressed as follows:

$$\mathbf{L}_{i} = \beta_{0} + \beta_{1} \mathbf{X}_{1} + \beta_{2} \mathbf{X}_{2} + \beta_{3} \mathbf{X}_{3} + \dots + \beta_{n} \mathbf{X}_{n}$$
(4)

where,  $\beta_0$  is the intercept term and  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$ ...  $\beta_n$  are the slope parameters in the model. The slope shows how the logodds in favor of being willing to participate in small-scale irrigation practices change as the corresponding independent variable changes. Since the conditional distribution of the outcome variable follows a binomial distribution with a probability given by the conditional mean  $P_i$ , interpretation of the coefficient would be understandable if the logistic model can be rewritten in terms of the odds and log of the odds [29]. The odds to be used can be defined as the ratio of the probability that a farmer would adopt ( $P_i$ ) to the probability that s/he would not adopt (1- $P_i$ ).

Equation (3) is the probability of adopters, and from this, the probability of non-adopters of small-scale irrigation can be expressed as:

$$1 - \mathbf{P}_i = \frac{1}{1 + \mathbf{e}^{\mathbf{z}i}} \tag{5}$$

The odds ratio, i.e., the ratio of the probability of adopters to the probability of non-adopters of small-scale irrigation, can be expressed as:

$$\frac{\mathbf{P}_i}{1 - \mathbf{P}_i} = \frac{1 + e^{zi}}{1 + e^{-zi}} = e^{zi}$$
(6)

where, and  $(1-P_i)$  is the probability of non-adoption. The odds of adoption (Y = 1) versus the odds of non-adoption (Y = 0) can be defined as the ratio of the probability that a farmer adopts (P *i*) to the probability of non-adoption  $(1-P_i)$ , namely, odds =  $P_i/(1-P_i)$  [30]. Taking the natural logarithm of Eq. (6), we obtain the prediction equation for the individual farmer:

$$L_{i} = \ln\left[\frac{P_{i}}{1 - P_{i}}\right] = \beta_{0} + \beta_{1}X_{1} + \beta_{2}X_{2} + \beta_{3}X_{3} + \dots + \beta_{n}X_{n} + U_{i}$$
(7)

where: L<sub>i</sub> is the log of the odds ratio,  $\beta_{1,} \beta_{2,} \beta_{3,...} \beta_{n}$  are the coefficients to be estimated, X<sub>i</sub> are the vectors of explanatory variables and U<sub>i</sub> is the disturbance term.

#### 2.5 Definition of variables and working hypotheses

Dependent variable: This is a dummy variable that takes the value of 1 for adopters and 0 for non-adopters of small-scale irrigation.

#### 2.6 Model diagnosis test results

Before running the model, multi-collinearity was tested using variance inflation factors (VIFs), and the results revealed that there was no multi-collinearity problem since the mean VIF was 1.14. Moreover, the Breusch–Pagan/Cook–Weisberg test for heteroscedasticity (hettest) was 0.2454, the Ramsey RESET test for omitted variables (ovtest) was 0.5819 carried out before running the logistic regression, and the model fitness test by using the goodness of fit (0.4908) was carried out after running the logistic regression (Table 2). Hence, there was no problem with multi-collinearity, heteroscedasticity, or model specification error, and the model fitness test of the logistic justified the fact that the model is adequate to explain the dependent variable. Therefore, based on the hypothesis (Table 3), all the variables were included in the model to estimate the factors affecting households' decision to adopt small-scale irrigation in the study area.

Tuble 2 model alagnosis te	50					
Variables	VIF	1/VIF	Variables	VIF	1/VIF	
Farmers' experience	1.42	0.702659	Livestock owned	1.10	0.906958	
Age of households	1.42	0.706246	Climate information	1.10	0.907174	
Perception of climate	1.17	0.855767	Distance from the market	1.09	0.915330	
Household size	1.15	0.869792	Distance from irrigation	1.09	0.918068	
Cooperative member	1.15	0.872545	Dependency ratio	1.07	0.933608	
Non/off-farm	1.14	0.878974	Extension contacts	1.07	0.936155	
Cultivated land size	1.12	0.889850	Educational level	1.06	0.942312	
Sex of households	1.12	0.891959	Access to credit	1.04	0.963885	
Model tests	Test names				Factors of adoption	
VIF		Multi-collinearity				
hettest		Prob > chi2 = 0.2454				
ovtest		Prob > F = 0.5819				
estat gof		Prob > chi2 = 0.4908				

Table 2 Model diagnosis test

Source: Computed from our own survey data, 2022

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Table 3 Definition of           explanatory variables and           expected effect	Variable description	Variable types and measurement	Expected sign
	Age of household head	Continuous; years	_
	Sex of household head	Dummy; 1 if male, 0 if female	+
	Educational level of household	Continuous; years of schooling	+
	Household size	Continuous; adult equivalent	+
	Extension contact	Continuous; number of days	+
	Access to credit	Dummy; 1 if yes, 0 if no	+
	Livestock owned	Continuous; measured in TLU	+
	Dependency ratio	Continuous; economically inactive to active	_
	Distance from the market	Continuous; hours	_
	Cultivated land size	Continuous; measured in hectares	+
	Participation in non/off-farm	Dummy; 1 if yes, 0 if no	+
	Membership in cooperative	Dummy; 1 if yes, 0 if no	+
	Distance from irrigation water	Continuous; hours	_
	Climate information	Dummy; 1 if yes, 0 if no	+
	Farming experience	Continuous; years of farming	+
	Climate change perception	Dummy: 1 if perceived, 0 if not	+

# **3** Results and discussion

# 3.1 Descriptive statistics results

# 3.1.1 Characteristics of sample households (Dummy variables)

The results of the descriptive statistics show that out of the sampled households, 87.85% were male-headed households, whereas 12.15% were female-headed households. Of the total adopters, the majority of the households were male-headed. The result of the chi-square test for sex shows that there was a statistically significant sex difference between adopters and non-adopters at less than 5% probability level. Of the total sampled households, 25.7% had access to credit, while the remaining 74.3% had no access to credit due to high interest rates and lack of awareness of existing credit facilities as well as due to religion. The results showed that there was a statistically significant difference between the two groups in terms of access to credit services. Moreover, the results show that among adopter households, 48.46% participated in off/non-farm activities, while 51.54% did not. Similarly, 37.34% of non-adopters participated in off/non-farm activities, while 62.65% did not participate. The chi-square test showed that there was a significant difference between the two groups in terms of participate. The chi-square test showed that there was a significant difference between the two groups in terms of participate. The chi-square test showed that there was a significant difference between the two groups in terms of participate. The chi-square test showed that there was a significant difference between the two groups in terms of participation in off/non-farm activities at less than 10% significance level (Table 4).

The results revealed that out of the total adopters, 66.92% were members of cooperatives, while 33.08% were not members. Among non-adopters, 49.37% were cooperative members, whereas 50.63% were not members of the agricultural cooperative. The results indicated that out of the sampled households, 35.42% had access to climate information, while the remaining households had no access to climate information. When classified as adopters (52.3%) and non-adopters, households (21.52%) had access to climate information. Furthermore, the results show that 70.49% of farmers perceived climate change, whereas 29.51% did not perceive climate change. Among the adopters, 78.46% perceived climate change, whereas the remaining 21.54% did not perceive climate change. On the other hand, out of non-adopters, 63.92% perceived climate change, whereas 36.08% did not perceive climate change (Table 4). The results show that there was a statistically significant difference in terms of cooperative membership, access to climate information, and perception of climate change between the two groups at less than 1% significance level.

Table 4Descriptive statisticsof dummy variables

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Variables	Dummy	Adopters (N=130)		Non-adopters (N=158)		Total (N = 288)		$\chi^2$ -value
		Freq	%	Freq	%	Freq	%	
Sex of HH	Female	10	7.70	25	15.82	35	12.15	
	Male	120	92.30	133	84.18	253	87.85	0.036**
Access credit	Yes	43	33.08	31	19.62	74	25.70	
	No	87	66.92	127	80.38	214	74.30	0.009***
Off/non-farm	Yes	63	48.46	59	37.34	122	42.36	
	No	67	51.54	99	62.65	166	57.64	0.057*
Membership	Yes	87	66.92	78	49.37	165	57.29	
	No	43	33.08	80	50.63	123	42.71	0.003***
Climate information	Yes	68	52.30	34	21.52	102	35.42	
	No	62	47.70	124	78.48	186	64.58	0.000***
Perception	Perceived	102	78.46	101	63.92	203	70.49	
	Not perceived	28	21.54	57	36.08	85	29.51	0.007***

\*\*\*, \*\*, and \* indicate significance at less than 1%, 5%, and 10% significance levels, respectively

Source: Computed from our own survey data, 2022

#### 3.1.2 Descriptive statistics of continuous variables

Table 5Descriptive statisticsof continuous variables

The results showed that the mean ages for adopters and non-adopters were 39.75 and 41.81 years, respectively. The mean age of the adopters is less than the mean age of non-adopters, with a significant difference between the two groups at less than 5% probability level. The average years of formal education of adopters and non-adopters of small-scale irrigation were estimated to be 6.07 and 4.72 years of schooling, respectively. The result of the t-test shows a significant mean difference between the two groups in terms of household heads' years of schooling at less than 1% significance level, implying that adopters were more educated than non-adopters. The average household size of the adopters in adult equivalents was larger than that of non-adopters. The results showed that the difference in household size of the adopters and non-adopters was significant at the p < 0.05 level of significance (Table 5).

The average frequency of extension contact for adopters was 1.66, while it was 1.37 for non-adopters. The t-value showed that there was a statistically significant mean difference in the frequency of extension contacts made between adopters and non-adopters of small-scale irrigation at less than 1% significance level. In addition, the average livestock holdings in tropical livestock units of the adopters and non-adopters were 3.27 and 2.52, respectively. Based on the survey results, the livestock ownership of households has a significant relationship with small-scale irrigation at a p < 0.01 level

Variables	Adopters (N=130)		Non-adopters (N=158)		Total (N = 288)		T-value
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	
Age	39.75	7.36	41.81	6.77	40.88	7.10	2.46**
Education	6.07	3.62	4.72	3.42	5.33	3.57	-3.25***
Household size	6.39	1.72	5.97	1.37	6.16	1.55	-2.28**
Extension contacts	1.66	1.03	1.37	0.76	1.50	0.90	-2.71***
Livestock	3.27	1.43	2.52	1.71	2.86	1.63	- 3.99***
Dependence ratio	0.73	0.30	0.84	0.40	0.79	0.36	2.60***
Market distance	0.95	0.38	0.98	0.30	0.97	0.34	0.78
Cultivated land	0.30	0.13	0.28	0.13	0.29	0.13	-1.24
Farm distance	0.58	0.15	0.61	0.08	0.60	0.12	1.92*
Farm experience	21.57	8.13	22.70	8.15	22.19	8.15	1.17

\*\*\*, \*\*, and \* indicate significance at less than 1%, 5%, and 10% significance levels, respectively Source: Computed from our own survey data, 2022

of significance. The dependency ratios of the adopters and non-adopters were 0.73 and 0.84, respectively. The result implies that households with a higher dependency ratio are less likely to participate in small-scale irrigation. The average distance of farmland from the irrigation water source was longer for non-adopters than adopters, and the t-test result showed that the difference was statistically significant at less than 10% significance level (Table 5).

## 3.2 Factors influencing the adoption of small-scale irrigation practices

The results of the maximum likelihood estimation of the logit model for factors influencing the adoption of small-scale irrigation in the study area are reported in Table 6. The results indicated that 11 of the 16 variables included in the model were statistically significant in influencing the probability that farmers would adopt small-scale irrigation practices. The logit model output showed that age, household size, extension contacts, access to credit, livestock ownership, dependency ratio, off/non-farm activities, membership in a cooperative, distance from irrigation water source, access to climate information, and perception of climate change are the significant factors that affect the probability of adoption of small-scale irrigation practices in the study area, as hypothesized (Table 3).

Age of the household head: The age of the household heads has a negative effect on their decision to adopt small-scale irrigation to improve their livelihoods and the resilience of farmers against climate change at less than 1% probability level. Moreover, the negative effect of this variable indicates that older people are less interested in participating in small-scale irrigation practices than younger people. Holding other factors constant, as the age of the household head increases by 1 year, the probability of adopting small-scale irrigation practices decreases by 1.7% (Table 6). This finding was in corroboration with Abebe [12] and Gadisa and Gebrerufael [31], where the age of the household head was negatively correlated with adopting irrigation practices. However, the findings contradict those of Zemarku et al. [32], who discovered that age and small-scale irrigation have a relationship, as previously hypothesized in Table 3.

Household size: Adult equivalent household size positively and significantly affected household decisions to adopt small-scale irrigation at less than 5% significance level. The value of the marginal effect shows that with one person's increase in household members, the probability of adopting small-scale irrigation increases by 4.7% (Table 6). The more likely reason is that household heads with larger family sizes are more likely to have more labor to engage in small-scale

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Variables	Coefficient	Std. err	Z	P >  z	M. effects (dy/dx)
Age of the HH	-0.070***	0.025	-2.77	0.006	-0.017
Sex of HH	0.193	0.480	0.40	0.687	0.047
Education of head	0.064	0.040	1.58	0.114	0.015
Household size	0.192**	0.097	1.98	0.048	0.047
Extension contact	0.382**	0.166	2.30	0.022	0.093
Access to credit	0.722**	0.340	2.12	0.034	0.178
Livestock holding	0.318***	0.095	3.32	0.001	0.078
Dependency ratio	-0.994**	0.410	-2.42	0.015	-0.244
Market distance	-0.212	0.440	-0.48	0.629	-0.052
Cultivated land	-0.196	1.104	-0.18	0.859	-0.048
Off/non-farm activity	0.618**	0.307	2.01	0.044	0.151
Membership in cooperative	0.902***	0.313	2.88	0.004	0.216
Distance from irrigation	-2.412**	1.217	- 1.98	0.048	- 0.593
Farmers' experience	-0.024	0.021	-1.14	0.255	-0.006
Climate information	1.085***	0.308	3.52	0.000	0.264
Perception of climate	1.101***	0.351	3.13	0.002	0.254
Constant	0.384	1.427	0.27	0.788	
Number of obs=288		LR chi2 (16) = 99.29			
Prob>chi2=0.0000		Pseudo R2=0.2504			
Log likelihood = - 148.61753		y=Pr (ACSSI) (predict)=0.436			

Table 6 Logit estimation of factors influencing the adoption of small-scale irrigation

\*\*, and \*\*\* indicate significance at less than 5% and 1% significance levels, respectively

Source: Computed from our own survey data, 2022

irrigation practices. In addition, the results of the focus group discussion showed that family labor is one of the most frequently used inputs for production under irrigation in the study area, most commonly for protecting the field, weeding, construction of canals, diversion of water from rivers, watering, and others. Thus, small-scale irrigation participation demands more labor, and households with a large labor force are more likely to adopt irrigation than households with a smaller labor force. This result is consistent with the findings of Bedaso et al. [21] and Gadisa and Gebrerufael [31], who found that household size positively increases the probability of participation in small-scale irrigation practices.

Frequency of extension contact: The results showed that the frequency of extension contact positively and significantly affected the adoption of small-scale irrigation at less than 5% significance level (Table 6). Keeping other variables constant, each additional day a farmer made contact with the extension agents will increase the likelihood of adopting small-scale irrigation by 9.3%. The results indicated that farmers who have more contact with extension agents have a higher probability of adopting irrigation than those who have less contact. This is because the frequency of contact with extension agents increases the probability of acquiring up-to-date information on small-scale irrigation and building their knowledge of using these technologies. This result is consistent with what the focus group discussants said: farmers who have more contact with development agents adopt irrigation than those with less contact. This result is consistent with Abebe [12], Leta et al. [33] and Kidanemariam [34], who indicated a positive relationship between the frequency of extension contact and participation in small-scale irrigation.

Access to credit service: This variable was significant at less than 5% level and positively related to adopting smallscale irrigation activities. This indicates that households with access to credit services are more likely to adopt irrigation by a factor of 0.178 than households without access to credit (Table 6). The positive relationship reveals that households that have access to credit have a better possibility of participating in small-scale irrigation because credit helps farmers purchase inputs such as seeds, fertilizers, irrigation equipment, and other production equipment, which would encourage them to produce a given cash crop such as vegetables and improve the livelihood of people. Indeed, this finding corroborates the findings reported by Belachew [35], Meneyahel et al. [36], and Yeshambel [37], who found that credit was more required in irrigation activities and that a lack of credit can be an impediment to irrigation technology adoption.

Total livestock holding: Consistent with a priori expectation (Table 3), livestock holding, measured in tropical livestock units, was found to have a positive and significant influence at less than 1% level of significance on the adoption of small-scale irrigation. This indicates that households with more livestock holdings are able to participate in small-scale irrigation compared to those with less livestock holdings. Livestock is an important source of income, food, and traction power for crop cultivation. The marginal effect shows that as the number of livestock in the TLU increases by one, the probability of participating in small-scale irrigation increases by 7.8% (Table 6). Abebe [12] and Bedaso et al. [21] reported the same result that livestock holding has a positive influence on participation in small-scale irrigation practices. The results contradict those of Zemarku et al. [32], who exposed that livestock holding and small-scale irrigation have an inverse relationship.

Dependency ratio: The dependency ratio has a significant and negative effect on small-scale irrigation adoption since the dependency ratio measures the number of economically inactive family members per active family members. The negative relation of the dependency ratio of the household indicates that keeping other variables constant, the marginal effect in favor of adopting small-scale irrigation decreases by a factor of 0.244 as the dependence ratio of the household increases by one person (Table 6). In a household where adults or productive age groups are higher than the nonproductive age groups, the probability of the household adopting small-scale irrigation would be high. This finding is in line with Abebe [12] and Jema et al. [38].

Off/non-farm activities: The findings showed that off/non-farm participation significantly and positively influenced the probability of households adopting small-scale irrigation at less than 5% significance level. Thus, households that participate in off/non-farm activities are more likely encouraged to adopt small-scale irrigation. The marginal effect result shows that household heads who engage in off/non-farm participation are 15.1% more likely to participate and adopt small-scale irrigation than household heads who have not participated in off/non-farm activities (Table 6). This could probably be because if some members of the household are involved in off/non-farm activities, they play a supportive role in agricultural practices, especially by providing an alternative source of rural financing. Thus, an increase in household members with off/non-farm employment increases the likelihood of adoption because of its reassuring role. This result is consistent with that of Mango et al. [39], who concluded that off/non-farm activities improve income for the farmer and that income can be used to complement irrigation activities.

Membership in cooperative: Membership in cooperatives is essential for information and experience sharing among households on the adoption of small-scale irrigation. Being a member of agricultural cooperative positively influences the adoption of small-scale irrigation. The model results showed a positive and significant effect of cooperative membership

on farmers' adoption of small-scale irrigation at a less than 1% significance level. Keeping other variables constant, being a member of a cooperative increases the probability of adopting small-scale irrigation by 21.6% (Table 6) and vice versa. This implies that farmers who are members of agricultural cooperatives are more likely to participate in small-scale irrigation practices to lessen the effects of climate change. This result is consistent with the findings of Mantegeb [40] and Ngango and Seungjee [41].

Distance of farm from irrigation water source: This variable was significant at less than 5% level of significance and had a negative relationship with household heads' participation decisions in small-scale irrigation practices. This indicates that as the distance of farmland from the irrigation water source increases by one walking hour on foot, the probability of participating in small-scale irrigated farming decreases by 59.3% (Table 6). The inference of this negative relationship was that the farther the plot of land from the irrigation source, the lesser would be farmers' initiative to participate in irrigation. The possible justification could be that households that are far from the irrigation scheme cannot follow up on the farm activity closely and frequently and may not obtain a better yield. In addition, in the study area, every activity is carried out manually, so an increase in the distance of farmland from irrigation water sources exposes households to high costs due to the difficulty of bringing water to their farmland. This finding is in line with the findings of Temesgen et al. [8], Bedaso et al. [21], Gadisa and Gebrerufael [31], and Masresha et al. [42].

Access to climate information: The results revealed that access to weather information has a positive and significant effect on farmers' adoption decision of small-scale irrigation at less than 1% significance level. This indicates that farmers who have access to weather information are 26.4% more likely to adopt small-scale irrigation than their counterparts (Table 6). The availability and accessibility of weather forecast information enables farmers to make appropriate decisions in their farming operations, including those made on the adoption of small-scale irrigation. This implies that obtaining access to weather-related information enhances the knowledge of smallholder farmers on how to adapt to climate change and climate variability-related risks so that they are prepared before it causes disaster by adopting small-scale irrigation. Similarly, Ngango and Seungjee [41], Wossen et al. [43], and Aman [44] reported in line with this study.

Perception of climate change: The results showed that households who perceived climate change were more likely to participate in small-scale irrigation schemes than those who did not perceive climate change at less than 1% significance level (Table 6). The coefficient of marginal effect shows that households who perceive climate change can possibly increase the likelihood of adoption decisions on small-scale irrigation by 25.4%. This means that farmers who perceive more climate change are more likely to adopt small-scale irrigation technologies, and they are more likely to implement climate change adaptation practices than farmers who do not perceive climate change well. This implies that when farmers' cognize climate change and its influence, they use adaptation practices against climate change, such as small-scale irrigation practices, in the study area. A study by Aman [44], Ayalnesh et al. [45], and Williams et al. [46] found similar results.

# 4 Conclusion and recommendations

This study was carried out to identify the factors that influence smallholder farmers' decisions to adopt small-scale irrigation practices as an adaptation strategy to climate change in Kersa district, East Hararghe Zone, Oromia, Ethiopia. A three-stage sampling technique was used to collect cross-sectional data from a sample of 288 households (130 irrigation adopters and 158 non-adopters) in four randomly selected kebeles. Smallholder farmers' decisions to adopt small-scale irrigation schemes are influenced by different factors. The results from the maximum likelihood estimation of the logit model revealed that the age of the household head, dependency ratio, and distance of farmland from the irrigation water source had a significant negative association with households' decision to adopt small-scale irrigation practices. Household size, frequency of extension contacts, access to credit services, total livestock holdings, off/non-farm activities, membership in agricultural cooperatives, access to climate change information, and perception of climate change had significant positive associations with households' adoption decisions in small-scale irrigation practices.

Based on the findings of the study, the following recommendations have been suggested for future research, policy, and development intervention activities to promote the adoption of small-scale irrigation practices. Development agents should provide training and experience sharing to increase farmers' awareness of small-scale irrigation adoption. Since livestock holding influenced the adoption decision in small-scale irrigation, mixed farming should be encouraged by governmental and non-governmental organizations to increase farmers' livelihoods and adaptability. Stakeholders should consider the distance of farmland from irrigation sources when constructing small-scale irrigation schemes, and modernizing the existing schemes can increase the size of irrigated land. It is important to strengthen the existing farmer cooperatives to reinforce farmer-to-farmer knowledge sharing by providing awareness creation, incentives, facilities, and climate change information to strengthen their perception of climate change. As a result, the agricultural and natural resources office should focus scientific attention on the most significant variables that influence the adoption of small-scale irrigation to improve farms' agricultural efficiency and mitigate the adverse consequences of climate change.

Author contributions I declare and affirm that this Research Article is our own work. we have followed all ethical and technical principles of scholarship in data collection, data analysis and compilation of this research. All sources of materials used for this article have been properly acknowledged. IDM designed the data collection tools, undertook the survey and most of the analysis, and developed the manuscript. JHM and MAO contributed by reading and editing the manuscript. All authors read and approved the final manuscript.

**Data availability** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available to respect the privacy of the responding individuals.

#### Declarations

**Competing interests** The authors declare no competing interests.

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