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Drought and consumption impacts of climate-smart-agricultural practices adoption in drought prone area of Eastern Hararghe, Ethiopia

Jafer Mume Ahmed [a,b,*,1], Jema Haji [c], Moti Jaleta [d], Kedir Jemal [c]

[a] *Agricultural EconomicsDepartment, Fadis Agricultural Research Center, Oromia Agricultural Research Institute, Addis Ababa, Ethiopia*
[b] *Africa Center of Excellence for Climate-Smart-Agriculture and Biodiversity Conservation (ACE-Climate-SABC) at Haramaya University, Ethiopia*
[c] *Agricultural Economics and Agribusiness school at Haramaya University, Dire Dawa, Ethiopia*
[d] *International Maize, and Wheat Improvement center (CIMMYT), Sustainable Agri-Food system (SAS) Program, Addis Ababa, Ethiopia*

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ABSTRACT

Annual consumption expenditure of the households is seriously affected by climate shocks in the country where the major livelihood of the community depends on rain-based agriculture. Multinomial endogenous switching regression (MESR) model was applied to analyze factors affecting adoption of climate smart agricultural practices and impact of adoption on consumption expenditure in Eastern Hararghe, Ethiopia. Irrigation, crop diversification and integrated soil fertility management were widely practiced in the study area. From East Hararghe zone four districts were randomly selected. The primary data was collected from 430 sample respondents during 2023 year. Using the rainfall data of 33 years, drought was analyzed by using standard precipitation index (SPI). The model result revealed that education of the family head, family size, livestock, market information, drought experience, climate information and drought significantly influenced the adoption of climate smart agricultural practice (CSAPr). The result showed that, the highest consumption expenditure was obtained when farmers adopted combination of crop diversification and irrigation practices ($F_0D_1I_1$) which is 12610.9ETB. The adopters also obtained 11274ETB when they adopted integrated soil fertility and crop diversification ($F_1D_1I_0$). All adopters obtained higher consumption expenditure per adult as compared to the non-adopters ($F_0D_0I_0$) which is 9434.5ETB. It also showed that, out of total consumption increased by adoption of CSAPr, 72.4 percent of incensement was obtained by adopting practices combination whereas 27.6 percent was by single practices. So, it is very important to advance farmers' information on drought and adoption strategy. The policymakers ought to develop and encourage farmers' asset building plan, adult education, market linkage facilities and extension service and weather information delivery system to enhance adoption of CSAPr practices to combat the current and future drought. Therefore, the study recommends that policies should promote joint adoption of climate smart practices in drought prone area to increase climate change mitigation and consumption expenditure.

1. Introduction

Climate change significantly impacts global agricultural productivity (Okolie et al., 2022). Furthermore, one of the most significant global concerns impacting agricultural products is climate change (Andati et al., 2023). Therefore, adopting the appropriate climate change adaptation was getting more attention to minimize the risk of climate change effect(Schneider and Asch, 2020).Climate shocks such as drought significantly affecting agricultural yields and income that leads to food production losses (Gomez-Zavaglia et al.,2020). Events that surpass society's capacity, such as droughts and floods are termed as climate shocks (Niles and Salerno, 2018) which leads to a loss of household income and reduces consumption expenditure (Dercon et al., 2005; WHO, 2022).Climate shocks can be explained as amount of rainfall deviations from long term normal condition (McKee et al., 1993).Drought is also complex components of climate shocks which can be due to moisture deficit that last from month to decades (WFP and CSSA, 2019). The farm productivity and level of food security of developing countries particularly the Africa is found at lower level compared to world average (FAO, 2020). This is mainly due to the African welfare is susceptible to the severe effects of climate shock (Gezie, 2019; Pieronon et al.,2019) and their major livelihood is depend on rain

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[*] Corresponding author at: Agricultural EconomicsDepartment, Fadis Agricultural Research Center, Oromia Agricultural Research Institute, Addis Ababa, Ethiopia.
E-mail address: mjaafer24@gmail.com (J.M. Ahmed).

[1] https://orcid.org/0009-0002-4188-1193

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fed agriculture(Akrofi-Atitianti et al., 2018; Ngoma et al., 2021; Matata et al., 2023).

Agriculture is the backbone of the economy and most important sectors for rural farmers' labor, poverty reduction and income earning from export item in Ethiopia (FAO Food and Agricultural Organization, 2015; Endashaw et al., 2022). Even if it plays a significant role, Ethiopia's agricultural sector suffers from high levels of climate variability and drought which is increasing from time to time (FDRE, 2019; Conway et al., 2019: Bekele et al., 2020; Mairura et al., 2021; Shukla et al., 2021). In Ethiopia the recent drought has affected around 7594,827 people in seven zones of Oromia region including East Hararghe Zone. In these zones 73 woredas were estimated to be affected by drought. The drought situation further worsens the food security, water shortages at the community levels after 2021 (WHO, 2022). And this also aggravated by poor and outdated agronomic practices which resulted in agricultural yield reduction (Horner, Wollni, 2021; Gadana et al., 2020). This reduction in agricultural yield also reduces consumption expenditure of the farm community including those in East Hararghe zone. Climate shocks directly or indirectly affect the households' consumption expenditure through affecting production and productivity. So, drought effects on consumptions is directly through reduction or failure of agricultural yields and productivity of farm (Bekele et al., 2020; Castells-Quintana et al., 2018; Ndehedehe et al., 2023) as results of agricultural drought, which is also true in this particular area of study. Thus, consumption expenditure (PaCE) of the farmers' can be affected by temperature and rainfall amount.

Therefore, it crucial strategy to investigate appropriate climate smart agriculture (CSAPr) practices to promote in drought prone area. Climate smart agricultural practice (CSAPr) is one of the most recently introduced and that reduces the negative impact of climate change (Tadesse and Ahmed, 2023). CSAPr significantly mitigated the detrimental effects of climate change (Malhi et al., 2021). It is implemented in farming activities to address the food desires of the global population while preserving the environment and adapting to climate change (Wakweya, 2023; Quarshie et al., 2023). In addition to this, the adoption of CSAPr can increase farmers' ability to cope with climate change (Abiyot et al., 2023) and it is the most effective way to lessen the adverse effects of climate change on agriculture (Khatri-Chhetri et al., 2020; Belay et al., 2023). This demonstrates significance effect of CSAPr adoption to mitigate climate change impact (Abera et al., 2020; Chen et al., 2020), and increases agricultural productivity (Acevedo et al., 2020). Generally, it is a strategy for agricultural improvement in the face of climate change (Tekeste, 2021; Ogola and Ouko, 2021; Akinyi et al., 2022), and guaranteeing production (Belay et al., 2023; Tesfaye et al., 2023). Therefore, CSAPr has significant effect on improving consumption expenditure (Biru et al., 2020) when practices are combined.

The adoption of irrigation, crop diversification and integrated soil fertility management practices were considered as climate smart agricultural practices in the study area. Crop diversification(CrD) is practices that plays significant role in improving soil fertility and enhancing agricultural yield and productivities against climatic shocks like drought (Nazir, Heman, 2022; Renard and Tilman, 2019;Fentie andBeyene, 2019; Mulwa and Visser,2020; Wondimagegn, Haji, 2021; Delphine et al., 2023). This is why farmers in moisture stress areas including those in Eastern Ethiopia do not depends on the cultivation of single cropping only. It also increases diversity and amount of food production (Bellon et al., 2020; Debela et al., 2021), due to minimized pests effects on the crop yield loss (Li et al., 2021).The other component of CSAPr that widely used is irrigation practice. Rain water harvesting for irrigating cash crop is also practicing to reduce negative effect of climate shocks. The study showed that farmers use irrigation practices as CSAPr (Adego et al., 2019). Despite the major attention was given for irrigation development, this sector has not sufficiently improved (Bont et al., 2019) as whole. For example, in Ethiopia, farmers' participation in irrigation practices is very lower (Awulachew and Ayana, 2011; FAO Food and Agricultural Organization, 2015). The soil fertility management practices are considered as climate smart agricultural practices that improve productivity (Tanti et al., 2024; Kihara et al., 2020). It includes adoption of manure, organic fertilizer, and efficient application of inorganic fertilizer and soil erosion control practices. As a CSAPr, farmers adopted fertilizer application (Weldegebrial et al., 2020: Tekeste, 2021: Tekeste et al., 2022).

Generally, CSAPr have potential to mitigate the negative consequences of drought caused by climate change while improving agricultural yield and then consumption expenditure. The adoption of CSAPr had a positive and significant impact on households' food consumption (Habtewold, 2021; Ali et al., 2022). Different previous studies show significant effect of CSAPr adoption on improving farmers' consumption expenditure. The adopters of CSAPr had better per capita nutrition consumption (Teklewold et al., 2019). Adopters had a greater total consumption spend per adult equivalent than non-adopters (Zegeye, 2021). The adoption of CSAPr had a significant impact on households' per capita consumption and crop income (Fentie and Beyene, 2019). CSAPr enhances food security and poverty reduction (Ouedraogo et al., 2019). The adoption of CSAPr such as crop diversity practices, irrigation, and soil fertility improvement were assumed to increase crop yield, enhance per capita consumption expenditure. This can be mainly due to reduced negative effect of climactic shocks in Ethiopia (Tadesse and Ahmed, 2023; Abdissa et al., 2017).

Even if Ethiopia has long time exposure to drought and climate shock events is growing from time to time (Bekele et al., 2020; Shukuru et al., 2020), farmers' adoption of smart practice against drought found at lower level in the African countries, including Ethiopia (Paulos, 2018; Mazhar et al., 2021) resulting in low production (Keba, 2019; Natnael, 2019). Unlike most of the studies mentioned above, this particular research was undertaken in drought prone area of Eastern Hararghe, where effect of drought caused crop failure frequently (Titay et al., 2021). Even if different components of CSAPr adopted, it is not clear to what level these CSAPr adoptions have resulted in increasing consumption expenditure against drought in the area. To the best of researchers' knowledge there is no prior study that investigated the impacts of climate smart agricultural practices adoption on farmers' consumption expenditure in Eastern Hararghe zone. In addition to this, the relation between consumption expenditure and adoption of CSAPr particularly irrigation use, crop diversification and integrated soil fertility management has been scarcely investigated in the area. Therefore, this research seeks to achieve its aim by addressing two research questions. Firstly, what are the factors that affecting farmers' adoption of CSAPr?, Secondly, do the adoption of the CSAPr improved the consumption expenditure of the farmers against drought?. In addition to this, the finding from this study can generate crucial information for the farm community, researchers and policymakers to encourage the adoption of climate smart practices. Thus, the working hypothesis that was tested in this study is that, the adoption of CSAPr increases the consumption expenditure of farmers in the study area. Therefore, the main objective of this study is to analyze factors affecting adoption of climate smart agricultural practices and its impacts on households' consumption expenditure per adult (PaCE) in drought prone area of Eastern Hararghe, Ethiopia.

2. The study methodology

2.1. Describing study area

This research was done at Goro-gutu, Gursum, Babile, and Kersa woredas of Eastern Hararghe zone, which is among 21 zones of Oromia Region. This zone spans 24,933 square kilometers and is situated at 07'36'N & 09'41'N41'18'E&43'00'Es. In The Eastern Hararghe zone, the highland area is around 7.7 percent, midland is 34.7 percent whereas the lowland is around 67.8 percent agro-ecologically (East Hararghe Zone Administration Office, 2018),. This zone has a total population of 3954,416, out of which 2000,202 are male and 1954,214 are femal (CSA, 2022). According to the East Hararghe Zone Administration Office (2018), the annual rainfall starts from less than 700 mm in the lowlands or lower kolla to around 1200 mm in the highlands. The temperature likewise varies from 14 to 25^{0}C. In the area, it is typical for the amount of precipitation to vary from year to year and to be unevenly distributed, mainly during the growth seasons. Moreover, the area was found to be affected by drought that causes food-insecurity problem (Lamesa et al., 2019) and also that aggravated by repeated drought (Tesfaye and Seifu, 2016; WHO, 2022) the agricultural production is also reduced (East Hararghe Administration Office, 2018), which caused crop yield loss repeatedly (Mulugeta et al.,2018).

2.2. Data description

Using a prepared questionnaire, the primary data were collected, covering details on the plot, the types of crops planted, the types of farm activities, irrigation infrastructure, and issues related to climate shocks for each crop grown on each plot of land. Additionally, the enumerators received one day of training on the questionnaire's content and how to use the Kobo Tool Box program on smart phones and tablets to collect the data. The Ethiopian National Meteorological Service Agency provided the meteorological data for the last 33 years (1990–2022) of monthly precipitation records for four representative stations. Using the multistage sampling procedure, four woredas were randomly chosen for data collection firstly. In the next stage, *kebeles* were selected randomly from selected woredas. Lastly, sample households were selected based on probability proportional to population size (PPS). To determine the required sample size, the formula developed by Kothari (2004) was used. However, the total sample size was made up of 430 households including 56 additional households who were included to provide contingencies for errors associated with data collection.

2.3. Descriptive analysis

Additionally, both econometrics approaches as well as the descriptive technique were applied for computing and evaluating the gathered data. Several analytical techniques were applied to the data examination process because the data comprised both qualitative and quantitative information. During data analyze STATA version.16 and ArcGis 10.8 version were used in drought analyze. Drought indices of SPI-3 value were also interpolated using multivalued spline technique over study area and then extracted by households' location to join drought and household data.

2.3.1. Households' demographic and socio-economic characteristics

For this particular parts of the research mean, percentage, standard deviation and frequency were used to analyze the data gathered from adopters of CSAPr and non-adopters. The statistical significances for both continuous and dummy variable were conducted by applying inferential statistics *t*-test and chi-squire test, respectively.

2.3.2. Measuring drought

To analyze drought situation in the study area, standard precipitation index method that was used. Standardized Precipitation Index (SPI) which applied to identify aspect of drought using rainfall data of 33 years (1990–2022) at a three-month time scale was applied/used. This means to quantify drought three months SPI which is mostly used in representation of effective agricultural drought. Therefore, the SPI value was to investigate drought magnitude, severity and also intensity of drought according to (Mekonen et al., 2022). The negative values of SPI indicated drought occurrences whereas positive indicated absence of drought. In these study 3-months SPI which is applied to compares the specified 3-months rainfall with similar three months of 33 years was applied in this study. Following the (McKee et al., 1993), the drought level categories were divided into mild, moderate, severe and extreme. The formula for Standardized Precipitation Index (SPI) used as follow:

$$SPI_{ij} = \frac{\mathbf{X}_{\mathbf{ij}-\mu_{\mathbf{ij}}}}{\boldsymbol{\sigma}_{\mathbf{ij}}} \quad (1)$$

Where SPI of the ith season at the 3th time scale.

The total amount of rainfall for ith season is X_{ij}

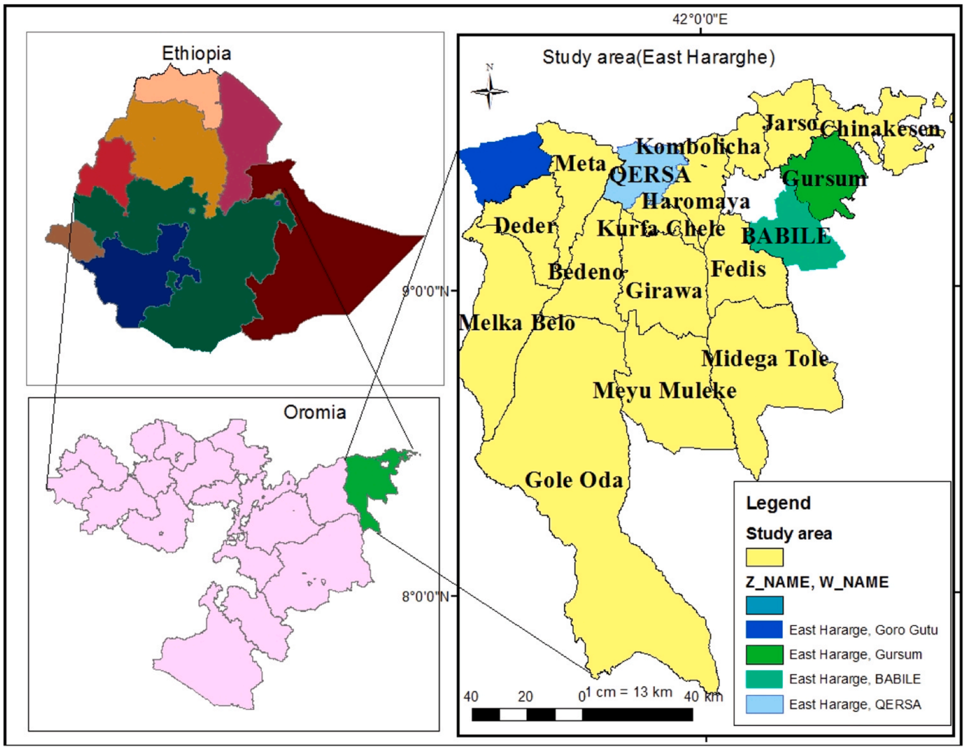

Fig. 1. The study area map.

The mean and standard deviation are presented as μ_{ij} and σ_{ij}

After that, a gamma probability density function fitted to the rainfall data was used. Next, the probability is equally transformed from the cumulative distribution to the standard normal distributions, which has a variance of one and a mean of zero which termed as SPI-value that used to analyze agricultural drought (McKee et al., (1993). In this particular study 3-months-SPI was computed using MS Excel for each rainfall station. Then SPI was set equal 1 if the value of SPI is less than 1.5, indicating a severe drought, otherwise, 0 for respective season.

2.4. *Econometric analysis*

The impact of adopting climate smart agricultural practices (CSAPr) on per adult's consumption expenditure (PaCE) was evaluated. n this study adoption of small-scale irrigation (I), crop diversification (D) and integrated soil fertility management (F) were considered as CSAPr practices. When these three CSAPr components are applied in a single practice or in combination, they result in eight mutually exclusive CSAPr including reference categories. In non-randomization method the fundamental problem that occurs in the impact evaluation is endogeneity(Hausman, 1978) and sample selection bias (Heckman, 1979). Due to the non-randomness of practice adoption, self-selection into climate smart agricultural practices may be questioned following (Pannell et al., 2014). Therefore, estimating the impacts of CSAPr adopting on consummation expenditure without accounting for self-selection could also results in biased estimate.

Moreover, different econometric approaches exist in literature to deal with such problem including instrumental variable (IV), propensity score matching (PSM) (Rosembaum and Rubin, 1985; Caliendo, Kopeinig, 2005), and Heckman selection model. However, PSM only controls for observed heterogeneity, instrumental variable (IV) control for unobserved heterogeneity. In the Heckman model, non-adopters are considered as they will never adopt under any circumstances (Jose, 1989). The PSM method requires unconfoundenness where all the variables that affect the treatment and the outcome must be observed (Caliendo, Kopeinig, 2005), assuming no selection bias due to unobserved. Propensity score matching (PSM) only applicable to situations where the treatment variable is binary in nature.

In response to the impact evaluation pitfalls of selection bias, endogeneity and unobserved heterogeneity problem, this study used multinomial endogenous switching regression(MESR) model that accounts for both endogeneity and sample selection following.This method is highly preferable to other methods as shown by. In addition to this, MESR has the advantage of evaluating both single and combinations of practices (Kumar et al., 2019). Generally, the use of MESR model has triple advantages. First, it helps to address a bias that arises from the unobservable variable. Second, the model allows for getting consistent and efficient estimates of the adoption process with reasonable correction for the outcome equation. Third, it assists in computing the impacts of both single and combined practice simultaneously (Abdulai and Huffman, 2014; Coulibaly et al., 2017; Wekesa et al., 2018).In this study there are multiple practices to be considered for impact evaluation. The application of MESR method enables the construction of a counterfactual based on returns to characteristics of adopters and non-adopters (Kassie et al., 2018). Therefore, in this study two stage MESR model was applied to analyze the impacts of CSAPr on consumption expenditure.

2.4.1. *Multinomial logit regression model*

This regression model was applied in first step for selection model. The farmers adopt a single or a combination of agricultural practices that can maximize their utility. This means farmers adopts if the utility of the adopted practices is higher than the utility of the other alternatives of practices. However, the utility that gained from adopting agricultural practice is not observed but only its choice of practice. In this case one can assume a random utility model which states conditional probability choice given farmers choice. This can be formulated as the following equation:

$$A_{ij}^{*} \quad = \quad Z_i\alpha_j + \varepsilon_{ij} \tag{2}$$

A_{ij}^{*} is a latent variable, which describes the i$^{\text{th}}$ farmer's behavior in adopting the alternative agricultural practices J (j = 0,1,2,3,4,5,6,7) with respect to another alternatives k. Z's are a vector of observed independent variables and ε_{ij} disturbance term.

It is assumed that the covariate vector of Z_i is uncorrelated with the unobserved error term ε_{ij}. Assumed as $E(\varepsilon_{ij}/X_i) = 0$ and ε_{ij} are not interdependent as well as follow identically Gumbeled distributions following independent irrelevant alternative assumption, analyzed by multinomial model (McFadden,1973). In this study multinomial logit model was applied to analyze factors affecting adoption of CSAPr. The Probability of adopting CSAPr practices j using MNLis adopted:

$$P_{ij} \quad = \mathrm{p}(\varepsilon ij < 0 \Big/ \mathrm{Xi}) \quad = \quad \frac{\exp(X_iB_j)}{\sum_{M=1}^{j}\exp(X_iB_M)} \tag{3}$$

2.4.2. *Impact evaluation procedures applying Multinomial endogenous switching regression*

The MESR model examines the relationship between the outcome variable (Y_{ij}) and covariate variables (X_i) for each of the adopted practice. The outcome (Y_{ij}) is observed when these practice adopted j has been adopted. The base category for this study is not-adoption ($F_0D_0I_0$) of any CSAPr, is denoted as j = 0. In the remaining practices combinations (j = 1,2, 3, 4 ….7), at least one CSAPr is adopted. Farm households may choice and adopt out of the *m* regimes where regime $j = 0$, can be applied as reference group of non-adopters. Then per adult annual consumption expenditure model for each regime can be set as follow:

$$\text{Regim1}.Y_{10} \quad = \quad Z_i\alpha_0 \quad + \quad \mu_{i0}\text{for i} = 0 \tag{4}$$

$$\text{Regimj}.Y_{ij} \quad = \quad Z_i\alpha_j \quad + \quad \mu_{ij}\text{for i} = \text{j}$$

Y_{ij} 's represents the per adult consumption expenditure of i individual farmers in regime jDisturbance term μ_{ij}'s were assumed as $E(\mu_{ij}/x.z)= 0$ &$Var(\mu_{ij}/x, z = \sigma_j^2)Y_{ij}$ can be observed if, practices j was applied, that is which obtained at $Y_{ij}^* > Max_{M\neq 1}$ (Y_{im}).

The OLS estimate for the above Eq.(4) is biased, if the disturbance term in Eq. (2) and Eq.(4) are interdependent. To get consistent estimate for α_j it needs insertion of selection correction terms from adopted practices in to the outcome Eq.(4). It generates consistent and efficient estimates by implementing selection bias correction terms in the impact evaluation model. Generally, MESR model assumes the following linearity assumption:

$E(\mu_{ij}|\varepsilon_{i0}\ldots\ldots\varepsilon_{ij}) = \sigma_j \sum_{m\neq j}^{j} r_j(\varepsilon_{im}\text{-}E(\varepsilon_{im}))$. Following zero correlation assumption of the two disturbance term, outcome equation was modified as follow:

$$\text{Regim1} : Y_{i0} \quad = \quad Z_i\alpha_0 \quad + \sigma_{i0}\lambda_i \quad + \omega_{i0}\text{for i} = 0 \tag{5}$$

Regim j:$Y_{ij} = Z_i\alpha_j + \sigma_j\lambda_j + \omega_{ij}$ for i = j

Whereas covariance term σ_j, used to represent variance between both disturbance terms ε's *& u's*

Whereas λ_{js} shows generated mills ratio obtained from the probabilities of Eq. (3) above:

$$\lambda_j \quad = \quad \sum_{m\neq j}^{j} \rho_j [\frac{P_{imLn(P_{im})}}{1 - P_{im}} \quad + \ln(P_{im})]$$

ρ_j is also correlation between ε'*s* & u's

ώij were disturbance/error terms of zero mean

There is also j-1sellection bias correction values during adoption anal impact analysis in the model. Therefore, this regression model corrected unobserved as well as observed factors so as to generate treatment effect on treated (Dubin and McFadden, 1984). Heteroskedasticity that can happen from the generated regressors were also corrected by bootstrapping of standard errors in Eq.(5).

2.4.3. Impact evaluation (ATT)

For impact analysis, the situation that explains what would be the consumption of adopter farmers when they had not adopted practices (counterfactual parts) computation was conducted to investigate significant impacts of practices adoption. This was done by evaluating mean of consumption expenditure for adopter farmers both with practices adoption as well as in the absence of adoption scenario. Following (Di Falco and Veronesi, 2011) average treatment effects on adopters (ATT) was obtained as follow:

Per adult consumption expenditure of adopters (Actual cases)

$$\mathrm{E}(Y_{i1}/\mathrm{i} = 1) \quad = \quad Z_i\alpha_1 \quad + \quad \sigma_1\lambda_1 \tag{6a}$$

$$\mathrm{E}(Y_{ij}/\mathrm{i} = \mathrm{j}) \quad = \quad Z_i\alpha_j \quad + \quad \sigma_j\lambda_j \tag{6b}$$

Per adult consumption expenditure if not adopted (conditional analysis)

$$\mathrm{E}(\mathrm{Yi0} \quad /\mathrm{i} = 1 \quad) \quad = \quad Z_i\alpha_0 \quad + \quad \sigma_0\lambda_1 \tag{7a}$$

$$\mathrm{E}(\mathrm{Yio}/\mathrm{I} = \mathrm{j}) \quad = Z_i\alpha_0 \quad + \quad \sigma_0\lambda_j \tag{7b}$$

Then, ATT formulation for impact evaluation is

$$= \left(Z_i\alpha_1 + \sigma_1\lambda_1 \right) - \left(Z_i\alpha_0 + \sigma_0\lambda_1 \right) = (6\mathrm{a}) - (7\mathrm{a}) \tag{8}$$

ATT is difference between adoption and in the absence of adoption (counterfactual cases)

λ_j this terms shows selection correction terms used to correct the effects of unobserved differences of the variables

2.4.4. Variables and definition

In this study, the adoption of CSAPr in terms of soil fertility management ($F_1D_0I_0$), irrigation ($F_0D_0I_1$), crop diversification($F_0D_1I_0$), combination of integrated soil fertility and crop diversification($F_1D_1I_0$), integrated soil fertility and irrigation($F_1D_0I_1$), crop diversification and irrigation ($F_0D_1I_1$), and the mix of all three practices($F_1D_1I_1$) were considered. Non-adopters ($F_0D_0I_0$) of the CSAPr practices also used as reference categories in this study. Therefore, one of the most widely used CSAPr is **soil fertility management**, which includes if the farmer applied compost or manure, efficiently fertilizer application and constructing erosion control structures on their farm. Another widely applied climate smart practice is **small-scale irrigation**, which is considered if the farmer practiced rainwater harvesting, cannel-based irrigation, and ground water to grow vegetables, and as supplementary irrigation water for other crops at least on one of his plot. Irrigation is crucial for maintaining agricultural production and reducing adverse influences due to drought. Similarly, **crop diversification** is the other component of CSAPr that widely used, to reduce effects of drought. Furthermore, Eastern Hararghe farmers cultivate a variety of crops, including sorghum, maize, groundnuts, haricot beans, sweet potatoes, vegetables, and *khat* to withstand the impacts of drought and increase productivity. Therefore, these practices are considered as CSAPr in this study as shown in the following Table 1.

Table 1
Variables and hypothesis used for model analysis.

Variables	Measurements	Expected effect on Adoption
Dependent variables		
CSAPr Adoption	= 0 if non-adopted(Reference group), 1 for adopters of integrated soil fertility management, 2 for crop diversification,3 for irrigation,4 for integrated soil fertility and crop diversification, 5 for integrated soil fertility management and irrigation,6 for crop diversification and irrigation,7 for a mix of soil fertility management, crop diversification and irrigation practices	
Log(Cosumtn.Expr)	Total annual per adult consumption expenditure in Birr	
Independent variables		
Age	Age of family head in year	+ /-
Gender	Male headed family = 1, otherwise 0	+
Household size	size of family in number	+ /-
Land area	Area of land in hectars	+
Education of head	Education in formal years schooling	+
Access to Extension	Access to extension = 1	+
Market distance	Distance to market in kms	-
Climate information	1 if accessed 0 if not	+
Farm Experience	Farm experience in years	+
Livestock holding	Total livestock holding in TLU	+
Organization membership	1 if membership, 0 if not	+
Market information	1 if accessed, 0 if not	+
Non/off-farm activity	1 if participated, 0 otherwise	+
Drought/shock experience	Drought experience in the last 10 years	+
Number of Oxen	Oxen owned in number	+
Number of farm plot	Number of plot owned	+
SPI-summer−22	1 if summer-spi is less than 1.5, or 0 for 2022	+
SPI-summer−20	1 if summer-spi is less than 1.5, or 0 for 2020	+
SPI-spring−20	1 if spring-spi is less than 1.5, or 0 for 2020	+

3. Results and discussion

3.1. Socio-economics characteristics

Result showed differences between adopter and non-adopter of CSAPr practices focusing on their socio economic factors. Regarding non-adopter of the CSAPr practices, farmers that do not practiced any of crop diversification; irrigation and soil fertility management on at least one of their farm plot were considered in this particular study. The results from descriptive statistics showed that farm experience, education, drought experience, farm size, livestock number and market distance were the variable that showed significant mean differences between the adopters and non-adopters (Table2).

Result revealed that, mean of farmer experience in the farm activities of non-adopter is 20.4 years while that of adopters was found to be 24.7 years with significant mean difference at 1 percent significant level. This implies that more experience in farming encourage farmers to adopt the CSAPr than non-experienced one. It also showed that the average formal

Table 2
Results of socio economies and demographic characteristics of sampled respondents.

Variable	Adopters		Non-Adopters		Difference		T-values
	Mean.	Std. er	Mean	Std. er	Mean	Std. er	
Famers' Age	36.56	0.536	36.78	2.015	0.222	2.304	0.097
Farm Experience	24.66	0.370	20.35	1.430	4.313	1.595	2.704***
Education	5.789	0.175	2.739	0.408	3.050	0.743	4.102***
Drought Experience	4.066	0.067	3.261	0.245	0.805	0.286	2.817***
Family Size	6.226	0.109	6.130	0.455	0.096	0.472	0.203
Farm Size	0.472	0.011	0.414	0.026	0.058	0.032	1.793**
Livestock	3.197	0.130	1.189	0.174	2.008	0.389	5.167***
Oxen owned	1.273	0.073	1.043	0.311	0.229	0.314	0.731
Market Distance	7.826	1.192	10.16	0.263	2.339	1.142	2.049**

Source: survey results, 2023

year of schooling of adopters was grade 5.8 whereas that of non-adopters is grade 3 showing the significance mean differences at 1 percent probability. The educated farmers adopted and implemented the appropriate CSAPr that increased their agricultural yield and income. From the results it could be also observed that on average the adopters of practices had 0.5 hectare of farm land while non-adopters had around 0.4 hectare. The results showed a significant mean difference between adopter and non-adopters' farm size at 5 percent significance level. The household that have large farm size can adopt different CSAPr simply than those with small land area. On average the market distance of non-adopters was 10 kilometers whereas that of adopter of practices is 8 kilometers from the market. This implies farmers that accessed market in short distance can get farm input and information to adopt CSAPr simply compared to distant farmers.

The sampled farmers were asked regarding drought/climatic shocks experience they faced within the last ten years. The result revealed that, on average the adopters faced drought/climatic shocks for 4.1 years whereas non-adopters experienced drought/shocks for 3.3 years within the last ten years. Result showed significant mean difference at 1 percent significant level. This implies that previous drought experiences of the farmers may encouraged them to adopt different climate smart agricultural practice on their farm. The results also showed that, on average adopters had 3.2 livestock in tropical livestock unit while non-adopters were having 1.2 livestock in TLU with significance mean difference at 1 percent probability level. The livestock are used as a power of draught, transportation and income source for rural households. The results showed that, on average the adopter owned 1.3 oxen number while non-adopters were found to having 1 ox in number showing no significant mean difference.

In the area, 73 percent of climate smart agricultural practice adopters accessed extension service while 27 percent of them do not accessed extension service. In the case of non-adopters of CSAPr practices 56.5 percent accessed extension service while 44.0 percent of non-adopters not accessed extension. A key factor impacting the implementation of CSAPr practice is having access to weather information. The result showed that 61.7 percent of climate smart agricultural practice adopters accessed information whereas 38.3 percent of them do not accessed information. In the case of non-adopters 56.5 percent of them accessed weather information while 43.5 percent of them not accessed information. This implies that adoption of CSAPr practices requires timely weather information to respond to and minimize the effect of climatic shocks (Table3.).

The results in the following (Table3), showed that 53.6 percent of climate smart agriculture adopters are male headed while 46.4 percent of them are female headed. Regarding non-adopters of practices 56.5 percent are male headed while 43.5 percent of non-adopters are female headed. It is significant variable that influenced adoption of CSAPr practices. The family head membership in farmers' social associations is very important variable in rural area. According to the result, 70.5 percent of CSAPr practice adopters participated in the social organization and the rest 29.5 percent of them do not participated. Out of the non-adopter of CSAPr, 60 percent participated while 40 percent of them not participated in any social organization as presented in the following (Table3).

Table 3

descriptive results of sampled respondents for dictate variable.

Variable		Percentage	Adoption status		Total
			Non-adopter	Adopter	
Gender of household head	Female	within Adoption	43.5	46.4	46.3
	Male	within Adoption	56.5	53.6	53.7
Extension Service	Not Accessed	within Adoption	43.5	27	27.9
	Accessed	within Adoption	56.5	73	72.1
Climate Information	Not obtained	within Adoption	43.5	38.3	38.6
	Yes Obtained	within Adoption	56.5	61.7	61.4
Social group participation	No Patricip	within Adoption	39.1	29.5	30
	Yes Particip	within Adoption	60.9	70.5	70

Sources: Survey results,2023

3.2. Perception of changing climate and drought analysis

The study result revealed that among non-adopters 41.7 percent in Goro-Gutu replied as rainfall amount is decreasing while 33.3 percent of them replied as rainfall is fluctuating as in (Table4). However, chi-square test showed that districts of study and rainfall amount not showed significant association among non-adopters. In the same district the adopters replied that 17.4 percent as rainfall is increasing, 23.8 percent replied as decreasing and 32.7 percent of them replied as the rainfall is fluctuating, in the last 10 year. The chi-square test showed that among adopter's households, there is no significant association between the districts of study and rainfall amount. In kersa district, about 39.1 percent of adopters replied that the rainfall amount is increasing, 28.9 percent replied as rainfall amount decreasing and 19.4 percent of adopters replied that the rainfall amount is fluctuating. This implies almost all household believed as rainfall decreases from time to time.

As indicated in the following (Fig. 2), the rain fall data of Babile, Karamile/Goro-Gutu and Gursum stations were used and 3-months scale SPI was computed as drought indexes for Summer season. The result showed that, in the three districts the summer season SPI-3 values showed fluctuation of drought which is mostly severe drought in the area. The value of SPI was written in parenthesis for respective year. In Babile district extreme drought was occurred in year 1991 (-3.199), in 2011(-3.214), in 2015 (-2.784) and in 2020 (-3.423).The severe drought also occurred in 2003 (-1.786), in 2012 (-1.608) and in 2019 (-1.786) with precipitation deficits in summer seasons. In Gursum district severe drought was observed in 1999 (-1.848), in 2005 (-1.785) and in 2022 (-1.7288). The extreme drought also observed in 2000 (-2.192), in 2001 (-2.199), in 2008 (-2.296), in 2013 (-2.429), and in 2014 (-2.219) as presented in (Fig. 2). This shows that how the severity of the drought is increasing from time to time which significantly affect the moisture stress area of Eastern Hararghe. This results also agreed with (Mohammed et al., 2022) showed spatially coherent trends of increasing extremes of hot and decreasing of cold temperature extremes. And it also agreed with finding the finding (Wubaye et al., 2023), that indicated an increasing trend of warm temperature extreme and a downward trend of cold temperature extreme, indicating the overall warming and dryness trends in the country

3.3. Climate smart adoption status of the farmers

Regarding components of climate smart agriculture (CSAPr) practices, that adopted, the following (Fiure.3) showed the percentage of farmers that adopted different in single and combination of practices. It revealed that 4.3.percent of the farmers adopted soil fertility management practices only while 8.8 percent of them adopted crop diversification and 7.4 percent of the farmers adopted irrigation practices. It showed 17.7 percent of respondents adopted combination of soil fertility and crop diversification, 11.4 percent of them adopted soil fertility and irrigation practices, 12.8 percent adopted combination of crop diversification and irrigation practices whereas 32.3 percent of the farmers adopted and implemented full combination of crop diversity, irrigation and soil fertility management practices. The non-adopters of the practices account for around 5.3 percent of the respondents as in the following (Fig. 3). This implies that significant number of farmers

Table 4
perception of households on trend of the rainfall amount in the last 10 years.

Climate SAP			Districts of study				Chi^2
	RF trend	Percentage (%)	Goro-gutu	Karsa	Babile	Gursum	
Non-adopter	Decrease	within RF Trend	41.7	8.3	8.3	41.7	0.86
	Fluctuate	within RF Trend	33.3	0	0	66.7	
Adopter	Increase	within RF Trend	17.4	39.1	26.1	17.4	6.84
	Decrease	within RF Trend	23.8	28.9	26.2	21.1	
	Fluctuate	within RF Trend	32.7	19.4	25.5	22.4	
Total	Increase	within RF Trend	17.4	39.1	26.1	17.4	6.96
	Decrease	within RF Trend	24.5	28.1	25.5	21.9	
	Fluctuate	within RF Trend	32.7	18.8	24.8	23.8	

Source: Source: Own survey result, 2023.

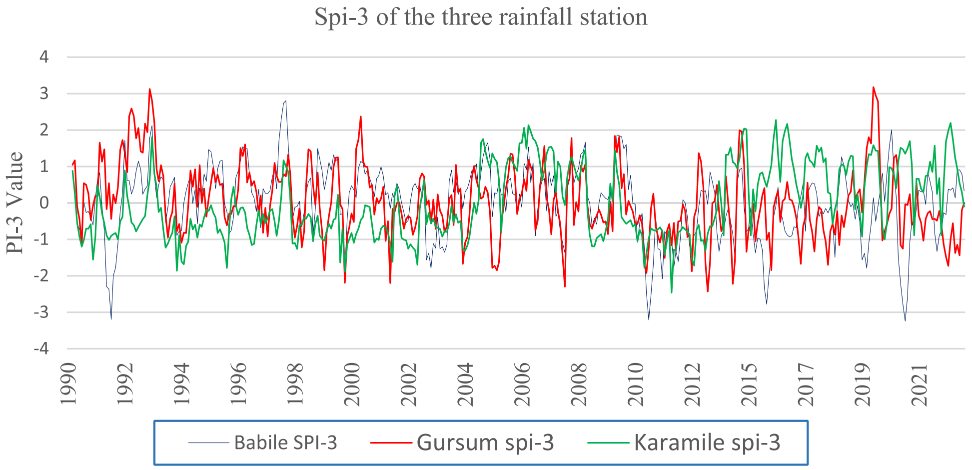

Fig. 2. Three districts monthly Spi-3 value of drought.

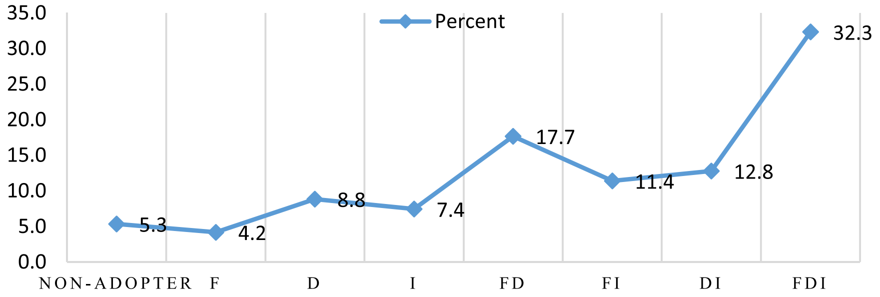

Fig. 3. CSAPr adoption status in percent.

adopted combination of the CSAPr against adverse impacts of drought on their farm in drought area.

3.4. Components of consumption expenditure

Annual farm income of the farm households includes income from sell of farm product including from sold crop, cattle and others in the area. When evaluating means annual farm income, adopters were found to have more farm income. On average total annual farm income of the adopters of CSAPr practices was 34716.31ETB whereas that of non-adopter was found to be around 27661.41ETB. This also indicated that the sampled households who do not-adopted and adopted have a significant mean differences in their annual farm income.

The total annual per adult PaCE is part of household expenses made by households divided by adult equivalent that adjusted by age and sex composition of households. It is the amount of money expended to buy several commodity mainly foods items and non-food items for the whole family members need within the last 12 months prior to survey. On average adopters had higher annual per adult consumption expenditure relative to non-adopters as shown below. As shown in the following (Table5), results showed total annual per adult consumption expenditure of the adopter was found to be about 10423.4ETB whereas that of non-adopters of practices was 9107.5ETB. The findings revealed that, significant mean differences in mean at 1 percent of significant level in terms of annual per adult consumption expenditure (PaCE). This implies that adoption of CSAPr improve the income of households that encourage consumption expenditure of the household.

Food and non-food expenses, as well as production costs were included in farmer consumption expenditures. However, food spending covers the cost of food that they bought or other foods that farmers did not grow on their farms. In addition to this, the worth of food that they harvested from their own farm land also included. The result showed that, out of total consumption expenditure, the annual food expenditure accounted for about 67.65 percent whereas non-food expenditure was 32.35 for adopters of CSAPr. Similarly annual food expenditure of non-adopter accounts for about 76.05 percent and non-food expenditures

Table 5

Annual per adult consumption, food, non-food expenditure and farm income.

Expenditure and Income in ETB	Adopter		Non-Adopters		Difference		T-values
	Means.	Std.er	Mean	Std.er	Mean	Std.er	
Total Expenditure/Ad/Eq	10423.36	171.86	9107.48	293.28	1315.88	518.92	2.5358^{***}
Annual Food Expenditure	27608.78	580.79	27228.66	1633.59	380.12	1806.65	0.2104
Non-Food Expenditure	13200.74	409.81	8574.43	770.95	4626.30	1242.15	3.7244^{***}
Annual Farm Income	34716.31	1580.37	27661.41	3952.52	7054.90	4256.75	1.6573*

Source: Survey results of 2023, ***,** and * shows at 1percent,5percent and 10 percent significant, respectively; ETB=Ethiopian Birr

accounts for 23.95 percent out of total annual household expenditure. This implied that, rural farmers allocate most of their annual income to fulfill the gap of family need. Moreover, the amount of annual food consumption expenditure is greater than the annual expenses used up for commodities other than food consumption. This is mainly due to food consumption expenditure is determined by family size and food is also basic item that needed daily by everyone to survive. And also the ratio of family food consumption expenditure is mostly used as a standard determinant of the households' welfare according (Pahlevi et al., 2016). However, there is no significance mean difference between the two groups in terms of annual food expenditures. This may be due to that non-adopters also increase their food expenditure as adopters did to feed the family, even in time of shock, they may purchase food by selling their livestock assets and other asset to feed family.

Results also showed significance mean difference at 1 percent for non-food consummation expenditure. This implies that adopters may increase their non-food expenditure due to increased more yields and farm income generated due to CSAPr adoption. However, there is no significant variation in food consumption expenditure between two groups. It is evident that when smallholder farmers experience climate shocks, especially drought, rural households prefer to reduce their use of non-important products and services in comparison to those who adopted practices. Furthermore, the findings demonstrated that households' chances of being food self-sufficient decreased by climate shocks (Table5).

3.5. *Determinants of CSAPr Practices Adoption*

This particular study considered adoption of irrigation practice, crop diversification and integrated soil fertility management practices that widely practiced in the area. In the investigation of factors influencing the adoption of CSAPr practices, multinomial logit model was applied using non-adopters ($F_0D_0I_0$) as reference group. The model estimate was interpreted as percentage variation in the likelihood of dependent variable as a unit change in independent variable which is marginal effect. Wald test (Chi^2 (105) = 246.82, Prob > Chi^2= 0.000) which shows rejection of all the model regression estimates are jointly zero. LR (Likelihood-ratio test) test of chi2(105)= 289.87 for Prob > chi2 = 0.000, revealed that full model was significantly different from restricted model as shown in (Table 6.). Additionally, variance inflation factors (VIF) was also undertaken to test multicollinearity test among independent variables and confirmed that data was free from multicollinearity problem (Appendix A.1). Similarly, the Breusch-Pagan test was also conducted and the result showed that there is no heteroscedasticity problem in the models as (Chi2(1) = 1.26, Prob > chi2 = 0.2623).

Assumption of this model which states that, the preference between pair of alternative practices should not be affected by removal of the practice or introduction of additional alternative. This assumption termed as interdependence of irrelevant alternative also crucial assumption in this model and it was also tested. This particular assumption helps for computation of independent influence of variable on the probabilities. The Violations of IIA assumption can result in biased estimates and inaccurate prediction. In the model test, the (Hausman and McFadden, 1984), test method was applied to test presence of IIA and it revealed as there is no problem of the violating the assumption. The test result of insignificant chi-square and the pro>chi2 for ($F_1D_0I_0$), ($F_0D_1I_0$), ($F_0D_0I_1$), ($F_1D_1I_0$,), ($F_1D_0I_1$) ($F_0D_1I_1$) and ($F_1D_1I_1$) were found to be for chi2 of 0.79 pro> chi2 is 1.0000, for chi2 of 1.64 pro> chi^2 is 1.0000, for chi^2 of 0.01 pro> chi^2 is 1.0000, for chi^2 of 1.08 pro> chi2 is 1.0000, for chi^2 of 17.11 pro> chi^2 is 0.3786, for chi^2 of 4.02 pro > chi^2 is 0.9989 and for chi^2 of 13.44 pro> chi^2 is 0.6402, respectively. Since the test statistic is not significant the assumption of IIA is accepted showing that the selected multinomial model is appropriate (Table 6.).

The result showed the adoption of crop diversification ($F_0D_1I_0$) negatively and significantly affected by age at 1 percent significant level. It showed that as age increased by year, then the likelihoods of adopting

Table 6

Multinomial logit results on factors affecting adoption of climate smart agricultural practices.

	$F_1D_0I_0$ ME(Std.Err)	$F_0D_1I_0$ ME(Std.Err)	$F_0D_0I_1$ ME(Std.Err)	$F_1D_1I_0$ ME(Std.Err)	$F_1D_0I_1$ ME(Std.Err)	$F_0D_1I_1$ ME(Std.Err)	$F_1D_1I_1$ ME(Std.Err)
Age Respondt	-0.001(0.0010)	-0.004^{***}(.001)	-0.001(0.0010)	-0.002(0.0017)	-0.001(0.0015)	0.005^{***}(.0016)	-0.002(0.0023)
Farm Exprienc	0.001(0.0010)	0.004^{**}(.0016)	0.001(0.0016)	0.002(0.0025)	0.006^{***}(.0019)	0.006^{***}(.0021)	0.001(0.0030)
Education	0.005^{**}(.0026)	0.003(0.0037)	0.001(0.0037)	0.004(0.0047)	0.001(0.0046)	0.008(0.0052)	0.007(0.0064)
Dry Experiance	0.014*(.0077)	0.023^{**}(0.0102)	0.006(0.0075)	0.002(0.0132)	-0.002(0.0113)	0.021*(0.0123)	0.019(0.0157)
Access ExteSe	0.023(0.0259)	0.025(0.0316)	-0.027(0.0244)	0.013(0.0397)	0.022(0.0326)	0.029(0.0327)	0.066(0.0516)
Sex Respondt	0.008(0.0192)	0.040(0.0272)	0.027(0.0239)	0.076^{**}(0.0362)	0.001(0.0304)	0.057*(0.0322)	0.027(0.0449)
Family Size	0.009*(0.0051)	0.002(0.0064)	0.002(0.0056)	0.001(0.0092)	0.004(0.0074)	0.014*(0.0079)	0.001(0.0101)
Plot Number	-0.006(0.0088)	0.004(0.0117)	-0.020(0.0122)	0.024(0.0161)	0.005(0.0152)	0.023(0.0146)	0.018(0.0211)
Livestock	0.008*(.0046)	0.002(0.0054)	0.016^{***}(0.0032)	0.028^{***}(.0089)	0.007(0.0063)	0.008(0.0058)	$0.031^{***(}$.0072)
Oxen Number	0.011(0.0094)	0.004(0.0091)	0.027^{**}(0.0124)	0.021*(0.0121)	0.006(0.0100)	0.005(0.0119)	0.027*(0.0145)
Climate Info	0.028(0.0195)	0.050*(0.0296)	0.059^{***}(.0223)	0.009(0.0357)	0.089^{***}(.0296)	0.003(0.0299)	0.127^{***}(.0447)
Market Info	0.010(0.0220)	0.063*(0.0345)	0.058^{***}(.0210)	0.005(0.0406)	0.009(0.0309)	0.044(0.0326)	0.013(0.0467)
Membership	0.003(0.0198)	0.039(0.0323)	0.046*(0.0275)	0.039(0.0388)	0.056*(0.0310)	0.006(0.0331)	0.038(0.0484)
Spi-summer-22	0.068*(.0363)	0.050(0.0381)	0.021(0.0277)	0.098^{**}(0.0467)	0.017(0.0340)	0.068^{**}(0.0343)	0.088(0.0547)
Spi-summer-20	-0.019(0.0231)	0.084^{***}(.0322)	0.086^{***}(0.0237)	0.073* (0.0412)	0.043(0.0365)	0.057*(0.0314)	0.127^{***}(.0467)

Log pseudolikelihood = -702.48905, Number of obs = 430

Source: own results, 2023; ***,** and * shows at 1percent,5percent and 10 percent significant, respectively

SPI=standard precipitation index; $\mathbf{F_1D_1I_1}$: $\mathbf{F_1}$ = integrated soil fertility management, $\mathbf{D_1}$ = crop diversification, $\mathbf{I_1}$ = Irrigation application crop diversity practice decreased by 0.4 percent. This shows that younger people are more understand the effects of climate shocks and motivated to implement crop diversification than older one. This results also agree with (Ncube et al., 2016) that showed older family head were more vulnerable to the impact of climate shock and Agreed with (Keba, 2019; Abewa et al.2020; Zegeye, 2021; Mebratu et al., 2022; Abebe et al., 2023) those noted negative relation of household head age with CSAPr adoption.

The result showed that, the adoption of crop diversification was influenced by farming experience of the famers. It showed that adoption of crop diversification is significantly and positively affected by farmers' experience at 5 percent significance level. It also showed that as farmers' experience increased by a year the likelihood of adopting crop diversification increased by 0.4 percent. Farmer experience also affected significantly and positively the adoption of integrated soil fertility management and irrigation practices combination at 1 percent significance level as shown in (Table 6). As farmer experience increased by a unit, the likelihood of adoption soil fertility management and irrigation practice increased by 0.6 percent as climate change mitigation. As the experience of the farmers increased by a year, the likelihood of adopting crop diversification and irrigation practice also increased by 0.6 percent. These findings also agreed with finding of (Mogoka et al., 2021; Godfrey et al., 2023), who noted that experienced farmers have more initiation to adopt CSAPr practices, which is accounted to sufficient awareness grew through time. Therefore, as farmers experience increased, the adoption of crop diversification and irrigation practice increased.

The results show that, the adoption of soil fertility management practice was positively and significantly affected by household head education at 5 percent significance level. The value of marginal effect showed that the probability of adopting soil fertility management raised by 0.5 percent as family head education increased by one year of schooling. This implies that knowledge, skill and ability to identify their local situation increased as farmer educated and adopted CSAPr. These also help them to simply predict farm risk related with climate shocks including soil erosion so as to adopt appropriate CSAPr against climate shocks. The finding also supported by (Abyiot et al., 2023; Meresa et al., 2023; Abebe et al., 2023) those showed that when education level of the farmers increased, the adoption of the soil fertility management practices also increased.

It revealed also that adoption of soil fertility management was influenced positively and significantly by past drought experience at 10 percent significance level. Similarly, the adoption of crop diversification was influenced positively and significantly by past drought experience at 5 percent significance level. As drought experience of farmers increased by a year, the likelihood of adopting soil fertility management increased by 1.4 percent. The likelihood of adopting crop diversification also increased by 2.3 percent as drought experiences increased by a year, It also showed that adopting crop diversification and irrigation practices combination were positively and significantly affected by past drought experience at 10 percent significance level. The result revealed that as drought year increased by a unit, the probability of adopting combination of crop diversification and irrigation increased by 2.1 percent. This implied that farm households who have drought experience in the last ten years have higher probability of adopting irrigation, soil fertility management, and crop diversification. The result agreed with (Mwungu et al., 2018) that estimated farmers experienced any climate shock have higher likelihood of adopting integrated soil fertility.

It showed that adopting the combination of soil fertility management and crop diversification was affected positively and significantly by family head sex (gender) being male at 5 percent significant level. Similarly, it also showed that adoption of crop diversification and irrigation practices combination was influenced positively and significantly by sex of family head being male at 10 percent significant level. The result also showed that adopting the combination of soil fertility management and crop diversification were increased by 7.6 percent as sex of family head is male. Similarly, the adoption of crop diversification and irrigation practices combination increased by 5.7 percent as sex of family head is male. In the rural area most of the female has not land for crop cultivation and most of the time the farm families transfer their land to male rather than to the female. In addition to this, female headed have not such potential in using their resources effectively compared to male headed. Therefore, family head being male affected the adoption of CSAPr positively. This results consistent with finding of (Kumasi et al., 2019) who showed that relative to male headed farmers, female were less capable of coping with climate shocks due to lack of sufficient climate information and access to irrigation facilities and (Ncube et al., 2016) that showed households with female headed probably to be more susceptible to shocks like drought.

The family size also affected positively and significantly the adoption of soil fertility management at 10 percent significant level. It also related significantly and positively to the combination of crop diversification and irrigation practices at 10 percent significant level. It showed that adoption of soil fertility management, and combination crop diversification and irrigation increased by 0.9 percent and 1.4 percent as family size increased by a unit, respectively. It can be seen that as the family labor increased, the likelihood of adopting CSAPr mainly; crop diversification, irrigation and soil fertility management increased. This can be due to implementation of CSAPr practices need more labor. This finding consistent with (Kumasi et al., 2019; Destaw and Fenta, 2021) those identified that farmers involved in sharing of family labour have more adaptation potential to mitigating negative effects of climate shocks.

The results showed that, the adoption of integrated soil fertility management and irrigation practices were affected positively and significantly by livestock at 10 percent and 1 percent significant level, respectively. It showed that as livestock number increased by a unit, farmers' probability to adopt soil fertility and irrigation practices increased by 0.8 percent and 1.6 percent, respectively. Similarly adopting the combination of soil fertility management and crop diversification was affected positively and significantly by livestock at 1 percent significant level. It showed that adopting the combination these practices increased by 2.8 percent as livestock increased by a unit. Adoption of full combination CSAPr also was affected positively and significantly by livestock at 1 percent significant level. It showed that when livestock increased in tropical livestock unit, the likelihood of adopting full combination of CSAPr increased by 3.1 percent. For the rural community livestock serves as main source of soil fertility components such as manure/compost that play important role in soil fertility improvement. It also used as source of households' income for purchasing input that enhances uptake CSAPr.The livestock enhances adoption of irrigation, fertilizer, various improved crop variety and other farm expenses. This findings are consistent with those of (Mesfn et al., 2016; Aryal et al., 2018; Etim et al., 2019; Legese et al., 2019; Tekeste, 2021; Mebratu et al., 2022; Abebe et al., 2023) those revealed households with number of livestock have higher likelihood of adopting and using organic fertilizer to improve their soil fertility. In most of rural area including study area oxen are mainly served as source of draught power to plough farm land. The ox number in the area enhances farm activity to be accomplished on time. That means it increases the activities to be done efficiently and effectively. Results revealed that adoption of irrigation, combination of crop diversification and soil fertility management were influenced positively and significantly by number ox at 5 percent and 10 percent, respectively. The adoption of full combination of CSAPr increased positively and significantly by number of ox at 10 percent significant level.

It can be seen that access to climate information positively and significantly affected the adoption of crop diversification, and irrigation practices at 10 percent and at 1 percent significant level, respectively. Similarly, the adoption of soil fertility management and irrigation was influenced positively and significantly by access to climate information at 1 percent significant level. The adoption of full CSAPr was also affected positively and significantly by climate information at 1 percent significant level. The likelihood of adopting full CSAPr increased by 12.7

percent as farmer accessed climate information. Having timely and real information regarding climate shocks particularly drought, encourage the farmers to adopt CSAPr. This also helps them to reduce the negative impact of climate shocks on the farmers' livelihood. According to (Gemada et al., 2023), the continues investigation and analysis on level of climate shock knowledge, its impacts and strategies against climate shocks is mainly required for designing policy and strategic support required. This agreed with (Hirpha et al., 2020) who showed that adaptation strategies had significantly influenced by climate information.

The adoption of crop diversification and irrigation practice was affected positively and significantly by market information at 10 percent and 1 percent significant level, respectively. The likelihood of adopting irrigation and crop diversification increased by 6.3 percent, and 5.8 percent as farmer gets market information. When the rural farmers obtained timely and sufficient market information on input and output prices, they can adopt CSAPr and produce the farm product that needed in the market. They can also get more information regarding source of input for the adoption of CSAPr against drought effects. It showed that participation in social organization (membership) has influenced positively and significantly the probability of adopting irrigation practices at 10 percent significant level. The adopting of combination of soil fertility management and irrigation practices also significantly influenced at 10 percent significant level. The probability of adopting irrigation practice increased by 4.6 percent as farmer participated in social organization. The adoptions of combination of soil fertility and irrigation practices were increased by 5.6 percent, when farmer participated in social organization. This also may be due to the fact that farmers' participation in such social group can enhanced them to join information network regarding climate shocks, adoption option and source of input from their area. The finding also agreed with (Mwungu et al., 2018; Etim et al., 2019) and (Abebe et al., 2023) those who showed adoption and implementation of CSAPr practices significantly influenced by social group.

Current drought of 2022 year was considered: Long term and short term climatic shocks such as drought can have major contribution to the adoption of CSAPr. Regarding drought or climate shocks variable, standard precipitation index (SPI) of 3-months scale was used which is mostly used in drought indices. The SPI is set equal to 1 if the value of SPI is less than 1.5, indicating a drought, and 0, otherwise. The results revealed that adoption of soil fertility management was significantly influenced by drought in summer season of 2022 at 10 percent significant level. The adoption of combined soil fertility management and crop diversification was significantly influenced by drought in summer season of 2022 at 5 percent significant level. Similarly, the adoption of soil fertility and crop diversification practices combination was significantly influenced by current drought at 5 percent significance level. The adoption of crop diversification and irrigation practice combination was also significantly influenced by current drought at 5 percent significance level. This implied that farmers that have challenged due to drought may found importance of cultivating different crop varieties and applying irrigation on their farm. This also shows importance of summer season rainfall for cultivation that agreed with finding of (Asfaw et al., 2016) that showed significant of the summer rainfall for crop cultivation.

Previous drought year: this variable constructed by using seasons of 2020 year. These season of the year are spring and summer. The adoption of crop diversification practice was affected positively and significantly by previous year drought at 1 percent significant level, The adoption of irrigation practice was also affected positively and significantly by previous year drought at 1 percent significant level, The adoption of crop diversification and soil fertility management practices combination was positively and significantly influenced by previous year drought at 10 percent significant level. The adoption of crop diversification and irrigation practice combination was also positively and significantly influenced by previous year drought at 10 percent significant level.Similarly, adoption of full combination of CSAPr was significantly affected by previous year drought at 1 percent significant level. The probability of adopting full combination of CSAPr was increased by 12.7 percent as drought occurred in previous year. This implied that, past year drought increases the probability of adopting CSAPr such as soil fertility, crop diversification and irrigation on their farm. Therefore, drought incentivized implementation of CSAPr practices. This results agreed with (Huang et al., 2014) that showed adoption of crop diversification practices determined by past drought shock experience. Similarly it agreed with (Khanal et al., 2018) who noted the likelihood to adapt and use practices influenced by drought/ flood in the last five years

3.6. *Impacts of CSAPr adoption on consumption expenditure*

Using MESR model, the inverse mills ratio was computed from probability of alternative CSAPr which is served as correction term for the next step of the model. Using OLS regression, the outcome model was computed by using mills ratios as additional variable. Then, the actual values and conditional expectation of consumption expenditure value was computed for both adopters and non-adopters under counterfactual (outcome of adopters, if not adopted) and actual scenarios as shown in the following (Table7.). In this impact evaluation, annual per adult consumption expenditure was calculated in terms of Ethiopian Birr (ETB). The result revealed that, adopters of the alternative CSAPr practice have higher total consumption expenditure per adult equivalent than they had not adopted practice. This shows that adoption of CSAPr provides more consumption expenditure compared to non-adoption. The highest annual consumption expenditure was obtained when farmers adopted combination of crop diversification and irrigation practices ($F_0D_1I_1$) which is 12610.9ETB.The adopter farmers also obtained higher annual consumption expenditure when adopted combination of integrated soil fertility management and crop diversification ($F_1D_1I_0$) which is 11274ETB. The effect of actual adoption on adopters' outcome showed that, out of total effect brought by adoption of CSAPr, 72.4 percent of incensement was obtained by combination of practices whereas 27.6 percent was by single practices compared to that of non-adopters.This result agreed with (Zegeye,2021),that indicated the adoption in package provides higher consumption than in isolation.

The value of treatment effect on adopters of CSAPr particularly, irrigation, crop diversification and soil fertility management was shown in the (Table7). It showed that adoptors of crop diversification increased their consumption expenditure per adult which is 1020.6ETB. The adoption of irrigation practice provided higher consumption expenditure per adult for adoters which is 877 ETB. The adoption of soil fertility and irrigation practices combination generated 354.2ETB, and full combination of practices provided the highest consumption expenditure per adult of adopters which is 2622ETB compared to the absence of adoption. The adoption of the combination of crop divarication and irrigation practice ($F_0D_1I_1$) showed also significantly increased per adult consumption adopters which is 2188.7ETB. The combination of crop diversification and soil fertility management practices adoption ($F_1D_1I_0$) generated 1263.4ETB.This implied that adopting the combination of CSAPr provided significant per adult consumption expenditure impacts than adoption of separate or single practices. This result agreed with (Zegeye,2021), that revealed adoption of multiple technologies increases consumption expenditure significantly. This results agreed with (Zegeye,2021; Biru et al., 2020) that showed combination of improved agricultural technologies have significant impacts on increasing consumption expenditure when farmers adopted the combination of multiple complementary practices.

Regarding adoption effects on non-adopters ($F_0D_0I_0$) or treatment effect on non-adopters(ATU) currently obtained consumption expenditure per adult of 9434.5ETB.But this expenditure would increased by 2.42 percent if they had adopted the soil fertility($F_1D_0I_0$) and 4.8 percent if they had adopted irrigation($F_0D_0I_1$). The consumption of non-adopter would increase by 6.7 percent if they had adopted the combination of

Table 7
Impacts of CSAPr practices adoption (ATT).

Sampled	Practices	Adopter outcome I	No-adopter outcome III	Impacts Treatment Effect
Household that adopted climate smart Agriculture	$F_1D_0I_0$	10383.3 (147.57)	10316.7 (192.86)	66.6
	$F_0D_1I_0$	10504.7 (403.99)	9484.09 (449.70)	1020.6^{**}
	$F_0D_0I_1$	9669.5 (236.46)	8792.46 (203.83)	877.0^{**}
	$F_1D_1I_0$	11274 (111.00)	10010.56 (173.49)	1263.4^{***}
	$F_1D_0I_1$	10219.4 (112.26)	9865.14 (135.17)	354.2^{**}
	$F_0D_1I_1$	12610.9 (455.97)	10422.19 (649.74)	2188.7^{***}
	$F_1D_1I_1$	9533.0 (162.71)	6911.12 (396.33)	2621.9^{***}
		IV	II	ATU
Household that do not adopted climate smart Agriculture	$F_0D_0I_0$	9668.9 (193.45)	9434.5 (183.5)	234.3
	$F_0D_0I_0$	9475.6 (183.51)	9434.5 (183.5)	41.1
	$F_0D_0I_0$	9912.0 (187.66)	9434.5 (183.5)	477.5^{**}
	$F_0D_0I_0$	10113.6 (200.26)	9434.5 (183.5)	679.0^{***}
	$F_0D_0I_0$	9732.5 (170.62)	9434.5 (183.5)	298.0
	$F_0D_0I_0$	10013.5 (167.38)	9434.5 (183.5)	578.9^{**}
	$F_0D_0I_0$	10320.9 (115.86)	9434.5 (183.5)	886.3^{***}
		BH_1	BH_0	TH (Transitional)
Transitional and base Heterogeneity effects of adoption	$F_1D_0I_0$	714.4 $(243.31)^{***}$	882.2 $(266.26)^{***}$	−167.8
	$F_0D_1I_0$	1029.1 $(481.49)^{**}$	49.6 (468.19)	979.5^{**}
	$F_0D_0I_1$	−242.5 (263.17)	−642.1 $(273.50)^{**}$	399.6
	$F_1D_1I_0$	1160.4 $(228.9)^{***}$	576.01 $(254.0)^{**}$	584.4^{**}
	$F_1D_0I_1$	486.9 $(204.24)^{***}$	430.6 $(232.14)^{**}$	56.3
	$F_0D_1I_1$	2597.4 $(485.72)^{***}$	987.6 (645.63)*	1609.7^{***}
	$F_1D_1I_1$	−787.9 $(199.8)^{***}$	−2523.4 $(422.6)^{***}$	1735.6^{***}

Source:Survey,2023; ***,** and * shows at 1percent,5 percent and 10 percent significant, respectively
The actual value for adopter and non-adopters were represented as ‘I’ and ‘II’ whereas the counterfactual for both adopter and non-adopters were represented by ‘III’ and ‘IV’
The adoption effect on adopters (ATT) =II-III whereas adoption effect on no adopters (ATU)=IV-II

soil fertility and diversification ($F_1D_1I_0$) practices and also would increased by 3.0 percent if they had adopted irrigation and soil fertility practices combination ($F_1D_0I_1$). Similarly their consumption would increase by 5.8 percent if they had adopted crop diversification and irrigation($F_0D_1I_1$) and it would increase by 8.6 percent if they had adopted the full combination of practices ($F_1D_1I_1$),. This showed significant impacts of combination of practices than separate one, if adopted by non-adopters. This results also agreed with (Teklewold et al., 2017),who revealed combination of agricultural practices such irrigation water application, improved crop variety and soil fertility has positively related to net income.

The heterogeneity among non-adopters (BH_0), and that of adopters (BH_1) of CSAPr shown as base heterogeneity (Table7). The negative BH_0 value of non-adopters showed that the adopters who actually adopted the CSAPr would have lower consumption expenditure compared to not adopting. The higher per adult consumption expenditure indicates higher welfare status of the farmers. Therefore, adoption of CSAPr mainly, diversification, irrigation and soil fertility management practices improved farmers per adult consumption expenditure. Generally, adoption of soil fertility management practice, irrigation and crop diversification increased the agricultural yield for non-adapter when they adopted. This is recognized due to the adoption of compost or manure improves the soil fertility as the same time reduces the cost of inorganic fertilizer. This also agreed with (Bedeke et al., 2018) that showed manure and crop residue retention improve soil fertility and reduces fertilizer cost.

4. Conclusion and recommendation

This study investigated the factor affecting adoption of CSAPr practice and its impact on per adult consumption expenditure. The multinomial endogenous switching regression model was used to analyze impact of adoption on consumption expenditure. The model results showed that education increased adoption of integrated soil fertility management. It showed educated farmers have better knowledge on agricultural risks and encouraged to apply CSAPr practices. The drought experience influenced adoption of soil fertility, crop diversification and irrigation practices. It implied that experience/exposure to drought within the last ten years increased the adoption of CSAPr practice. Large family size also positively influenced crop diversification, soil fertility and irrigation. This may be due to the large family member serves as labor that encourages adoption of labor intensive practices. The results showed access to climate information influenced adoption of crop diversification, irrigation, soil fertility and full combination of practices. It implied that having sufficient information regarding adverse effect of drought encourages adoption of practices. The adoption of appropriate CSAPr also reduces negative effects of drought. Access to market information positively influenced the adoption of irrigation and crop diversification. This may be due to input and output prices information increasing. The large number of livestock impacted adoption of crop diversification, irrigation, soil fertility and full combination of practices. The livestock served as main source of manure/compost for soil fertility and income source.

Current drought of 2022 and previous year drought of 2020 year influenced adoption of crop diversification, irrigation, soil fertility and full combination of practices. The occurrence of drought in the past year influenced adoption of practices through influencing input choice for current season. Farmers can learn from past drought and adopt appropriate practices. This adoption also used as climate shocks copping strategy. So, it can be concluded that, past drought affects adoption of CSAPr practice. In this impact evaluation, annual per adult consumption expenditure was calculated in Ethiopian Birr (ETB). The result showed that, the highest annual consumption expenditure was obtained when farmers adopted combination of crop diversification and irrigation practices ($F_0D_1I_1$) which is 12610.9ETB. The adopter also obtained higher annual consumption expenditure when adopted combination of integrated soil fertility management and crop diversification ($F_1D_1I_0$) which is 11274ETB. The result showed that, all the adopters obtained higher consumption expenditure per adult as compared to the non-adopters ($F_0D_0I_0$) which is 9434.5ETB. It also showed that, out of total consumption expenditure increased by adoption of CSAPr, 72.4 percent of incensement was obtained by adopting combination of practices whereas 27.6 percent was by single practices. The average treatment effects on treated (ATT) confirm that adoption of CSAPr significantly increased consumption expenditure compared to non-adopters. Moreover, the adoption of combined full CSAPr ($F_1D_1I_1$) significantly increased per adult consumption expenditure. Drought trends also shows increasing over time and needed mitigation.

The result revealed that, the adoption of irrigation, crop diversification and soil fertility management significantly increased consumption expenditure. The education, livestock, climate information and access to market information increased CSAPr adoption. So, it is crucial strategy to advance the farmers and experts' awareness regarding climate shocks and adoption strategy. Provided that various factors affected the adoption of CSAPr, policymakers ought to encourage institutional services including adult education, market information service, and weather information delivery system. This e so as to enhance adoption of CSAPr practices. Observing the livestock benefit, it is important strategy to increase farmers' asset building against drought. This can be through facilitating credit for livestock purchasing. Therefore, the policymaker should target on farmers' asset building plan. The other implication is for facilitating adult education and market linkage facilities for products. The other important implication is to improve extension service and weather related information delivery system to combat the current and future drought. Observing the drought tend in the area, it is imperative that GOs and NGOs should focus on promoting the adoption of different climate smart techniques against drought.

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Ethics Approval

There were no human or animal tissue used in this work because the research was conducted based on survey questionnaire. Therefore, the ethical approval was not applicable.

Consent to participate

The authors confirmed that verbal consent was obtained from all participants. Participants were well informed in local language about the objectives of the research before starting the data collection by informing them the data would be used for scientific research only.

CRediT authorship contribution statement

Jema Haji: Writing – review & editing, Validation, Visualization, Supervision. **Mume Jafer Ahmed:** Methodology, Conceptualization, Software, Formal analysis, Writing – original draft, Data curation. **Moti Jaleta:** Writing – review & editing, Visualization, Supervision, Validation. **Jemal Kedir Ibrahim:** Writing – review & editing, Visualization, Supervision, Validation.

Declaration of Competing Interest

Concerning competing interest, all authors declare that they have no known competing financial interest and personal relationship that could have related to influence the work reported in this paper.

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Appendix

Table A.1
Multicollinearity Test

Variable	VIF	1/VIF
Spring Spi	1.38	0.7269
S-Spi	1.38	0.72712
Family Size	1.29	0.77641
Labor Force	1.27	0.78799
Education of Respndt	1.25	0.80162
Age Respndt	1.23	0.81059
Non-Farm Activities	1.18	0.84683
Irrigation	1.16	0.86368
Number of Oxen	1.15	0.87076
Farm Experience	1.13	0.88381
Crop Diversification	1.13	0.88497
Access to Extension	1.13	0.88703
Organization Membership	1.12	0.89281
Livestock TLU	1.11	0.90355
Sex Respndt	1.1	0.91185
Market Distance	1.09	0.91928
PSNP Participation	1.08	0.93008
Access Climate Infor	1.07	0.93154
Market Information	1.07	0.93729
Farm Size	1.06	0.94107
Plot number	1.06	0.94285
Drought Experiance	1.06	0.94755
Mean VIF	1.16	

Table A.2
Diagnostic test of the model

Tests	Test name	Statistics value	Prob/decision
LR(Likelihood-ratio test) Chi^{2}(105	Model fitting test	289.87	0.0000
Hausman and McFadden test	IIA assumption test	All chi^{2}-insignificant	AII is not violated
hettest(Breusch-Pagan test) (Chi^{2}(1)	Hetroscedasticity	1.26	0.2623
vif test	Multicollinearity	1.16	No problem

Data availability

Data will be made available on request.

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