ORIGINAL ARTICLE

Factors Affecting Adoption of Climate Change and Variability Adaptation Strategies on Smallholder Farmers: Evidence from Senan District, Northwest Ethiopia

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Abstract

Ethiopia has been experiencing serious challenges due to climate change and variability. Hence, investigating factors influencing farmers' climate change adaptation strategies is very important. This study intended to investigate determinants of climate change adaptation strategies in Senan district (woreda), Northwest Ethiopia. The study employed a mixed research design. Survey data were collected from 124 sample household heads and interviews were conducted with office heads, team leaders and Development Agents. FGDs were undertaken with Kebele administrators and woreda experts. Descriptive statistics; such as percentage, mean, standard deviation; and inferential statistics i.e. independent t-test and chi-square test were used to identify determinants of climate change adaptation strategies. Binary logistic regression model was used to show positive and negative determinant factors. As the result, age, educational level, economic level, extension support, credit access, perception, family size, and farming experience were significant factors and others were not. As binary logistic regression result revealed, education, economic level, extension support, credit access, perception, and family size were positive significant factors, but age and farming experience were negatively significant in adaptation strategies of climate change. This shows that the adaptation strategies are affected by different factors. Thus, capacity building trainings should be given; extension services should be enhanced; and collaboration with NGOs should be strengthened.

Keywords: Adaptation, Climate Change and Variability, Vulnerability, Strategies, Senan District

Introduction

Climate change has been identified as the greatest environmental challenge, and it will persist in the future across the world (Edame et al., 2011; Yohannes, 2012; Inter-governmental Panel on Climate Change, 2014). Recently Climate change is one of the major sources of contributing challenge to humans and their livelihoods due to the fact

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that the livelihoods of farming communities face severe constraints related to intensive cultivation, overgrazing and deforestation, soil erosion and soil fertility decline, water scarcity, livestock feed, and fuel wood demand (Simane, et al., 2016). Climate change will also have a profound impact on the availability and variability of freshwater as the frequency of climatic extremes such as heat waves, drought, and change in rainfall patterns increase in response to global warming (Inter-governmental Panel on Climate Change, 2012).

One of the most vulnerable locations is African continent where Ethiopia is located. This is largely due to the fragility of African economies and their low adaptive capacities. This event adversely affects the physical, socio- economic and biological conditions. Humans and wild animals face new challenges for survival because of climate change. More frequent and intense drought, storms, heat waves, rising sea levels, melting glaciers and warming oceans can directly harm animals, destroy the places they live in, and wreak havoc on people's livelihoods and communities (Arslan et al., 2015). Nowadays, the agricultural sector in sub-Saharan Africa is believed to be negatively affected by climate change. The impact of climate change is more pronounced on smallholder farmers who are highly dependent on this economic sector. Land degradation, frequent floods, and droughts are among the manifestations of climate change leading to losses in productivity (Lotanna, et.al, 2022). Hence, efforts made to minimize the adverse effects of climate change on smallholder farmers in particular and agriculture in general are very crucial, and also, response options to climate change are necessary to adjust to the effects of climate change and commendably lessen substantial vulnerability (Nega, 2022).

Currently, Ethiopia is one of the most vulnerable countries to climate change and variability which is frequently affected by climate-based hazards such as floods and drought. Major severe droughts have occurred in Ethiopia, which have led to food shortages and famines in the early 1980s (World Bank, 2010). Furthermore, major flood occasions have occurred in different parts of the country. However, the vulnerability of populations living under different social, economic, political, institutional and environmental conditions is not the same because of differences in adaptive capacity, exposure, and sensitivity (Bizuneh, 2013). The country has also been experiencing serious challenges from climate variability and land use/land cover changes like other Sub-Sahara countries (National Meteorological Agency, 2021). Ethiopia's economy has experienced a significant downturn due to climate change, with an estimated annual Gross Domestic Product (GDP) loss ranging from 8% to 10 % (Abebe, 2020). Berihun and Steven (2022) also estimated that a percentage of annual temperature variability could reduce Ethiopia's GDP by up to 4.5 percent annually. The agricultural sector in the country has been threatened and being affected by climate variability and extreme events in terms of high rainfall variability and increase in temperature that leads to frequent drought, severe land degradation, and poor land management practices (World Bank, 2010; Conway and Schipper, 2011; Ethiopian Panel on Climate Change, 2015).

Amhara National Regional State is among the most severely affected areas in Ethiopia due to climate change and variability. Climate change and variability have aggravated the vulnerability of the people in the region. Climate change-induced problems such as drought and land degradation are the vital physical challenges to rain-fed agriculture in the Regional State. The recurrent droughts, and climate change and variability occurring in the region are some of the indicators of susceptibility to climate change. In line with this, climate adaptation is a fundamental and necessary response to the threat posed by the current and future climatic changes in farming systems of Ethiopia in general and in Amhara region in particular (Bewket, W & Alemayehu, A, 2017).

Regarding this issue, various studies were conducted by researchers in different parts of Ethiopia (Asfaw, et.al, 2018; Mihiretu, et.al, 2019; Tamene, et.al, 2023; Bewket, W & Alemayehu, A. 2017). But, none of these researches strives to classify the HH heads based on adoption of adaptation strategies in different categories based on defined parameters. They only focus on identifying the determinants that affect the adaptation strategies. The present research work was conducted in Senan woreda, which is part of the Choke watershed which is a highly affected area. Besides, this area needs a critical attention since it is the source of Abay River and its tributaries. Moreover, no similar researches have been conducted on this issue in the selected area. Then, the above reasons initiated the researcher to study on the selected title and the area. Hence, the main objective of this study was to investigate the major factors affecting adoption of climate change and variability adaptation strategies on small holder farmers in Senan district, Northwest Ethiopia.

Materials and Methods

Description of the Study Area

Senan woreda is located in East *Gojjam* Administrative zone of Amhara National Regional State, Northwest Ethiopia. *Senan is* one of the rural *woredas* which lies within the range of 10° 25' 13" N and 10° 40' 30"N latitudes and 37° 40' E and 37° 50' 20" E longitudes. According to the Plan Commission (2019) of the *woreda,* S*enan* is located at about 327 km away from Addis Ababa in North West direction; at about 292 km from Bahir Dar, the capital city of Amhara National regional state in South East direction and at about 27 km from Debre Markos, in North direction. There are 18 *Kebeles* in the *woreda.* According to official sources from the Plan Commission (2019), agro-ecologically, the *woreda* is classified in to three agro-ecological zones. These are *Wurch* (Alpine) 2%, *Dega* (temperate) 73%, and *Weina Dega* (sub-tropical) 25%.

The land form of the *woreda* is made up of plateau and plain surface (25%), mountain and hills (60%), and valley (15%) (*Senan Woreda* Plan Commission, 2019). The vegetation of the study area is largely dominated by *Juniperus procera* and *Eucalyptus globules*.

According to **the** Agricultural Office (2017) of the *Woreda, Senan* is dominated by Nitisols & Acrisols which constitute 75%, and Cambisol &Vertisols type which constitute 25 %. The main crops mostly growing in the study area include barley, potatoes, wheat, and in some areas, maize and *teff*. In addition to these agricultural products, the area is also known for its edible apple fruit.

According to sources from the Plan Commission (2019) of the *woreda, the* population of the study area(*Senan woreda*) was 119242 in 2019, with 59168 and 60074 being male and female respectively. The rural population size constitutes 105979 (88.87 %), where 53218 are male and 52761 female. The w*oreda* occupies a total area of 43134ha, out of which 24178 ha (56.05%) is cultivated land; 6477 ha (15.01%) is covered with forests, wood lands and bushes; 8503 ha (19.71%) is grazing land; 1326 ha (3.07%) is covered by villages; and 2440 ha (5.65%) is out of use and the rest 210 ha (0.48%) is used for other purposes.

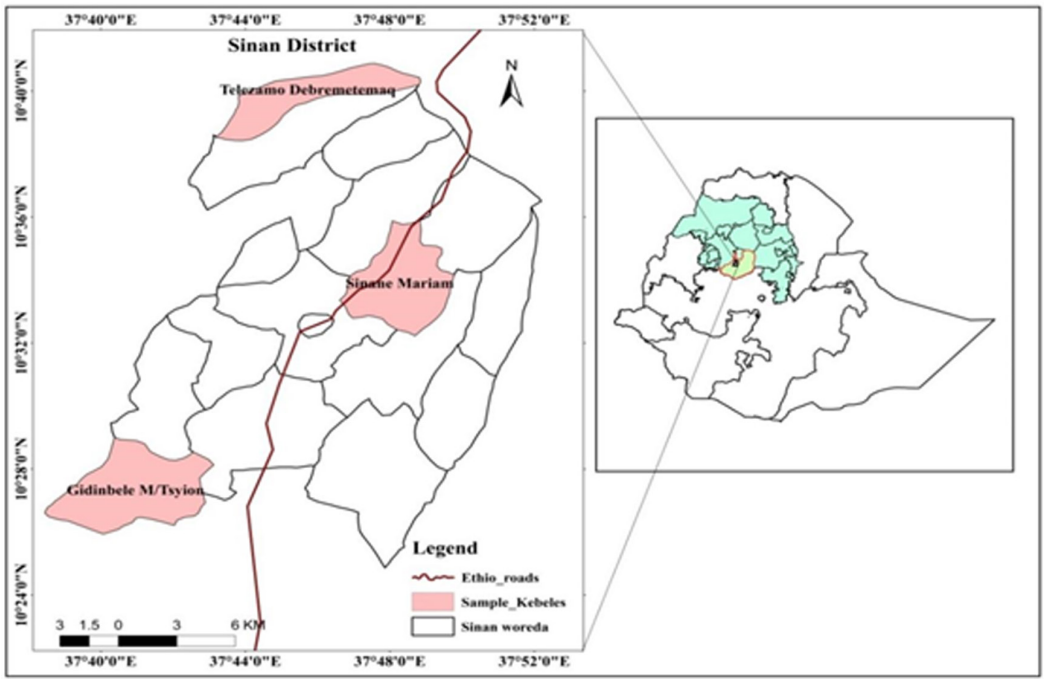

Figure 1: Map of *Senan Woreda*/District/

Research Design

Mixed research design particularly concurrent design by merging both quantitative and qualitative research approaches were used in this study. A convergent (or parallel or

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 Determination and Sampling Techniques

Senan woreda was selected purposely as a target area because of lack of previous studies conducted on the similar issue. In addition, its location at Choke Watershed, where many streams that supply water to Abay are sourced, and the fact that it is one of highly affected area due to climate change and variability contributed significantly to its selection as a study area. The *woreda* is clustered in 18 *kebeles*,out of which 3(three) kebeles *(Gidinbele, Sinane Mariam and Telezamo*) were selected purposely from different agro-ecological zones i.e Woina Dega, Dega, and Wurch respectively. The target population of the study included households from each *kebele, kebele* Development Agents (DAs), *kebele* administrative staffs, and *Woreda* agricultural office experts, team leaders and office heads.

Systematic sampling techniques from households' list of each *kebele* were used to identify sample respondents as to give equal chances. Due to their responsibility and their understanding of the issue, *kebele* agricultural administrative staffs were selected through purposive sampling technique. *Kebele* DAs; and *woreda* agricultural office heads, team leaders, and experts were selected through comprehensive sampling techniques as the members were small in number and they were all essential for the study. The size of sample *kebele* households was determined by using the formula (Kothari, 2004) as follows:

$$n = \frac{Z^2 * P * Q * N}{e^2(\mathrm{N}-1) + Z^2 * \mathrm{P} * \mathrm{Q}} \qquad (1)$$

$$n = \frac{(1.96)^2.(0.03).(1-0.03).(2466)}{(0.03)^2.(3060-1) + (1.96)^2.(0.03).(1-0.03)}$$

$$n = \frac{(3.84).(0.03).(0.97).(2466)}{(0.0009)(2465)+(3.84).(0.03).(0.07)}$$

$$n = 342/2.86 \sim 124$$

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

In the next stage, the proportional sample size of each sample *kebele's* household heads wwere identified by using the proportional sampling formula as follows:

$P = t/T$ where, P = common multiple
t = number of sample size
T = total number of household heads of the selected *kebele*

P=124/2466=0.05 = 5%; Gidinbele=45 sample HH heads; *Senane Mariam*= 42 sample HH heads and *Telezamo*=37 HH heads Total=124 HHs

Sources of Data and Data Gathering Instruments

Primary and secondary sources of data were used in this study. Primary data were obtained from questionnaires, interview and FGD. Closed and open ended Questionnaires were prepared and administered for the systematically selected 124 HHs based on the formula. In addition to questionnaire, interview was administered to *Senan Woreda* agricultural office team leaders (5 in number), office heads (2 in number) and *kebele* Development Agents (6 in number i.e., two from each *kebele*). Focus group discussions were also held with *kebele* administrative staffs (3 FGDs, i.e. one in each *kebele,* and their total number was 18) and *woreda* experts (1 FGD, 9 in number). Secondary sources were obtained from documents from w*oreda* office and internet sources.

Data Analysis Techniques

The gathered quantitative data were coded and entered in SPSS version 20 computer software program. And then, the data were analyzed using descriptive and inferential statistics. The descriptive statistics describes the frequency, percentage, mean, and standard deviation value of the explanatory variables, whereas, inferential statistics; such as Chi-square test and independent t-test were used to show the association and differences between dependent and independent variables in relation to adoption category. And also, binary logistic regression model was used in this study. The analysis of the qualitative data was conducted using narrative analysis.

Model Specification Binary Logistic Regression

Binary logistic regression is a model used to show the relationship between categorical dependent variables and one or more explanatory variables that may be continuous or categorical (StatNews, 2011). Following Maddala (1992) and Gujarati (1995), the logistic distribution function for the adoption of adaptation strategies can be specified as:

$$\mathrm{Pi} = \frac{1}{1+e^{-z(i)}} \qquad (2)$$

Where, P_i = is the probability of adoption of adaptation strategy for the i^{th} farmer, and it ranges from 1 –2 (i.e., the binary variable, p = 1, an adopter, p = 2, non- adopter). e^{zi} = stands for the irrational number e to the power of Zi. Zi = a function of n-explanatory variables which is also expressed as: $Zi = B_0+B_1X_1+B_2X_2+\ldots +B_nX_n$ Where, B_0 – is the intercept, B_1, B_2 … B_n are the logit parameters (slopes) of the equation, X_1, X_2,…X_n = explanatory variables in the model. The slopes tell how the log-odds ratio in favor of adoption of adaptation strategy changes as an explanatory variable changes. The relationship between P_i and X_i which is non- linear can be expressed as follows:

$$Pi = \frac{1}{1+e^{B0+BiXi+\cdots BnXn}} \quad (3)$$

Therefore, in this study, binary logistic regression model was used to identify the determinants of farmers' adoption of climate change adaptation strategies and to show the relative significant relationship of explanatory variables with the dependent variables. Because the study's dependent variable was dummy represented as 1 = adopters and 2= non–adopters, the predictor variables were of all type (discrete, categorical and continuous), had large sample size (124).

Model Specification for Collinearity and Model of Fitness

In a given study, before taking the selected variables into the binary logistic regression model, it is necessary to check for the existence of multi-collinearity among the continuous variables and verify the associations among discrete variables. The reason for this is that the existence of multi co-linearity will seriously affect the parameter estimates. The coefficients of the interaction of the variables indicate whether or not one of the two associated variables should be eliminated from model analysis (Gujarati, 2003). Formally, Variance Inflation Factors (VIF) technique was employed to detect the problem of multi-collinearity for continuous explanatory variables. If VIF value is equal to 1, there is no a multi-collinearity problem among the factor variables. A VIF value greater than 10 is used as a signal for the strong multi-collinearity (Gujarati, 1995). A multi-collinearity measurement associated with the VIF (Xi) is specified as:

$$\text{VIF (Xi)} = (1\text{-Ri2})\text{-}1 = VIF = \frac{1}{1-Ri^2} \quad (4)$$

Where, Ri^2 is the coefficient of multiple determinations when the variable Xi is regressed on the other explanatory variables. Additionally, there are also associations between discrete variables, which can lead to the problem of multi-collinearity or association. To detect this problem, contingency coefficients were computed from the survey data. Contingency coefficient is a chi-square based measure of association where a value 0.75 or above indicates a stronger relationship (Healy, 1984).The coefficient contingency is expressed as follows:

$$C^2 = \frac{X^2}{n+X^2} = C = \sqrt{\frac{X^2}{n+X^2}} \quad (5)$$

Where, C = Coefficient of contingency, n = total sample size and x^2 = a chi- square value Therefore, in this study multi-collinearity diagnostic test was used to identify the situation weather the correlations among and between explanatory variables were strong or not. Thus, variance inflation factor (VIF) was used for testing the existence of multi-collinearity problem among and between continuous variables, and Coefficient of Contingency was used for discrete variables. There are different statistical testes for determining the significance or goodness of fit for logistic regression models. These are Pearson chi-square, Likelihood Ratio test, Hosemer-Lemeshow Goodness-of-Fit test and Nagelkerke Pseudo R - square. Goodness-of- fit of the model can also be measured by considering how well the model classifies the observed data or examining how likely the sample results actually are and given the estimates of model parameters. The goodness-of-fit is considered to be good if the overall correct classification rate exceeds 0.05. The goodness-of-fit test statistic is greater than 0.05, as we want for well-fitting model; the model's estimates fit the data at an acceptable level. Therefore, in this study, Pearson chi - square and Hosemer-Lemeshow Goodness-of-Fit test were used to test the model-of -fitness of the study.

Table 1: Description and Measurement of Explanatory Variables

Definition of variables	Variable Nature	Measurement of variables
Dependent Variable		
Adoption of adaptation Strategies	Dummy	1=Adopter,2 = Non-adopter
Independent Variables		
Sex of households	Dummy	1=Male, 2=Female
Age of households	Categorical	1=young, 2=Adult, 3=Old
Marital status	Dummy	1=Married, 2=Unmarried
Educational level	Dummy	1=Literate, 2=Illiterate,
Economic status	Categorical	1=Low, 2=Medium, 3=High
Extension Support	Dummy	1=Yes, 2=No
Credit Access	Dummy	1=Yes, 2=No
Perception	Dummy	1=Positive, 2= Negative
Family size	Continuous	Number of family members
Farming experience	Continuous	Number of Years

Result and Discussion

Adoption Categories of the Household Heads

The study attempted to use certain parameters to categorize the HHs based on their adoption of adaptation strategies. For this purpose, only the following parameters were used. These are Green legacy initiative, Improving water storage strategy, Enhancing early warning systems and access to disaster information, integrated watershed management strategy, and installing green spaces. Then, based on the above parameters, as revealed in table 2, the sample households were categorized in to two categories based on their adoption decision of the referenced climate change adaptation strategies i.e. adopter and non-adopter which account 46 % and 54 % respectively. This indicated that majority of the respondents were non-adopters of adaptation strategies.

Table 2: The Distribution of Sample Household Heads in Relation to Adoption Categories.

Adoption categories	Number	Percentage
Adopter	57	46 %
Non-adopter	67	54%
Total	124	100

Source:-Survey result

Categorical Variables and Adoption Category

Based on the result of the study, being femaleness and maleness have no significant relationship with the adoption of climate change adaptation strategies at a 5% significant level. From this, 21 % non-adopters and 15.8 % adopters were females while 84.2% adopters and 79.1% non-adopters were males from the total number of sample respondents. The result of the chi-square test indicated that there was insignificant association between household heads' sex and adoption of adaptation strategies at 5% significance level ($p > 0.05$) (Table 3). And also, as responded by the FGD participants and interviewees, sex has not any relation with the adoption of adaptation strategies.

In this study, sampled households were grouped in to three age groups: Young, Adult and Old age groups. Out of 57 adopter sample households, 52.6% were young, 28.1% adult and 19.3 % were old. On the other hand, 10.44%, 31.3% and 58.2 % were young, adult and old age group HH heads from the non – adopter sample households respectively. Chi-square test was undertaken to test the significance association between age group and adoption of climate change adaptation strategies. The result of the chi-square test

indicated that there was significant association between households' age group and adoption of strategies at 1% significance level ($p<0.01$) (Table 3).

As indicated in table 3, in relation to marital status and adoption categories, out of 57 adopter HH heads, 84.2% and15.8% were married and unmarried respectively. Whereas, from 67 non-adopter house hold heads, 70.1% were married and 29.9% were grouped in thee unmarried status. In this study, to assess the level of significance, chi-square test was employed. And the result indicated that there was no significant association between HH heads marital status and adoption categories at a 5% significance level ($p>0.05$). On the other hand, as shown in table 3, out of 57 adopter sample households, 22.8 % were illiterate and 77.2% were educated, whereas 73.1% and 26.9% were illiterate and educated respectively among the non-adopter sample households. The chi-square test showed that there was significant association between the educational status of the household heads and the adoption of strategies at 1% significance level ($p<0.01$). Aligned with this result, the participants of FGD and interviewees confirmed that education has its own positive effect on the adoption of different adaptation strategies. As they revealed, when some one's awareness increased, then, his/her level of adaptation will increase as well.

Economic level can affect the adoption of adaptation strategies. It is assumed that if the farmers' economic level is high, then, they can use technologies i. e they can prepare different strategies and apply them in an effective way. In this study, out of 57 adopter HH heads 15.8%, 24.6% and 59.6% were grouped in to poor, medium and rich respectively. And from 67 HH heads who did not adopt strategies were poor, medium and rich classes and accounted 47.8 %, 38.8% and 13.4% respectively. In this study, to assess the level of significance, chi-square test was employed. And the result indicated that there was significant association between HH heads economic level and adoption categories at 1% significance level ($p<0.01$) as shown in table 3. The samples who participated in the interview said that economic level of the household heads has been affected the adoption of strategies in their farm lands as it enables HHs to use different strategies when they require certain expenses.

As indicated in table 3, 78.9% of adopter farmers have got extension service while 23.9% from non- adopters got extension service. From the adopters, 21.1% and from non-adopters 76.1% had no access of extension service. The probability of using extension service has significant association with adoption strategies at 1% significance level ($p< 0.01$). The sample interviewees confirmed that the households' heads that have got proper extension service are more likely to adopt adaptation strategies in their farm land since their awareness increases. In relation to credit access, from the adopters and non-adopters, 71.9% and 31.3% had access to credit. While 28.1% adopters and 68.7% non-adopters had no credit access to use adaptation strategies and there is a significance association between and adoption of strategies and credit access at 1% significance level ($p< 0.01$). Additionally, when we see the perception of HH heads on adoption strategies,

from adopters and non- adopters, 63.2% and 34.3% had positive attitude towards adoption of climate change adaptation strategies respectively. And also, from adopters (36.8%) and from non-adopters (65.7%) samples had negative attitudes towards adoption of strategies. Then, there is a significant association between farmers' positive attitude and adoption of the selected strategies at 1% significance level ($p<0.01$). This indicated that when farmers have positive attitude towards the newly incoming strategies, then, it will be easier for them to accept and implement as intended.

Table 3: Distribution of Categorical Variables and Adoption Category

Variable		Adopter		Non-Adopter		X^2 value	Sig. Level
		No	%	No	%		
Sex	Male	48	84.2	53	79.1	0.53	.466^{ns}
	Female	9	15.8	14	21		
	Total	57	100	67	100		
Age	Young	30	52.6	7	10.44	30.04	0.000**
	Adult	16	28.1	21	31.3		
	old	11	19.3	39	58.2		
	Total	57	100	67	100		
Marital Status	Married	48	84.2	47	70.1	3.39	0.065^{ns}
	Unmarried	9	15.8	20	29.9		
	Total	57	100	67	100		
Education level	Literate	44	77.2	18	26.9	31.22	0.000**
	Illiterate	13	22.8	49	73.1		
	Total	57	100	67	100		
Economic status	Low	9	15.8	32	47.8	30.42	0.000**
	Medium	14	24.6	26	38.8		
	High	34	59.6	9	13.4		
	Total	57	100	67	100		
Extension support	Yes	45	78.9	16	23.9	37.36	0.000**
	No	12	21.1	51	76.1		
	Total	57	100	67	100		
Credit access	Yes	41	71.9	21	31.3	20.29	0.000**
	No	16	28.1	46	68.7		
	Total	57	100	67	100		

Perception	Positive	36	63.2	23	34.3	10.26	0.001**
	Negative	21	36.8	44	65.7		
	Total	57	100	67	100		

**significant at 0.05, ** significance at 0.01, ns=not significant*

Source:-Survey result

Continuous Variables and Adoption Category

As shown in table 4, the average family size of the adopter and non -adopter was 6.02 and 4.25 with a standard deviation of 1.768 and 1.307 respectively. The result of the independent t-test showed that there was significant mean difference among the adoption categories of adaptation strategies and family size at 1% level of significance ($p<0.01$). This implied that households with large family size have a potential to adopt adaptation strategies more than families with small size.

As shown in table 4, regarding the mean farming experience of the adopters and non-adopters shows, there is a great difference between them i.e. adopters (16.81) with standard deviation of 6.140 and non-adopters (26.42) with standard deviation of 9.686. This indicated that the farming experience of the adopters and the non-adopters showed greater variation, and those who are less experienced had high tendency of adoption of climate change adaptation strategies.

In line with this, those who participated in interviews and FGD responded that farmers with long farming experiences had less understanding of the current adaptation strategies, and they clang to the old and traditional ways of adaptation strategies.

Table 4: Distribution of Continuous Variables and Adoption Category

Continuous variables	**Adopter**	**non-adopter**	**Independent t test value**	**Sig. level**			
	No	**Mean**	**Sd.**	**No.**	**mean**	**Sd.**	
Family size	57	6.02	1.768	67	4.25	1.307	6.375 0.000**
Farming experience	57	16.81	6.140	67	26.42	9.686	-6.465 0.000**

**significant at 0.05, ** significance at 0.01, ns=not significant*

Source:-Survey result

Binary Logistic Regression Model Results and Adoption Category

In this study, 10 frequently used independent variables were assessed. Out of these 10 independent variables that affect the adoption of adaptation strategies, 8(eight) were significant which have determined farmers' decision to use the selected strategies as climate change adaptation strategies.

The explanations of significant explanatory variables were presented as follows:

Age of the HH heads (Age): the binary logistic regression result showed that age was found to be significant at 1% level of significance and had Negative logit coefficient and odds ratio of 0.265. This implied that the probability of the farmers to use adaptation strategies decreased by a factor of 0.265 as age of the households increased by a 1 unit. This suggested that younger farmers more likely used climate change adaptation strategies than old ones. The result of this study is inconsistent with Tamene et.al (2023) and Molla et.al (2023) since they reported old age groups as more active in climate change adaptation than young age groups.

Educational Status of the HH heads (Education): the regression result indicated that educational status of the households was significant at 1% level and had a positive logit coefficient with 9.231 odds ratio on the use of adaptation strategies. This implied that the probability of the households to adopt adaptation strategies increased by a factor of 9.231 with a unit increase in level of literacy of the households, other things being equal. This showed that education enhances the understanding and utilization of modern adaptation strategies. As the result, more educated household heads are more likely to adopt the adaptation of strategies than illiterate household heads. The result is similar with the findings of Asfaw et.*al* (2018), Molla et.al (2023) and Hassen *et al.* (2012), as they revealed that education significantly affected the use of climate change adaptation strategies effectively.

The Economic Level of the HH heads (Eco-level): the result of the regression revealed that economic level of the households was significant at 1% level of significance and had a positive logit coefficient with 0.272 odds ratio on use of strategies. This implied that the probability of the households to adopt adaptation strategies increased by a factor of 0.272 with a unit increase in the level of economy of the households. The finding of this study is uniform with that of Asfaw et.*al* (2018).

Extension Support of the HH heads (Expert): this was significant at 1% significance level and had a positive logit coefficient. It had odds ratio of 11.979. Households who have had a better access to contact with extension service providers got better information and

perceived the importance of application of strategies to protect themselves from climate change impacts. The result goes in harmony with the findings of Hassen *et al.* (2012) and Mihiretu et.al (2019) as they stated that farmers who were contacted by an extension worker were found to be better users of adaptation strategies.

Credit Access of Farmers: the binary logistic regression result showed that availability of credit access was found to be significant at 1% level of significance and had positive logit coefficient and odds ratio of 5.168. This implied that the probability of the farmers to use adaptation techniques increased by a factor of 5.168 as the credit of the households increased by a 1 unit. This study conforms to the findings of Molla et.al (2023) and Tamene et.al (2023) which stated that when credit access is adequately available, then the adoption rate will increase.

Perception of Farmers: As revealed in table 5, the binary logistic regression result showed that, the perception of farmers was found to be significant at 1% level of significance and had positive logit coefficient and odds ratio of 3.039. This implied that the probability of the farmers to adopt adaptation strategies increased by a factor of 3.039 as perception of the households increased (being positive) by a 1 unit. The finding of the study is congruent with the findings. Asfaw et.*al* (2018), Molla et.al (2023)

Family Size of the HH heads (Family): the binary logistic regression result indicated that family size was found to be significant at 1% level of significance and had positive logit coefficient and odds ratio of 0.033. This implied that the probability of the farmers to adopt adaptation techniques increased by a factor of 0.033 as the family size increased by a 1 unit. This showed that, farmers with high family members were more likely to adopt strategies than those with small number of family members. The result of this study stands in opposition to the findings of Tamene et.al (2023) and Mihiretu et.al (2019) which stated that if the family size increases at a certain unit, the adoption of the adaptation strategies also decreases at the same unit.

Farming Experience: the binary logistic regression result showed that farming experience was found to be significant at 1% level of significance and had Negative logit coefficient and odds ratio of 0.123. This implied that the probability of the farmers to adopt adaptation methods increased by a factor of 0.123 as the farming experience decreased by a 1 unit. This revealed that farmers with a better farming experience were less likely to adopt adaptation techniques than those with low farming experience. This result goes inconsistent with the result of Mihiretu et.al (2019), as their study revealed, farming experience has a positive correlation with adaptation strategies.

Table 5: Binary Logistic Regression Model Results with Adoption Category

Explanatory variables	B	S.E.	Wald	Sig.	Exp(B)
Sex	-0.102	0.426	0.058	.466^{ns}	0.903
Age	-1.330	0.267	24.753	0.000**	0.265
Marital status	-.127	.507	.063	.065^{ns}	.802
education	2.223	0.419	28.141	0.000**	9.231
Eco_ level	1.303	0.269	23.452	0.000**	0.272
Extension_ service	2.483	0.33	32.873	0.000**	11.979
Credit_ access	1.642	0.391	17.626	0.000**	5.168
Perception	1.118	0.374	8.933	0.001**	3.039
Family size	3.422	0.865	15.646	0.000**	0.033
Farming experience	-2.093	0.913	5.25	0.002**	0.123

**significant at 0.05, ** significance at 0.01, ns=not significant*

Source:-Survey result

Conclusion

The main objective of this study was to investigate the basic factors influencing farmers' adoption of modern climate change adaptation strategies in *Senan woreda*, Northwest, Ethiopia. According to the finding, the number of adopters in the study area was found to be lower than no-adopters (46 %< 54%). Results from this study showed that farmers' adoption of adaptation strategies in the study area has been affected by different factors. As the study revealed, age, educational levels, economic level, extension support, credit access, perception of farmers, family size, and farming experience of the household were significant, whereas sex and marital status were insignificant determinants. Binary logistic regression result also identified the positive and negative determinants. Thus, educational level, economic level, extension support, credit access, farmers 'perception, and family size were positive significant determinant factors, whereas age and farming experience were negatively significant ones on adoption of modern climate change adaptation strategies.

This implies that when educational level, economic level, extension support, credit access, farmers ' perception, and family size increase by a certain level, then, the adoption intensity also increases in parallel. Besides the results of the study revealed that, when age and farming experience of farmers increase within a certain unit, then, the adoption level will decrease. But, from explanatory variables, sex and marital status were insignificant

determinants. Interviewees and FGD participants also confirmed that there is a great difference in adoption of strategies among farmers depending on farmers' perception, economic level, family size, extension support, and farming experience of the households. In general, farmers' adoption of different selected methods of adaptation strategies determined by different factors. So, to enhance the adoption rate of adaptation strategies, frequent capacity-building trainings should be given to DAs and HH heads on adaptation strategies, and appropriate extension services should be provided in line with current environment and development policies of the country. Also, experience sharing between adopters and non-adopters should be implemented. And collaboration with NGOs and government agencies should be enhanced to solve financial and technical problems. The results of this study will benefit all concerned bodies including the residents of the *Senan* district to acquire some important climate related information. They will also be helpful for policy makers and subsequent researchers. The limitations of this research work will be addressed by other researchers.

Declaration of Competing Interest

The present author declares that this is the sole work of the author's, and the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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