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Determinants of farmers' choice of adaptation strategies to climate change in Semen Bench District, Southwest Regional State, Ethiopia

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ABSTRACT

Relevance. Climate change is a severe problem in Ethiopia as a whole, but especially in the study area, where people rely on subsistence rain-fed farming. Effective adaption changes in climatic conditions are critical to securing resilient farmers' livelihoods.

Methodology. As a result, this study investigated farmers' choices and factors influencing their adaptation strategies to climate change in Semen Bench District, Southwest Ethiopia, which is heavily impacted by climate change pressure. This study utilized a cross-sectional survey and time series data research design. A multistage stratified random sampling procedure collected from 216 randomly selected sample households using a pretested questionnaire survey. The supplementary data were collected from purposely-selected fifteen key informants; (twenty) focus group participants. Farmers' climate change adaptation techniques were described using descriptive statistics and an econometric model. To determine the characteristics influencing household adaptation methods to climate change, a multivariate probit model was used.

Results. The model results showed that the likelihood of families employing soil and water conservation (SWC), enhanced and diversified crops, tree planting and agroforestry, irrigation, and organic fertilizers were 47.8%, 38.9%, 54.1%, 63.4%, and 59.6%, respectively. Multivariate probit model were applied to identify factors that influence the farmer's decision to adapt to climate change. The MVP model confirmed that the factors had statistically significant (P<0.01, 0.05, and 0.1) effects on the choice of adaptation responses such as the household head's sex, age, education level, household size, farm size, farm income, ownership of tropical livestock, access to credit, extension visit, farmer-to-farmer extension, access to climate information, farmer experience, and the average distance from home to the farm.

KEYWORDS:

Climate change, Adaptation strategies, Multivariate probit model, Ethiopia

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Факторы, определяющие выбор фермерами стратегий адаптации к изменению климата в районе Семен Бенч, Юго-Западный региональный штат, Эфиопия

АННОТАЦИЯ

Актуальность. Изменение климата является серьезной проблемой в Эфиопии в целом, но особенно в исследуемом районе, где люди зависят от натурального хозяйства, основанного на дождевом орошении. Эффективная адаптация к климатическим изменениям имеет решающее значение для обеспечения устойчивого жизнеобеспечения фермеров.

Материал и методы. В связи с этим в данном исследовании изучали предпочтения фермеров и факторы, влияющие на их стратегии адаптации к изменению климата в районе Семен Бенч, Юго-Западная Эфиопия, который сильно пострадал от давления изменения климата. В исследовании использовали метод поперечного обследования и метод анализа временных рядов. Многоступенчатая стратифицированная случайная выборка была проведена на основе данных 216 случайно выбранных домохозяйств с использованием предварительно протестированного опросника. Дополнительные данные были собраны у пятнадцати специально отобранных ключевых информаторов (двадцати) участников фокус-группы. Методы адаптации фермеров к изменению климата были описаны с использованием описательной статистики и эконометрической модели. Для определения характеристик, влияющих на методы адаптации домохозяйств к изменению климата, использовали многомерную пробит-модель.

Результаты. Результаты модели показали, что вероятность использования семьями методов сохранения почвы и воды (SWC), улучшенных и диверсифицированных культур, посадки деревьев и агролесоводства, орошения и органических удобрений составила 47,8%, 38,9%, 54,1%, 63,4% и 59,6% соответственно. Многомерная пробит-модель была применена для выявления факторов, влияющих на решение фермера адаптироваться к изменению климата. Модель MVP подтвердила, что факторы, оказывающие статистически значимое (P<0,01, 0,05 и 0,1) влияние на выбор мер адаптации, такие как пол главы домохозяйства, возраст, уровень образования, размер домохозяйства, размер фермы, доход от фермы, владение тропическим скотом, доступ к кредитам, визиты специалистов по распространению сельскохозяйственных знаний, консультации между фермерами, доступ к климатической информации, опыт фермера и среднее расстояние от дома до фермы.

КЛЮЧЕВЫЕ СЛОВА:

Изменение климата, стратегии адаптации, многомерная пробит-модель, Эфиопия

1. Introduction

Climate change adversely affects the environment, human health, food security, economic activities, resources, and physical infrastructures in the world [1]. The impact of climate change on the different sectors varies in degrees, the worst hit is supposed to be rain-fed agriculture due to its high sensitivity to climate stimuli. The impacts of climate change unevenly vary spatially in magnitudes. The developing countries and the poorest peoples will suffer more than the others will, even though their contribution to the change is minimal. Because the economic activities of these countries mostly depend on rain-fed agriculture and natural resources which are susceptible to climate change [2,3].

Climate change has a direct and indirect impact on agricultural production and productivity in rural areas. It has a direct impact on agriculture by affecting weather variables such as temperature, solar radiation, rainfall, wind speed, and humidity [4], as well as indirectly through disease and pest outbreaks and the development of climate-related diseases such as malaria, which affect the labor force [5]. According to Newton et al. [6] climate change alters the complex connections between crops and pathogens, resulting in more pest and disease outbreaks. Ethiopia is an agrarian country, with agriculture accounting for 43% of total GDP [7].

Agriculture in Ethiopia is marked by a lack of modern inputs, low outputs, and reliance on rainfall. According to the CSA's (2008) farm management practices study, smallholders account for 96.3% of total cultivated land and 95% of total crop production. Irrigation accounts for only approximately 1.5% of farmed land. Ethiopian agriculture is one of the most sensitive industries to current climatic variability and future climate change, potentially exposing millions of people to recurring food shortages and famines. Climate change and variability's negative influence on crop and livestock output could lead to a statewide food crisis and significantly harm the economy [8].

Adaptation is an important technique for farmers to deal with the negative effects of climate change and variability, which increases agricultural productivity in impoverished farm households [9]. Similarly, understanding adaptation methods on the part of smallholder farmers may help to address the challenge of climate change [10]. When bad conditions prevail, adaptation can be considered as lowering the severity of various impacts. That is, adaptability minimizes the extent of potential injury. The fact that climate has changed in the past and will continue to change in the future highlights the need of understanding how farmers perceive climate change and adjust in order to guide future adaptation initiatives.

Climate change and fluctuation have had the greatest impact on the rural parts of Ethiopia's Semen Bench District. The region's natural resource base is severely damaged, and present global warming exacerbates the people's vulnerability to climate change impacts. Several studies concur that the district has been enduring droughts that have happened in the country, showing the susceptibility of the region's response to climate change revealed that the most important climate change was in temperature and rainfall variability, which caused drought and flooding in the districts

In previous studies, there was a gap in the methodology used to identify the factors that influence the choice of adaptation strategies. Previous studies have mainly relied on the multinomial logit (MNL) model, which assumes that farmers select only one adaptation strategy from a set of discrete options. However, in reality, farmers may choose multiple strategies simultaneously, and these strategies can be interdependent [11]. Therefore, it was necessary to conduct research at the household or farm level in different areas of Ethiopia to understand the climate trend, identify adaptation strategies, and determine the factors influencing these choices using the multivariate probit (MVP) model.

To the best of the researcher's knowledge, little empirical study has been conducted in the study area to determine the factors influencing these choices. Therefore, it is crucial to analyze and identify the factors that affect their choice of adaptation strategies.

2. Materials and Methods

2.1. Study area

The study was conducted at Semen Bench district, Bench Sheko zone in southwest National regional state, Ethiopia (Figure 1). It is about 583 km southwest of Addis Ababa and 17 km far from Mizan town. Geographically, it is located between 6055'00'' to 707'30'' N latitude and 35032'30''-35045'00'' E longitude (SBDADO). In its relative location, Semen Bench district is bounded on the North by the Sheka Zone, on the Northeast by Kaffa Zone, on the Southeast by Shey Bench district, on the South by Mizan Aman town and on the West direction by Sheko District. In the Semen Bench district there are 21 Kebeles and cover a total area of 60,254.173 ha.

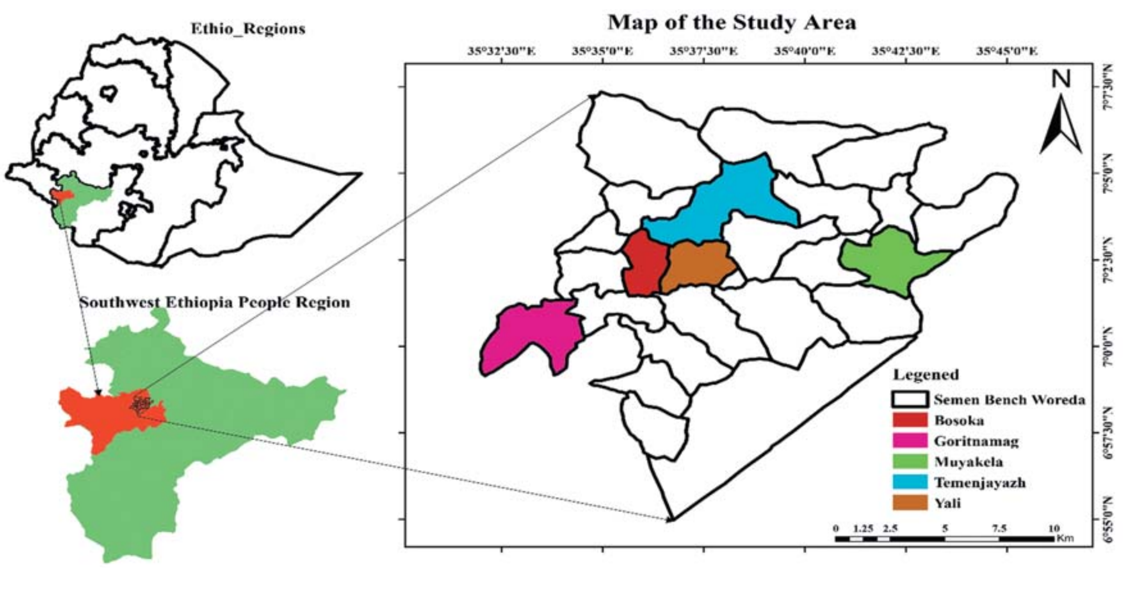

Figure 1. Location of the Study Area

2.1.1. Topography and climate characteristics of the study area

The Semen Bench district is categorized into three agro ecological zones based on altitude: Weyna Dega, Dega, and Kola. The area's topography includes flat terrain, rugged landscapes, plateaus, and steep slopes. Altitudes range from 1400 to 2500 meters above sea level (Masl). Mean annual rainfall ranges from 400 to 2000 mm, and temperatures range from 15°C to 27°C.

2.1.2. Population and socio-economic activities

The district is home to various ethnic communities, including Kaffa, Bench, Amhara, Oromo, Wolayita, and others. According to the 2019 population projection by the Central Statistics Agency in Mizan Teferi, the total population is estimated at 137,407, with 66,902 males and 70,505 females. The Semen Bench District features a mixed farming system. Dominant crops include cereals like maize, barley, wheat, teff, sorghum, rice, sesame, fava beans, and common beans, which account for 26% of cultivation. Tree crops such as coffee, mango, papaya, banana, and avocado represent 65%, while root and tuber crops like potatoes, sweet potatoes, carrots, inset, and taro make up 9%. Livestock, including cattle, sheep, goats, poultry, and donkeys, are vital for income and livelihoods.

2.2. Research Design and Approach

This study employed a cross-sectional survey and time series data research design, integrating both quantitative and qualitative approaches. These methods were selected to comprehensively gather and analyze data on climate perception and farmer adaptation strategies, including socioeconomic household characteristics. Data collection tools included questionnaires and structured interviews for quantitative data, along with interviews, focus group discussions, and key informant interviews for qualitative insights. Additionally, temperature and rainfall data from the Ethiopia Meteorological Institute (EMI) were used to enhance the climate change analysis.

2.3. Sampling technique and sample size determination

Multi-stage random sampling technique was used for this study. among six districts of the Bench Sheko zone, Semen Bench District was selected purposively, because the district is more constrained by environmental factors (rainfall variability, temperature variability, excessive runoff, and local flood) as well as socioeconomic factors (scarcity of water, improper land use and lack of infrastructures) than other districts, also, which are more vulnerable to climate change and prone to risks and the climate trends and local climate change adaptation strategies and factors affecting the choice of climate change adaptation strategies were very limited studied before, even in the neighboring district also there was not a lot of studies.

In the second step, stratified random sampling was used because the district is heterogonous in agroecology. The entire population that is number of households within the district is divided into three strata considering the agro ecological zones. Because agro ecological variation creates heterogeneity in the adaptation strategies of the farmers. Therefore, the entire district was stratified into three classes based on data of agroecological zones.

The agroecological zones were Woyna Dega (midland), Kola (lowland), and Dega (highland). In the third step, five sample kebeles were selected randomly (lottery) method (three kebeles from Woyna Dega, one kebele from Kola, and one kebele from Dega) then households randomly selected from the three agroecological zones of five sampled kebeles using probability proportional to size. Finally, due to time constraints to cover the vast and very difficult geographical extents having an extremely dispersed settlement of the household heads and budget limitations, from the total of 2978 household heads, 216 were selected using simple random sampling (SRS). This method of sample selection gave each kebele and every household head in each kebele an equal chance of being included in the sample. The probability proportional to size technique was applied to determine the number of samples required at each stage of disaggregation. So, finally, the household sample sizes were determined by using the Cochran&Talwani [12] sampling formula with 95% confidence level and at 7% precision level to determine the required sample size.

$$n = \frac{z^2 \cdot P(1-P)}{(e)^2} \quad \text{................................} \; eq1.$$

Where n is required sample size (when the population is >10,000), P is the approximate proportion of people having the basic knowledge attitude, and behavior of local adaptation strategies. Since there is no data on the local adaptation strategies of in the target regions (50%).

Z is the value of 1.96 to achieve the level of confidence of 95%; e is the tolerable error margin, as defined in 0.07 (i.e., 7% maximum discrepancy between the sample and the general population).

Then 1.962*0.5(1-0.5)/0.072=196 an additional 10% contingency was added to compensate possible non-response rate; therefore the total sampled size is 216.

$$ni = \frac{n \cdot Ni}{\sum Ni} \quad \text{................................} \; eq2.$$

Where n = determined sample size the research paper was used

ni = households of the ith kebele, and

Ni = total households of the ith kebele.

2.4. Sources of data

This study used both primary and secondary data sources. Primary data were collected via household surveys, focus group discussions, key informant interviews, and direct observations with farm households, kebele agricultural experts, and development agents.

Table 1. Distribution of Sampled households by sample kebeles

Agro-ecology Total	Kebeles	Total population	Total household (Ni)	Sample household (ni)
Woyna Dega	Temenj yezh	4361	976	71
	Yali	2563	720	52
	Boseka	2092	300	22
Dega	Moyakela	4220	495	36
Kola	Goritina mag	3031	487	35
Grand total		16267	2978	216

Secondary data were obtained from published and unpublished sources, including government offices, the NMI, the Central Statistical Agency, online sources, universities, public libraries, and local offices related to agriculture, water development, and health in the Semen Bench district.

2.5. Data collection tools

A survey with structured, semi-structured, and unstructured questionnaires was conducted among 216 households to understand the determinants of farmers' climate change adaptation strategies. Focus group discussions (FGDs) with eight members from different kebeles included long-term residents, local elders, religious leaders, women, extension agents, and young farmers. Informal interviews with 20 key informants from agriculture, livestock, natural resources, forestry, environmental protection, and water sectors were conducted to validate and expand on the collected information. Additionally, secondary data were reviewed from district and kebeles documents, including census reports, activity progress reports, archived data, and economic information.

2.6. Method of Data Analysis

The result of the study was analyzed and presented by using; descriptive statistics and Multivariate Probit model. The collected data were analyzed using both qualitative and quantitative methods. Descriptive statistics (mean, standard deviation, percentages, and graphs) were used to present socio-economic characteristics, perceptions of climate change, and adaptation strategies. The chi-square test measured associations between categorical variables and agroecology zones, while the F-test assessed mean differences in continuous variables among these zones. Qualitative data from focus group discussions, field observations, and key informant interviews were presented through simple narrations.

The present study aimed to identify the factors that determine climate change adaptation strategies in the study area. Many studies on farmers' adaptation decisions commonly use analytical approaches such as multinomial logit (MNL) and multinomial probit (MNP). These approaches are suitable for evaluating different combinations of adaptation strategies, including individual strategies [13].

In the MNL model, it is assumed that each farmer faces a set of discrete and mutually exclusive choices of adaptation measures, and they choose exactly one adaptation strategy. The model also assumes the independence of irrelevant alternatives (IIA) property, which means that the ratio of probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set [14]. However, in real situations, farmers may choose more than one adaptation strategy simultaneously, and each strategy are interdependent with others. Therefore, the MNL model may not be suitable for such cases, and an alternative model that can address these limitations is needed.

However, this study was employed a multivariate probit (MVP) model and this is an appealing model of choice behavior because it allows a flexible correlation structure for the unobservable variables because farmers who choose more than one adaptation strategy at once are so-called mutually inclusive [11]. It is a generalization of the probit model used to estimate several correlated binary outcomes jointly. The MVP is one form of a correlated binary response regression model that can simultaneously estimate the influence of the set of explanatory variables on each of the different practices, while allowing for the potential correlation between unobserved disturbances as well as the relationship between the adoptions of different practices [15]. The model is based on the multivariate normal distribution and is recommended in cases of interdependence among the irrelevant alternatives [16].

The judgment of whether or not to use any adaptation option could fall under the general framework of its value and production improvement capacity. Consider a rational farmer who pursues to improve agricultural productions over a specific time and must choose among a set of $'j'$ adaptation options. Hence, the farmer $'i'$ decides to use $'j'$ adaptation options if the perceived benefit from option $'j'$ is greater than the utility from other options (say, $'k'$) stated as:

$$U_{ij}(\beta_j X_i+\varepsilon)>U_{ij}(\beta_k X_i+\varepsilon_k), k\neq j \quad .... \quad eq3$$

Where U_{ij} and U_{ik} are the perceived values by farmer i of adaptation options and k, respectively; X_i is a vector of explanatory variables that influence the choice of the adaptation option: β_j and β_k are parameters to be estimated and ε_j ε_k are the error terms.

Under the revealed preference assumptions, the farmer practices an adaptation option that generates net benefits and does not practice an adaptation option otherwise; we can relate the observable discrete choice of practices to the unobservable continuous net gain variable as $Yij=1$ if $Uij>0$ and $Yij=0$ if $Uij<0$. In this formation, Y is a dichotomous dependent variable taking the value of 1 when the farmer chooses an adaptation option in question and 0 otherwise [17].

According to [18] and [17], the MVP econometric approach that was used for this study is characterized by a set of five binary dependent variables like Improved crop and Crop diversification, using Soil and Water conservation, using Tree planting and Agroforestry, using Irrigation and water harvesting, and using fertilizer such that: $Y^*_{ij}\beta_{j+}\varepsilon_{ij}$

$$(j=Y_1, Y_2, Y_3, Y_4, Y_5,) \quad .... \quad eq4$$

Thus, the econometric approach for this study is by using the indicator function; the unobserved preferences in Eq. (4) translate into the observed binary outcome equation for each choice as follow

$$Y_{ij}=\begin{cases} 1 \text{ if } & Y^*_{ij} >0 \\ 0\,, & Otherwise \end{cases} \qquad (j=Y_1, Y_2, Y_3, Y_4, Y_5,) \quad .... \quad eq5$$

Where Y_1 = Improved crop and Crop diversification, Y_2 = Soil and Water conservation, Y_2 = Tree planting and Agroforestry, Y_4 = Irrigation and water harvesting, and Y_5 = using organic Fertilizer, X is a vector of explanatory variables, β_1 $\beta_2,.....\beta_5,$ are conformable parameter vectors, and random error terms ε_1 $\varepsilon_2,.....\varepsilon_5$ are distributed as multivariate normal distribution with zero means, unitary variance and an contemporaneous correlation matrix $R=[\rho_{ij}]$, with density $\emptyset\,(\varepsilon_1,\varepsilon_2,.....\varepsilon_5;R)$. The likelihood contribution for an observation is the 5-variate standard normal probability:

$$Pr(y_1,y_2,..\beta y_5 x)=\int_{-\infty}^{(2y_1-1)x'\beta_1}\int_{-\infty}^{(2y_2-1)x'\beta_2} .... \int_{-\infty}^{(2y_5-1)x'\beta_5} \emptyset\,(\varepsilon_1,\varepsilon_2,...$$

$$...\varepsilon_5,; \; ZRZ) \; d\varepsilon_5...d\varepsilon_2 \; d\varepsilon_1$$

Where Z=diag

$$[2y_1 - 1,.....2y_2 -1] \quad .... \quad eq6$$

The maximum likelihood estimation maximizes the sample likelihood function, which is a product of probabilities across sample observations as shown above [17].

2.7. Model Specification and test

Variance Inflation Factor (VIF) was checked for the existence of multicollinearity between all the explanatory variables included in the model using SPSS - version 26.

2.8. Basic definition of dependent and explanatory variables

Dependent variables: The dependent variables of the present study were the adaptation options that the farmers employ in response to climate change. The most common adaptation methods cited in the literature include different crop varieties, mixed crop and livestock farming, soil conservation, tree planting, changing planting dates, diversifying from farm to nonfarm activity, and irrigation [10]. Based on the literature and the researcher's knowledge in the area, the study uses the following adaptation strategies improved crop and crop varieties, tree planting, soil and water conservation, irrigation, and no adaptation.

Improved crop and Crop diversification (Y1): This implies planting of duration crop; and drought-tolerant crops and farmers could change the date of planting crops concerning the change in the climate (early or late planting) that survive in adverse atmospheric conditions [19].

Soil and Water Conservation (Y2): Include soil erosion preservation, management and care of the soil to make it suitable for their crops, dam construction, conservation of rainwater for watering the crops in times of deficient rain, groundwater harvesting, and ago forestry [19].

Tree planting and agroforestry (Y3): planting trees for shading, fuel woods, construction, fruit, preventing erosion, carbon sink, and economic purpose.

Irrigation and water harvesting (Y4): Includes irrigation development from rivers or lakes and dams to cope with the challenges of climate change [19]. It involves the adoption of farmers to build water, harvesting schemes such as traditional hand-dug or shallow open wells for the abstraction of groundwater for irrigation, and diversion, and pumping of spring water to practice irrigation. Solomon et al. [20] identified the use of irrigation as one strategy for climate change adaptation

Use of organic fertilizer (Y5): including animal manure, mulching, green manure, and waste materials (compost) that enhance/ improve soil fertility and increase productivity as well as production and this is also important to reduce soil erosion and climate change impacts.

Explanatory variables: The independent variables were the factors that affect the choice of adaptation methods to climate change. Different literature was reviewed on the factors that affect farmers' choice of adaptation method to climate change. The majority of them have been focused on household characteristics, farm characteristics, institutional factors, and environmental factors. Accordingly, the researcher conceded the following as exogenous variables i.e., factors that influence farmers' choice of adaptation strategies to climate change.

Age of the household head (AGE): This is a Categorical variable, and this variable was predicted to possess a positive sign. Obayelu et al. [21] stated that age will influence farmers' efforts to adapt to climate change. The variable was hypothesized to have either a positive or a negative effect on the choice of adaptation strategy.

Gender of the household head (SEX): Gender is a dummy variable that indicates zero if the male household head and one otherwise. The expected sign of this variable was indeterminate. Hassan&Nhemacjena [22] reported that female-headed households are more likely to take up climate change adaptation methods.

Education level of the household head (EDU): Education level increases farmer's ability to induce process and use information and increases farmers' willingness to adopt a new technology. According to Addisu et al. [23] education improves the level of understanding about climate change adaptation which increases the likelihood of using drought-tolerant varieties. Therefore, it was hypothesized that education influences adaptation strategies positively.

Farming experience (FAREX): it is a continuous variable, and it is assumed that farmers who have more farming experience can adopt agricultural adaptations earlier than farmers with shorter farming experience can. Thus, farmers with longer farming experience are expected to be more knowledgeable and skillful. Hassan&Nhemacjena [22] reported that more farming experience increases the probability of a farmer adapting to climate change. Therefore, this variable was assumed to positively influence adaptation.

Household size (HHS): it is a continuous variable. Household size is the total number of family members in the household. A sizable amount of family members can adapt to the effects of climate change easily [24]. Research done by Abid et al.[25] also revealed that the increase in family size increases the likelihood of using SWC practice and agro-forestry. Therefore, it is expected that household size was a positive sign for the farmers' who will be using adaptation methods to climate change.

Farm income (FARM): farm income is an income return to the household from farming activities. This will be measured in the form of Ethiopian Birr. Deressa et al.[10] asserted that as farm income increases the probability of adopting irrigation, adjusting planting dates, and using drought-tolerant varieties increases. This is a continuous variable and is expected a positive sign for the farmers who used adaptation methods to climate change.

Access to credit service (CREDIT): The availability of credit is important for the farmers to make adaptation strategies. Credit can be used for the farmers to introduce new technology, to buy modern crops, fertilizers, and oxen. The study by Nhemacjena&Hassan [17] demonstrated that access to credit improves the probability of adopting irrigation, adjusting planting dates, using different crop varieties, and SWC practices in response to climate change. Therefore, thus was expected a positive sign for the farmers' who used the adaptation method to climate change and is a dummy variable indicating 1 if the farmers have access to credit and 0 otherwise.

Agricultural extension service (AGRIEXS): This is a formal service and plays a great role that affecting farmers to adopt strategies in response to climate change. Deressa et al. [10] disclosed that extension contact enhances the likelihood of using irrigation, SWC practices, planting trees, and improved variety in response to climate change. The expected sign was a positive.

Farmer-to-farmer extension service (FFEXTS): This variable is a dummy variable that indicates one if the farmer has available farm-to-farm extension service zero otherwise. It serves as a source of information and exchange and sharing of experience among farmers. Deressa et al. [10] found that access to farmer-to-farmers" extension services positively affected adjusting planting date, planting trees, using improved variety, SWC practices, and irrigation in response to climate change. This variable is a dummy variable that indicates 1 if the farmer has available farm-to-farm extension service and 0 otherwise. The expected sign was a positive

Farm size (FARMSZ): - The farm household withholding big farmland has more to use adopted and the farm size is measured in terms of hectares. Tesfoye&Seifu [26] also found that large landholding increases the use of SWC practice. Therefore, the variable is continuous, and it was expected a positive sign for

Table 2. Summary of explanatory variable descriptions

Variable Code	Type	Description	Value	Expected sign
AGE	Categorical	Age of HH head	1= 20-40, 2, 41-60, 3,>60	±
DMKT	Continuous	Market distance	Kilometer	-
SEX	Dummy	Sex of HH Head	1 if male 0 female	±
CREDIT	Dummy	Access to Credit	1 = yes, 2 = No	±
CLIMINFOR	Dummy	Access to climate	1 = yes, 2 = No	+
DFARM	Continuous	Distance from home to farm	Kilometer	-
EDU	Categorical	Educational Level of HH	0 for illiterate,1= read and write, 2=primary school,3 secondary and above	+
FARM	Continuous	Farmer's income	ETB	+
TLU	Continuous	Livestock holding	Tropical-Livestock-Unit	±
AGRIEXS	Dummy	Extension contacts	1=yes, 2= No	+
FARMSZ	Continuous	The area of farmer farm	Hectare	±
HHS	Continuous	Farm size of household	Years	+
FFEXTS	Dummy	Farmers to contact	1, yes 0 no	+
FAREX	Continuous	Year of farmer experience	Years	+

the farmers' who will be using adaptation methods to climate change.

Livestock holding (TLU): - Livestock is a vital instrument in the case of climatic change to adopt. This is because livestock is essential for farm households to use as for harvesting, transportation and also for financial purposes by selling them. This implies that farmers with more numbers of livestock is the richer and can respond to the adverse impact of climate change through adaptation method. Belay et al. [13] revealed that owning large number of livestock in tropical livestock unit increases farmers" likelihood of planting trees, adjusting planting dates, and use of SWC practices. This is a continuous variable and is expected a positive sign for the farmers' who will be using adaptation method to climate change.

Distance from home to the farm (DFARM): This variable is a continuous variable represented by walking time (in minutes) from farmers' residence/home to their farming place. This value also expected that the farmer whose farm is far from his residence is less likely to continuously follow up on his farm as compared to those whose farm is nearer to their home. Thus, it is expected that farmers who live near their farms are likely to have regular follow-up of their farms, hence motivated to respond to the impact of climate change on their agricultural activities. According to Gizaw et al. [27] distance from home to farm decreases the probability of using improved variety and agroforestry. Therefore, it was expected to negatively affect choice of adaptation strategy.

Distance to the market (DMKT): - This is a continuous variable that measures in terms of time spent from the residence of farm households to the market area. The residences of farmers are nearest to the market they get many opportunities as compared to the far ones. Because the nearest one obtains agricultural inputs, information, and experiences. According to Addisu et al. [23] that distances to the market negatively affected the use of irrigation. Therefore, this variable was expected a negative sign for the farmers' who will be using adaptation methods to climate change.

Access to climate information (CLIMINFOR): This is a dummy variable indicating 1 if the household head has access to climate change and 0 otherwise. Belay et al. [13] also revealed that the use of SWC practices, adjusting planting dates, and planting trees in response to climate change is enhanced by access to climate information. This variable a positive sign for the farmers' who will be using adaptation methods to climate change.

3. Results

3.1. Descriptive summary of a categorical variable

The majority (68%) of respondents were aged 41-60, while 31% were aged 20-40, and 1% were over 60. In both agro ecological zones, most respondents aged 41-60 were in the active labor force. Specifically, 20% of those aged 20-40, 71% of those aged 41-60, and 5.6% of those over 60 lived in the Kola, Woyna Dega, and Dega agro-climatic zones, respectively. The results showed that there is no statistically significant association between respondents' ages and agro ecological zones at the $p<0.01$ level.

Most respondents, 188 (87.0%), were male-headed households, while 28 (13.0%) were female-headed. Results show that 86.1% of male-headed households were in highland (Dega) zones, whereas 14.3% of female-headed households were in lowland (Kola) zones. A results show that there is a statistically significant association between respondents' gender and agro-climatic zones at $p<0.01$ (Table 2). Similarly, Minwuye [28] found significant gender differences between agro ecological zones using $\chi 2$ and t-tests.

Most respondents (80.6%) were illiterate, while 17.6% could read and write, and 1.5% had attended primary school, with no secondary education represented. Cross-tabulation by agro-climatic zone showed that 85.7% of illiterate household heads were in the Kola zone, whereas 5.6% of literate heads were in the highland zone. A chi-square test indicated a significant association between education status and agro-climatic zones at the $p<0.05$ level. Most respondents (88.5%) were married, 3.2% were divorced or widowed, and 5.1% were single. Additionally, 78.7% of respondents used extension services, while 21.3% did not. Most extension service users (50.5%) and non-users (16.2%) were in the Dega and Woyna Dega agro-climatic zones, respectively. A chi-square test indicated a significant association between extension service use and agro-climatic zones at the $p<0.01$ level. This aligns with Ojo&Baiyegunhi [29] who found that access to extension services significantly influences farmers' decisions to participate.

Similarly, the study questions the respondents about the accessibility of weather information to the farmers. Over two-thirds (69.4%) of the respondents had access to weather information, according to the assessment, while the remaining samples (30.6%) said that they were unable to obtain the information. Many of the accessible respondents (88.9%) are found in a Dega agroclimatic, while the remaining 85.5% and 72.4% are found in Kolla and Woyna agroclimatics, respectively, according to the poll, which shows that weather information is available in practically all agro-ecologies. The respondents with access to weather information, as well as those without, are found across all three agroecological zones. However, most of the respondents are taken from the Woyna dega agro-climatic zones (26.9%) and the other 14.3% and 11.1% of them are found in Kola and Dega agro climates, respectively.

As a result shows the accessibility of weather information and the existence of the diverse agro climate as Kola, Woyna dega, and Dega areas in the same livelihood source has a significant association at P<0.01 probability level. A study of Deressa et al.[10] underlined that access to extension and weather information is indispensable to making the right decision to adapt to climate change and variability. Therefore, the chi-square test result is consistent with previous studies

3.1.2. Descriptive summery of continuous variables

The survey findings indicated that the average household size among the respondents was 5.11. Furthermore, when examining the data based on different agro-climatic zones, it was observed that the average household size in the lowland zone was 4.7, while in the Woyna Dega and Dega zones, it was 5.2 and 5.22, respectively. This suggests that the average household size in the lowland zone was smaller compared to the overall observation, whereas in the Woyna Dega and Dega zones, it was larger. An F-test was conducted to assess the differences in average household size among the agro-climatic zones, and the results confirmed that these differences were statistically significant at a significance level of p<0.01. This finding aligns with the conclusion reached by Deressa et al. [10] which states that a larger household size significantly enhances households' capacity and options to cope with climate change.

The study also calculates the average land holding of the respondents. It is estimated to be an average of 1.2 hectare in the study area. It shows there are much higher (1.32 hectare) and much lower (0.95 hectare) land holding than the average (1.23 hectare) in the lowland and mid land agro ecologies respectively. Kola ecological zone has higher in small land holding size of the household followed by Woyna Dega household and the high land holding size is highest in Dega agro ecological zone. Furthermore, the applications F- test with the three groups of agro-climatic showed there are highly significant mean differences in farm size of the households in between Kola, Woyna Dega and Dega agro-climatic agro ecologies at P< 0.01 probability level This result is parallel with previous study [28].

The average agricultural experience of the selected households was 74.4, according to the survey results. According to the current study, the average farm experience of the Kola, Woyna Dega, and Dega agro-climatic zones was 25.1, 22.7, and 26.9, respectively. This revealed that the Dega agro-climatic zones average agricultural experience was greater than the other two agro-climatic zone. Furthermore, the Woyna Dega agro-climatic was less typical agricultural experience than the kola kebele. According to Hassan&Nhemachena [22] more farming experi-

Table 3. Characteristics of categorical variables of sample respondents

Variables		Kola	Woyna dega			Dega				
		Freq	%	Freq	%	Freq	%	Total (%)	P-value	X2
Age	20-40	14	40.0	62	42.8	10	27.8	36.9	0.46ns	4.79
	41-60	21	60.0	80	55.2	24	66.7	60.6		
	>60	0	0.0	3	8.0	2	5.6	4.5		
Sex	Female	5	14.3	38	17.6	5	13.5	13.3	0.00***	6.05
	Male	30	85.7	6	2.8	31	86.1	88.7		
Educational status	Illiterate	30	85.7	119	82.3	28	77.7	81.9		
	Read & write	5	14.3	25	17.2	6	16.7	17.6		
	Primary school	0	0.0	1	0.7	2	5.6	1.9	0.00***	8.73
	Secondary school	0	0	0.0	0.0	0	0.0	0.0		
Marital status	Single	2	0.9	4	1.9	11	5.1	7.9		
	Married	53	24.5	34	15.7	98	45.4	85.6		
	Divorced	1	0.5	4	1.9	2	0.9	3.2	0.00***	16.01
	Widowed	1	0.5	2	0.9	4	1.9	3.2		
Extension service	No	8	23.9	46	31.7	13	36.1	30.6	0.01***	5.29
	Yes	27	77.1	98	67.6	23	63.9	69.4		
Access to weather information	No Yes	5 30	14.3 85.8	39 105	26.9 72.4	4 32	11.1 88.9	17.6 82.4	0.00***	5.68

*Note: *** refers to significant at p<0.01, ns= non-significant* ence enhances the likelihood of a farmer adjusting to climate change.

The present study revealed that the average on farm income of the respondents is 58, 381.35 Birr. The study found that the lowland agro-climatic had the highest on farm income (92,663 Birr) and the Woyna Dega agro-climatic had the lowest on farm income (17,063.10 Birr), while the Dega agro-climatic farmers had an average on farm income of 57,198.30 Birr. Similarly, the study found that the Kola agro-climatic ecology has the greatest on-farm income earning of 10,047 Birr and the maximum earning of 3,838.00 Birr, with an average earning of 9,273.00 Birr in the Woyna Dega region.

Hence, the table shows there are a lower on farm income than the average in the midland and in the Dega agro-climatic. Additionally, the F-test checked the existence of a highly significant mean difference in the three dis aggregated groups of agro-climatic for on farm income earnings in Semen Bench district households at P< 0.01 probability level. Studies in Ethiopia by (30) show that an increase in farm income increases the financial capacity of rural households to adopt climate change and variability strategies. Therefore, the F-test result of this study was similar with the findings of previous studies.

Table 5. Variance Inflation Factor (VIF) for continuous variable

Variable	VIF	1/VIF
AGEHH	1.80	0.56
EDULHH	1.51	0.66
HHS	1.18	0.84
FAMSHH	1.33	0.75
FINCOM	1.19	0.84
TLU	1.10	0.91
DFARM	1.31	0.77

Mean VIF 1.35

Table 4. Characteristics of continuous variables of sample respondents

Variables	Kola	Woyna Dega	Dega	Total	F-value	P-value
Household size	4.7	5.2	5.2	5.11	7.69	0.000***
Farm size	0.95	1.23	1.32	1.20	52.3	0.000***
Farm Experience	25.16	22.69	26.89	74.73	43.2	0.967ns
Farm income	92663	17063.10	57198.30	58381.35	19.38	0.001***

**** refers to significant at p<0.01, respectively*

3.2. Determinants of smallholder Farmer's Adaptation Strategies to climate change in the study area

Model Specification and Test

Before estimating the multinomial probit model, it was important to look for outliers and determine whether the explanatory variables under consideration were multicollinear. The reason for this is that multicollinearity has a significant impact on parameter estimates. If multicollinearity is shown to be significant, the presence of both variables at the same time will either weaken or strengthen their respective impacts. In summary, the coefficients of variable interaction indicate whether or not one of the two linked variables should be removed from model analysis [31].

Thus, before estimating the model's parameters, regression diagnostics were performed to ensure that the regression assumption was met. The Variance Inflation Factor (VIF) was examined for the presence of multicollinearity among all explanatory variables included in the model and was determined using SPSS – version 26. The variance inflation factor for all explanatory variables was less than 10, indicating that multicollinearity is not a major issue in the model (Table 5).

Furthermore, there was interaction between dummy variables, which may contribute to multicollinearity. To detect this issue, coefficients of contingency were calculated from survey data. The contingency coefficients (CC) were calculated using SPSS version 26, and the results indicated that there was no strong link between the various discrete explanatory variables, as the respective coefficients were very low (less than 0.75) (Table 6).

Table 6. Contingency Coefficients (CC) for Dummy Variables

Variable	Contingency Coefficient (CC)
SEXHH	0.2
CRAHH	0.16
CLIMINF	0.15
AEXCHH	0.1
FFEXTS	0.04

Correlation coefficients

According our finding, farmers utilized various climate change adaptation practices such as soil and water conservation, crop diversification, improved crop variety, planting trees and agroforestry, organic fertilizer, and irrigation. The success rate of farmers in implementing adaptation strategies was approximately 8.2%, while the failure rate was around 0.042% (Table 7). Adaptation measures protect farmers from losses caused by temperature and rainfall changes.

The correlation coefficients of the error terms for each pair of equations should be significant to employ the MVP model. At the 5% significance level, the likelihood ratio test of Rhoij = 0 is significant, suggesting that at least one pair of adaptation tech-

Table 7. Correlation matrix of adaptation strategies from the MVP model

	Tree planting and agroforestry	Improved crop and crops diversified	SWC practices	Irrigation and-water harvesting	Organic fertilizer
	Coef.	Coef.	Coef.	Coef.	Coef.
	(Std. error)	(Std. error)	(Std. error)	(Std. error)	(Std. error)
Rho1	1.000				
Rho2	0.0505*	1.000			
	(0.4606)				
Rho3	0.0551*	0.0332**	1.000		
	(0.4207)	(0.6280)			
Rho4	0.0563*	0.0580*	(0.0372*	1.000	
	(0.3396)	(0.3961)	(0.1547)		
Rho5	0.0431**	0.1092	-0.0203**	0.0000***	1.000
	(0.5284)	(0.1094)	(0.7664)	(1.000)	
Predicted probability	0.541	0.389	0.478	0.634	0.596
Joint probability success					0.082
Joint probability failure					0.00042

*Likelihood ratio test of rho21 = rho31 = rho41 = rho51 = rho32 = rho42 = rho52 = rho43 = rho53 = rho54 = 0 chi2(10) = 19.710**
****, **and*significant at 1%, 5% and 10% probability respectively.*

niques has a correlation coefficient that is statistically different from zero.

As a result, the five combinations' correlation coefficients are statistically different from zero, indicating that the MVP model specification is suitable and that the solutions for adapting to climate change are mutually inclusive (Table 7). This indicates that the various adaptation strategies employed by farmers have complementarities (positive correlations) and substitutability (negative correlations). The many options for adaptation are interdependent. Planting trees and improved crops, agroforestry and the use of organic fertilizer, agroforestry and irrigation, and the use of improved crops and irrigation all have a positive link (complementarity). This suggests that several adaptation option combinations can be applied simultaneously. Additionally, these combinations can support one another. Additionally, there is a negative association (substitutability) between organic fertilizer and SWC practice utilization.

Table 8. Multivariate probit results of farmers' climate change adaptation decisions

	Climate change adaptation strategy									
Variables	Tree planting and Agroforestry		Improved crop and crop diversification		SWC practices		Irrigation and water harvesting		Organic fertilizer	
	Coef.	p>z	Coef.	p>z	Coef.	p>z	Coef.	p>z	Coef.	p>z
SEXHH	-.432	0.046**	.686	0.000***	-.091	0.673	-.025	0.903	-.229	0.310
AGEHH	-.0158	0.099*	-.011	0.259	-.001	0.919	-.018	0. 053*	-.009	0.395
EDULHH	-.0173	0.919	.344	0.056*	.348	0.033**	-.002	0.991	-.031	0.866
HHS	.0420	0.337	-.0145	0.723	.091	0.043**	.056	0.191	.083	0.081*
FAMSHH	.0150	0.092*	.177	0.214	.210	0.173	.242	0.001**	.148	0.311
FINCOM	-.182	0.277	.075	0.062*	.295	0.049 **	.212	0.161	.340	0.030**
TLU	.0986	0.074*	.051	0.277	.0249	0.626	.098	0.055*	.109	0.034**
CRAHH	.152	0.496	.389	0.077*	.212	0.345	.491	0.019**	.340	0.030**
AEXCHH	.167	0.054*	.535	0.025**	.034	0.089*	.257	0.321	.001	0.996
FFEXTS	.340	0.132	.082	0.044**	. 097	0.042**	.249	0.254	.319	0.185
CLIMINF	.004	0.984	.331	0.104	.320	0.015**	.478	0.034**	.200	0.375
DFARM	-.365	0.094*	.118	0.581	-.426	0.061*	.141	0.509	.317	0.195
FAEXP	.0029	0.662	.0199	0.011**	.003	0.656	.003	0.585	.013	0.046**
_cons	.424	0.634	1.128	0.168	0.209	0.014	.964	0.249	.868	0.336

Number of Observations 216
Log-likelihood -546.344
Wald chi2(70) 107.25
*Prob.> chi2 0.000****
****, **and*significant at 1%, 5% and 10% probability respectively*

3.2.1. Determinants of Farmers' Choice of Adaptation Strategies

The MVP results showed that the correlation coefficients of error terms are statistically significant at a 1% significance level, indicating that climate change adaptation strategies were complementary. Table (8) displayed the MVP model estimation results as well as the levels of statistical significance of the components.

At a 1% significance level, the Wald χ2(70) and p < 0.000 are statistically significant, indicating that the model's subset of coefficients is jointly significant and that the explanatory power of the factors included in the model is satisfactory; thus, the MVP model fits the data reasonably well. Similarly, the model is significant because the null hypothesis that the five-climate change adaptation strategy choice decision is independent was rejected at the 1% significant level. The findings suggested that diverse household and institutional variables influenced their choice significantly.

Sex of the household head: Sex of the household head affects the choice of climate change adaptation strategies, where the sex head of the household was positively associated with the probability of choosing improved crop and crop diversification and negative influence on the use of tree planting and agroforestry practice to adapt climate change generating strategy at less than 1% and 5% level of significance respectively. It indicates that males are more highly engaged in farm activities than females and have better farm experience and information in the study area. It also implied that males are more likely to use improved crop and crop diversification practices than females while females are more likely to adopt home garden agroforestry practices than males to adapt to climate change.

The reason behind that home garden agroforestry practices are generally undertaken near home and women are more readily responsible. The other reason is that they invest more time in domestic roles such as childcare, cooking, washing cloth, gathering firewood, and fetching water with high participation in low economic value and time-consuming agricultural activities like weeding and harvesting, so account for this women are less likely to use improved crop and crop diversification than male. This finding aligns with the research conducted by Abraham et al. [32] that women have less access to different farm activities due to different factors such as culture, energy, and lack of raw materials in this case they have little bit of contribution to agricultural work, whereas males are more likely to plant diversified crops and adjust planting date to adapt to climate change.

Age of the household head: The result of the MVP model showed that the age of the household head was negative significant with the probability of choosing tree planting and agroforestry and irrigation and water harvesting as an adaptation strategy to climate change both at a 10% level of significance. It implies that young household heads were more perform and participated in climate change adaptation strategies. Due to the reason of young household heads were more energetic, closest to information technology, and could afford to take the risks associated with climate change adaptation strategies. In supporting this Onubuogu et al. [33] also confirmed that younger farmers are more inclined to actively seek out new technologies and information, thereby they apply different climate change and variability adaptation strategies.

In contrary to this finding, the study by Atinkut&Mebrat [34] shows that the age of the respondents had a positive and statistically significant relation with climate change adaptation strategies. This implies that old-aged household heads apply different climate change and variability adaptation strategies more than those young-aged household heads because old-aged household heads confront an active labor force to apply and manage different adaptation strategies. This reflects that old-aged household heads most of time come up with their previous knowledge and they are not keen to adopt new and most recent demonstrate.

Education levels of the household head: The result of the MVP model showed that the education level of the household head was found to be significantly and positively related to using improved crops and diversified crops and SWC practice. This indicates that those farmers who have more educational levels were more likely to adapt to climate change using SWC and improved crops and diversified crops by acquiring high self-employment activities than those do have lower educational levels. The reason is that the household head who attends education can more likely choose climate change adaptation strategies as education equips them with more skills and knowledge about different drought-resistant and pest and diseases-resistant crops and SWC practices activities.

This result was consistence with the finding of (20) who found that the highest level of education in the household head was more likely to understanding climate change adaptation strategy, so the likelihood of using drought tolerant and short-season variety crops increases. A study by Abraham et al. [32] also confirmed that education has a positive significance on the use of SWC practices because it is likely to increase farmers' ability to receive, understand, and gather information important to make innovative and investigative decisions in the farms. Moreover, the educational level of the household head increases the knowledge of smallholder farmers about the adverse effects of climate change and climate change adaptation strategies [35].

Household size: The households that have large family sizes have a probability of choosing farm SWC practices and use of organic fertilizer as climate adaptation strategy less than 5% and 10% significance levels respectively. This indicated that when family size increases the household labor increases proportionally. This also leads that a higher demand for special needs in the household which implies that an additional member to the household increases the probability to participate in climate change adaptation i.e., SWC practice and use of organic fertilizers as climate change adaptation activities in order to meet basic needs to the family. The reason for this trend is that larger family sizes provide more labor resources, which can be utilized to carry out adaptation practices. This, in turn, reduces the labor costs associated with implementing these practices.

The result strongly agrees with Onubuogu et al. [33] that farmers with larger family sizes are more likely to adopt soil and water conservation practices and use organic fertilizer than farmers having small family sizes. This finding contradicts the research conducted by Obayelu et al [20] who found that farmers with larger family sizes might allocate some of their labor to non-farm economic activities to generate additional income.

Landholding size: The MVP model revealed that the farm size of the household was found to be significant and positively related to the use of tree planting and agro-forestry and irrigation and water harvesting. This implies that households who have more hectares of land are more likely to join agroforestry and tree-planting activities and irrigation. As a result, those farmers who have relatively larger areas of farm size tend to involve more in farming activities than those households who have smaller areas of land to cultivate. The reason is that households that have large farm size enable the farmer to adopt different tree planting and agro-forestry and irrigation and water harvesting activities. According to the focus group discussions, the other reason is that farmers with very limited land area cannot use agro-forestry. It is primarily because they generate consumer goods on their farms. Furthermore, farms of some households with limited landholdings are less well suited for the use of irrigation and agroforestry practices.

This result agrees with the study of Nhemachena&Hassan [17] who noted an increase in landholding increases the likelihood of applying irrigation in response to climate change. The findings of Marie et al. [3] also found that farmers who have a large farm size are more likely to apply any adaptation decisions because they have the resources to implement new agricultural technology. The findings of this study are also confirmed by Pello et al. [36] who reported that an increase in farmers' farm size led to a rise in the adoption of AF among contact farmers.

This finding contradicts the previous research conducted by Amare&Simane [37] who found that farmers with large farms were more inclined to take on the risk of climate change and invest in adaptation practices. The researchers suggested that farmers with large plots of land may have more confidence in their ability to handle the impacts of climate change and therefore may not worry as much about implementing adaptation practices. It is also contrary to Shiferaw [30] that large landholding size decreases the use of irrigation while it is similar with the same author regarding the positive effect of landholding size on the use of agro-forestry in response to climate change.

Farm income: Farm income has a positive and significant influence on the likelihood of choosing improved crops and crop diversification, SWC practices, and use of organic fertilizers at less than 10%, 5%, and 5% levels of significance respectively. This result implies that households having large farm incomes are more likely to diversify the use of their adaptation strategy to climate change. This result showed that those farmers with low farm income are less likely to participate in adaptation strategies for climate change. Those farmers who have adequate farm income can overcome financial constraints to engage in alternative adaptation strategy activities. On the other hand, on-farm income strengthens the financial capacity of smallholder farmers to adopt climate change adaptation strategies by investing more money in technology procurement and implementation.

Additionally, farmers that have better farm income have more chance to adopt climate change adaptation strategies than farmers with less income. Farm income enables the farmer to perceive and adapt to climate change by devoting more money for the purchase of seeds and seedlings whenever rain comes, buying a drought tolerant variety and apparatus for the use of SWC practice and irrigation at a higher price. Contentedly, Deressa et al. [10] support a result who confirmed that as farm income increases the probability of choosing improved crops and crop diversification, SWC practices, and use of inorganic fertilizers increases. The findings of Marie et al. [3] revealed that a unit increase in total annual farm income increased farmers' probability to adopt a climate change adaptation strategy by a factor of one.

Livestock ownership: Ownership of livestock was statistically significant and positively influenced the probability of choosing agroforestry, irrigation, and use of organic fertilizers to adapt to climate changes less at 10%, 10%, and 5% levels of significance respectively. This implies that households that have a greater number of livestock in tropical livestock units are more likely to adapt to climate change. The reason behind this is that households that have a greater number of livestock enable them to earn more income from livestock production, therefore, they highly participate in climate change adaptation activities, this also can be attributed to the fact that farmers who own large livestock can invest their income from livestock into purchasing agroforestry materials, irrigation facilities, animal manure and agricultural inputs. This is consistent with the study of Abraham et al. [32] who reported that households with more livestock holding can participate in climate change adaptation activities putting them in a better position than those households with a small size of livestock hold.

Access to credit: Access to credit was statistically significant and had a positive effect on choosing improved crops, irrigation, and organic fertilizer as an adaptation strategy to climate change at less than 10%, 5%, and 5% levels of significance respectively. Farmers who have credit accessibility were more likely to adopt those climate change adaptation strategies. Also, this indicated that affordable credit increases the financial resources of farmers and their ability to meet transaction costs associated with various adaptation options they might want to take. It enables farmers to change their management practices in response to changing climatic factors and to buy drought-tolerant varieties of crops, irrigation technologies like water pumps, and other inputs to smoothen production and reduce the negative impact of climate change.

This finding is aligned with Gadedjisso-Tossow et al. [38] study which indicates that farmers who have access to credit are more inclined to embrace the cultivation of short-season varieties. It is also consistent with the work of Nhemachena&Hassan [17] who strongly advocated the positive effect of access to credit on the probability of adopting irrigation, use of fertilizer, and using different crop varieties in response to climate change by strengthening their financial capacity.

Extension visits: The model results show that access to extension service had positive and statistical associations on choosing agroforestry, improved crop, and SWC practices at less than 10%, 5%, and 10% significance levels respectively. This entails that having extension service access increases the probability of adopting climate change adaptation strategies. The reason is that the extension service provides the necessary information so that farmers are able to acquire new skills and knowledge that help to adapt different adaptation strategies to improve their living standards and to improve climate-smart. In this case extension service users could adopt climate change adaptation strategies, and have the better technical skills to manipulate improved technologies and the opportunity cost of not adopting climate change adaptation strategies.

In addition to this, extension service providers give training for farm households about climate change, its effect on farm production and productivity, possible measures to cope with clime change adverse effects, and the advantages of climate change adaptation strategies that would increase their awareness of adaptation strategies. Therefore, extension service acts as a bridge to fill the gap in farm households' perception of climate change and its effect on farm production and productivity and remedial measures.

In line with this as discussed by Pello et al. [36] access to extension services increases farmers' knowledge of climate change adaptation strategies through field visits, experience sharing, and practical application of best practices. This implies that extension service users have a higher probability of adopting climate change adaptation strategies than extension service non-users. This finding contradicts other studies, such as the one conducted by Tesfaye&Seifu [26] which suggested that farmers who have contact with extension services and cultivate different crops are more likely to prioritize profitability over climate change risk adaptation practices.

Farmer-to-Farmer extension: Farmer-to-farmer extension has a statically significant and positive influence on choosing improved crops and SWC practice both at less than 5% of significant level. This indicates that farmers who have access to farm-to-farm extension services were more likely to adapt to climate change through improved crop and diversification crops and SWC practices. The reason is that farmers have a high chance to meet and communicate with their friends that have to enables them to share experiences about and collectively apply SWC practices. Further, it serves as a source of information and experience sharing among the farmers about the selection of improved and diversified crops and SWC practices. This result is supported by Deressa et al. [10] who found that accessibility to farmers-to-farmers extension services has positively influenced improved crop and SWC practices in response to climate change.

Access to climate information: Access to weather information had positive and statistical affected using improved crop and SWC practices both at p<0.05 significance level. This implies that access to weather and climate information is crucial to easily introduce and implement climate change adaptation strategies. The reason is farmers who have access to climate-related information from different media like newspapers, manganese radio, and television are more likely to use improved crop varieties and SWC practices as an adaptation strategy in response to climate change. This awareness poses a question of how to respond adverse effects of climate change. Most likely, the reason is that access to climate information permits one to perceive the change and choose appropriate strategies in response to climate change. Therefore, weather and climate information users have a better understanding of climate change and its effect on crop and livestock production and productivity.

Farmers who have access to up-to-date climate information are more likely to be motivated and make informed decisions to adopt adaptation practices to mitigate the risks associated with climate change, compared to farmers who do not have access to such information. [39] that confirmed access to climate information increases the use of irrigation supported this finding. From the focus group discussion, radio is the major source from which farmers obtain climate-related information. It is also supported by Destaw&Fenta [40] that access to climate information improves rural households' awareness and knowledge of the climate and variability besides the role of adaptation measures.

The average distance from home to the farm: The average distance of the farm from farmers' homes was statistically significant and negatively influenced by the use of agroforestry and SWC practices, both at less than 10% of the significant level. This implies that since the farm of the farmer is located far from her or his house, he or she is less likely to use agroforestry and SWC practices as an adaptation option to climate change. The reason is that farmers whose farms are far from their homes cannot frequently follow up on their farms as compared to those whose farms are nearer to their homes. In support of this, a study by Geremew et al. [41] found that agroforestry practices need due management and more follow-up. Therefore, those farmers whose farm is on average far from their home are less likely to use agroforestry as an adaptation strategy because they cannot easily manage these investments.

Farmer experience: The MVP result indicated that farming experience has positive and significant effects on improved crops and diversified crops, and the use of organic fertilizer by farmers with much farming experience can increase the probability of using adaptation strategies. This indicated that farmers who had more farming experience were more likely to adapt to climate change. The reason is that farming experience increases, farmers' ability to understand the climate and weather conditions, crop types, and the value of organic materials like manure and compost. This result agrees with the result of [42] and [43], who stated that an increase in farming experience is more likely to adapt to climate strategy than lower farming experience.

Conclusion

Cross-sectional data obtained from five kebeles in the Semen Bench Districts was used to analyze climate trend analysis and farmers' adaption techniques to climate change. The core data for this study was acquired using structured and semi-structured questionnaires from 216 randomly selected sample households. The data collected were analyzed using descriptive statistics and a multivariate probit model, which was employed to the parameters of the explanatory variables expected to determine farmer's choice of adaptation strategies to climate change.

The present study revealed that there are five major adaptation strategies: SWC, using improved and diversified crops, using tree planting and agroforestry, using irrigation, and using organic fertilizers. An MVP was estimated to identify the explanatory variables that affect the farmer's choice of climate change adaptation strategies. The choice of adaptation strategy by farmers has also been affected by different factors. Accordingly, the result of the MVP model verified that sex of the household head, age of the household head, education level of the household head, household size, farm size, farm income, tropical livestock ownership, access to credit, extension visit, farmer-to-farmer extension, access to climate information, farmer experience, and the average distance from home to the farm are statistically significant determinants of farmers choice of adaptation strategies.

Age, farm size, tropical livestock units, and agricultural extension service all had a positive impact on agroforestry practice, but the average distance from home to farm and the gender of the household head had a negative impact. Sex, education level, farm income, access to credit, farmer experience, extension services, and farm-to-farm extension services all had a beneficial impact on the usage of enhanced crops and crop diversity. Education level, family size, farm income, extension services, access to climatic information, and farm-to-farm extension services all had a positive impact on SWC practice, while the average distance from home to farm had a negative impact. Finally, age, landholding size, tropical livestock unit, availability of credit, and access to climatic information all had a significant positive impact on irrigation harvesting utilization.

Generally, the result of this study provides applicable information for policymakers and other stakeholders about the perception level of farmers toward climate change. It also identifies the principal choice of adaptation strategies used by farmers that need to best respond to existing climate change.

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