Assessing small-holder coffee farmers' awareness and choice of climate change/variability adaptation strategies in Mattu Woreda, southwestern Ethiopia

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ABSTRACT

It is advocated that smallholder coffee farmers' characteristics and perceptions strongly affect the use and selection of climate variability/change response mechanisms. Therefore, we investigated the climate change/variability perceptions and determining factors of the selection of smallholder coffee farmers' adaptation strategies over the period 1992–2022 in Mattu woreda, Ethiopia. This study used cross-sectional research design as the data was collected from different groups (adaptor and non-adaptor) at a time. A sample of 325 coffee farmers were randomly selected for a self-administered questionnaire supplemented with face-to-face interviews and focus group discussions. A multinomial logistic regression model was used for statistical analysis. The findings of the study showed that 79% of coffee farmers are conscious of the prevailing climate change and related consequences on coffee growth, production, productivity, and quality. Coffee farmers practiced planting coffee under shade, close spacing, mulching, and irrigation, developing an adaptable coffee variety, developing disease and heat-tolerant varieties, changing the location and planting date, and pruning as strategies to lessen the influence of climatic change on coffee production. However, most coffee farmers prefer to plant coffee under shade and pruning. The selection of climate change/variability adaptation strategies among coffee farmers is significantly influenced by age, family size, coffee farm experience, land holding size, income of HHs, distance to coffee farm plots, access to climate information, and training and TLU ($P < 0.05$). Therefore, provision of climate information, extension services, and seed varieties to farmers, and improving social and physical infrastructures are recommended to better adapt and mitigate the effect of climate change/variability.

KEYWORDS

adaptation strategies; climate change/variability; determinants; multinomial logistic regression model

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1. Introduction

Climate change (hereafter CC) was an environmental problem since the Industrial Revolution, and currently a critical universal challenge, as industries have been the main contributors to the increasing trend of atmospheric greenhouse gases (Zandalinas et al. 2021). It causes an increasing temperature, flooding, drought, and depletion of environmental resources (Naqvi and Sejian 2011; Parry et al. 2004). Climate change is predicted to cause significant (3–30%) crop yield and 15–37% of fauna and flora species loss by 2050 if no adaptive measures are taken (Nelson et al. 2009). Africa's smallholder farmers are more vulnerable to the influences of climate change/variability ([hereafter CCV]; Mubiru et al. 2018; Makate 2019; Naab et al. 2019). The problem is predominantly serious within the smallholder societies (Hein et al. 2019); whose livings are deeply reliant on the healthiness of seasonal climatic situations (Gemeda et al. 2021).

It is estimated that 62.8% of Ethiopia's workforce is employed in agriculture (African Economic Outlook 2024), which also provides more than 85% of the country's foreign exchange earnings and accounts for 32.4% of Ethiopia's GDP (National Bank of Ethiopia 2022). However, it is anticipated that Ethiopia's agricultural output will decline by 50% in the near future related to CCV (FDRE 2011). It has therefore been shown to have potentially serious effects on development and livelihood (Mengestu 2011).

Recent reports indicated that eastern Africa is experiencing severe drought and wet scenarios currently. Ethiopia as a typical East African nation, experiences severe fluctuations in the trend of rainfall and even temperature in different areas. Several recent research reports documented a decreasing (Asfaw et al. 2019; Hill and Porter 2017), increasing (Gemeda 2019; Tesfamariam et al. 2019; Wedajo et al. 2019), and both (Gebrechorkos et al. 2018; Degefie et al. 2019) annual and seasonal rainfall trends in different parts of Ethiopia.

As part of southwestern Ethiopia, the Illu Aba Bora zone (in which Mattu woreda is its part) is a moist evergreen Afromontane forest area (Friis et al. 2010) with high potential for wild Coffea arabica production, but starting from the recent past it has been influenced by recurrent CCV (Desta and Belayneh 2023). It is documented that the highest reduction in rainfall (Gemeda et al. 2021) and increase in temperature (Desta and Belayneh 2023; Gemeda et al. 2021) is observed. Besides, rainy days in the high coffee-growing region of the southwestern parts of Ethiopia declined from 9 to 5.5 months (almost by 39% the previous; Fekadu et al. 2020). Similarly, the projected information depicted that an increasing trend (2.2 °C rise annually) of temperature in all regions is expected by the 2050s (Conway and Schipper 2011).

Climate variability/change pointedly affects the valuable cash crops in southwestern Ethiopia (Gemeda et al. 2021). For instance, a study by Desta and Belayneh (2023) reported that the rise in temperature significantly affected coffee production in southwestern Ethiopia. The deteriorating bioclimatic suitability for Coffea arabica in the coffee-growing wettest topography of Ethiopia is an alerting climate change-linked negative effect (Davis et al. 2012; Moat et al. 2017). Coffee-growing landscapes are projected to decline to nearly 100% in 2080 (Davis et al. 2012).

Adaptation, therefore, remains among the list of policy and implementation options to better prepare and respond to climatic change challenges that prevail in the agrarian population such as coffee farmers. There are several causes and compelling arguments for a more general consideration of CCVAS (Amare et al. 2018). For instance the world has experienced some degree of CC due to past greenhouse gas emissions, which cannot be prevented even by the most ambitious reductions in emissions (Füssel and Klein 2006). The effects of emissions reductions will take decades to fully manifest, but most adaptation measures have more immediate and lasting benefits (Rahman 2013). Adaptations can be effectively implemented on a local or regional scale and most adaptations reduce climate variability-associated risks, which cause frequent hazards in different parts of the world (Amare et al. 2018). Similarly, smallholder Ethiopian coffee farmers have practiced adaptation techniques to resist extreme events and high inter-annual climate variability, despite their high level of vulnerability to climate change. Furthermore, farmers have been practicing, evaluating, and embracing a variety of coping techniques (AEO 2016). Nevertheless, still, coffee production has shown a reduction mainly related to climate change-associated consequences (Desta and Belayneh 2023).

In these regards, understanding farmers' knowledge of CCVAS is important to better prepare them to respond to the upcoming negative consequences of CCV on coffee production and smallholder coffee farmers. However, studies conducted in the wettest landscapes; particularly in southwestern Ethiopia are very limited (Gemeda et al. 2021). This is mainly related to aligning the effect of CCV to the past drought and famine scenarios in the dry lands of Ethiopia. The thoughtfulness of smallholder coffee farmers about CCV and the determinants of the selection of responding mechanisms is noteworthy; take lessons and immediately respond to it as a precautionary measure. Therefore, the main purposes of this study were to 1) assess the perception of coffee farmers about climate change and variability and 2) identify the main determining factors of selection and use of different climate change adaptation strategies among smallholder coffee farmers. This study presents smallholder coffee farmers' knowledge of CCV and determinants of the choice of effective adaptation strategies, which is expected to give scientific evidence for policymakers for intervention.

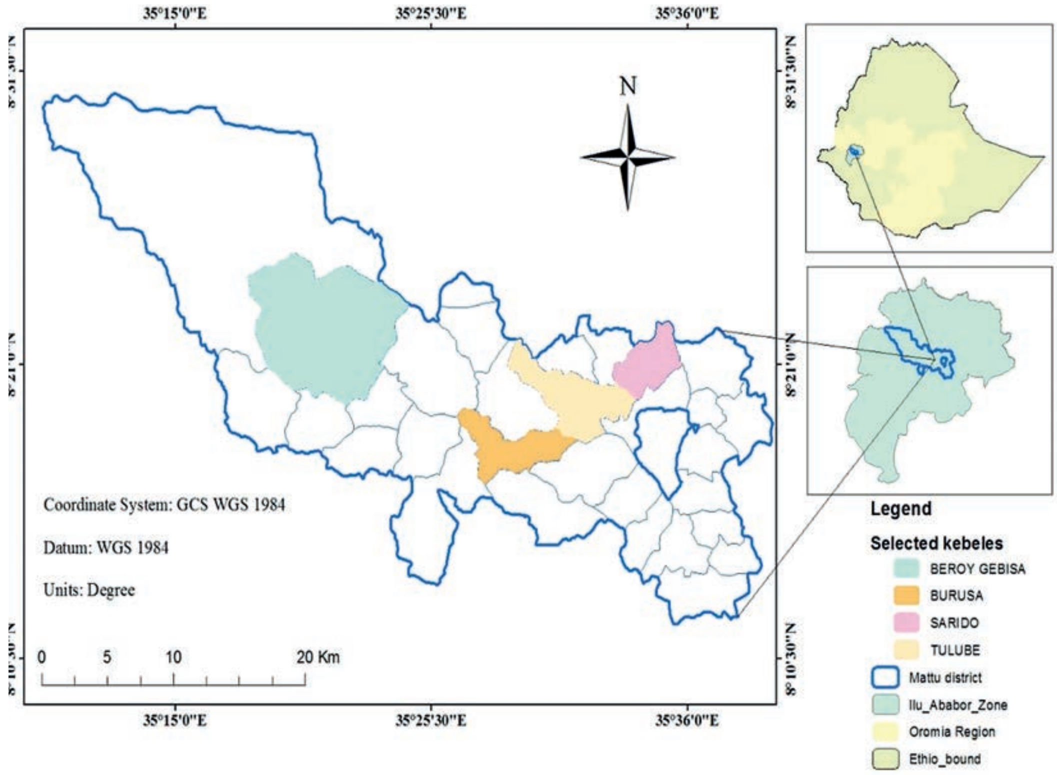

Fig. 1 Mattu woreda and study kebeles in Illu Aba Bor zone, southwestern Ethiopia.

2. Materials and methods

2.1 The study site

Mattu woreda[1] is found in the wettest highland landscapes of southwestern highlands, Oromia National Regional State, Ethiopia (Fig. 1). It is located between 8°11′20″ to 8°30′12″ latitude and 35°10′20″ to 35°40′12″ longitude. Mattu woreda covers a total area of 1452 km^2. The major city (Mattu), is situated about 600 km southwest of the country's capital (Addis Ababa) via the Addis-Mattu-Gambella road.

The area is described by diverse landscapes typically called the wettest highland of Ethiopia. The area is dominated by wet Woina Dega/Sub-tropical and Kolla/tropical agroecological zones. The area receives rainfall almost year-round (6 to 9 months), although recently declined to 5.5 months (Fekadu et al. 2020). The long-term mean total rainfall of the woreda is 1,408.6 mm (thirty years of yearly rainfall data). The area's temperature increased over time, reaching an average of 19.67 °C.

The area is a typical coffee crop production area, specifically the wild Coffea Arabica in Ethiopia. Subsistence mixed crop and livestock farming is the key means of livelihood for the community. The predominant cash crop of the area is coffee, which plays a significant role in smallholder farmers' source of cash and the local economy. It is reported that approximately 60% of the local community directly depends on coffee-based livelihoods (Mattu woreda agricultural office 2021).

2.2 Research design and approach

The study used a cross-sectional research design. Cross-sectional research design was used in this study because the data were collected from two groups (both the CCSAS adaptors and non-adaptors) at a time. Creswell (2012) states that a mixed research approach yields a more comprehensive understanding of the research problem and questions than either method alone. For this reason, mixed research approach was employed for this study. Simultaneous collection of data is the hallmark of concurrent parallel mixed research strategy was adopted for this study. The combined data sets are then analyzed to reinforce the limitations of the quantitative data and provide a more comprehensive understanding of the research problem.

2.3 Sources of data

Data concerning smallholder coffee farmers' knowledge about CC were collected from small-holder coffee farmers' HHs, developmental agents (DAs) working in each kebele[2], woreda, and zonal experts.

1 *Woreda* is the second lowest administrative division in the Ethiopian current administration tiers (five tiers).

2 Kebele is the lowest administrative division in the Ethiopian current administration tiers.

2.4 Sample size determination

Among 30 kebeles in the woreda, four (Beroy Gebisa, Tulube, Burusa, and Sardo) were selected purposely considering their high coffee-producing trends and better experience of farmers' use of CCVAS. Then, 325 smallholder coffee farmers were selected using systematic random sampling. Kothari (2004) formula was used for sample size determination from the target population (2256 HHs). A proportional sample allocation technique was applied to get a representative sample from the selected kebeles (Tab. 1).

Tab. 1 Sampled kebeles, total HHs, and samples.

No.	Name of Kebeles	Total HHs			Sample HHs
		Male	Female	Total	
1	Beroy Gebisa	391	38	429	62
2	Burusa	606	105	711	102
3	Tulube	506	108	614	89
4	Sardo	420	82	502	72
Total		1923	333	2256	325

Source: Mattu *Woreda* Administration Office, 2022.

$$\frac{Z^2 pqN}{e^2 (N-1) + Z^2 pq},$$

where n = sample size
Z = the standard variant at 95% confidence interval (Z = 1.96)
N = total population (2256)
P = proportion of sampled population (0.01)
e = 0.01 (since the estimate should be within 1% of the true values)

$$q = 1 - p$$

Using their knowledge, experience, and expertise of CCVAS in the area as a criterion, five model farmers, two agricultural officers, two developmental agents (DAs), and two natural resource management offices were chosen for in-person interviews. Four focus group discussions each consisting of seven farmers from each sample kebele were conducted.

2.5 Data collection instruments

Data were gathered using a questionnaire that included both open-ended and closed-ended questions. Questions were prepared in Afan Oromo (local language) for a simple understanding of the questionnaire by the respondent households. Professionals from the offices of climate, agriculture, and natural resource management as well as woreda administration were interviewed in person. Due to their close interactions with coffee growers, these individuals are more knowledgeable about the issues of climate change and variability. For this purpose, open-ended, semi-structured interview questions were used. Additionally, focus group discussions were held with seven specifically chosen HHs from each kebele. A total of four focus group discussions were made. It will be crucial to gather diverse opinions and data regarding CC and adaptation techniques from smallholder coffee farmers. Lastly, the researcher made direct, first-hand observations at the study site to observe conservation practices related to climate variability/change adaptation practices.

2.6 Method of data analysis

The textual organization and analysis of the qualitative data took the shape of narratives and descriptions. Both descriptive and inferential statistics were applied to the analysis of quantitative data. Descriptive statistics including percentage, and frequency of occurrence were used and presented in the form of tabulations, graphs, and charts. A multinomial logistic regression model was employed with the help of Statistical Package for Social Sciences (SPSS) version 26.

A multinomial logit was utilized to ascertain the determinant variables affecting the selection of adaptation tactics used by smallholder coffee farmers. With six possible outcomes (planting coffee under shade, close spacing, mulching, and irrigation; using adaptable coffee varieties; applying disease- and heat-tolerant varieties; altering the location, planting date, and pruning), dependent variables are different strategies used by coffee farmers to adapt CCV.

Therefore, for this study, HHs' selection of adaptation strategy (Yi) is determined by various explanatory variables X_1, X_2, X_3, X_4, X_5, X_n, which can be formulated as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon$$

Where; Yi: Is HH participation in adaptation strategies to CCV X_1, X_2, X_n: are explanatory variables that are related to adaptation strategies, **ε** is the error term, followed by B_1 and B_2, B_n: are the slopes of the model's explanatory variable coefficients (Tab. 2).

Log likelihood ratio (LR), Chi-square (X^2), and Pseudo R^2 goodness-of-fit tests were performed to assess the predicting ability of the model. Multi-collinearity describes the correlation between multiple independent variables in a model. When two variables have a correlation of +/−1, they are said to be perfectly collinear. Menard (2000) explained that there is no multi-collinearity if the tolerance value is >0.25 and the VIF value for each variable is <10. It is calculated as:

$$VIF_i = \frac{1}{1 - Ri^2}$$

Tab. 2 Independent variables and their expected effect on the choice of climatic variability/change adaptation practices among smallholder coffee farmers in Mattu woreda.

Variables	Variable type	Description	Exp. sign
Sex	Dummy	1 = Male; 2 = Female	+*
Age	Continuous	Age of the HH	+
Coffee Farm exp.	Continuous	Coffee farm experience of the HH	+
Landholding size	Continuous	Total land owned by the HH in hectares	+
Credit access	Dummy	0 = No; 1 = Yes	+
Family size	Continuous	Number of family members per HH	+/−
Educational level	Continuous	The education level of HH	+
Climate information	Dummy	1, if a HH has access to climate information; 0 otherwise.	+
Extension service	Dummy	HH head access to extension advice and training per year [0 = No; 1 = Yes]	+
Income of HHs	Continuous	HH farm income	+
Incentives	Dummy	Incentives are given while participating in adaptation practices [0 = No; 1 = Yes]	+
Livestock holding (Tropical Livestock Unit (TLU))	Continuous	Number of livestock the HH owned in TLU	+/−
Distance to farm plot	Continuous	Accessibility of farm plots in kilometers	−

* refers if the household is male headed it will have an expected positive effect on the adoption decision.

3. Results and discussion

3.1 Sample HHs characteristics

As shown in Tab. 3, males were the predominant HHs (hereafter HHs; 84.7%), while the remaining 15.3% were females. Several authors argue that male-headed HHs have access to new technologies and take more appropriate actions than female-headed HHs (Asfaw et al. 2019; Deressa et al. 2011). Usually under the agrarian economy of rural Ethiopia, women HHs are classified under poor wealth rank.

The majority of the HHs were between 56 and 65 years old, which accounts for 31.4%. Among the total households considered in this study, 35.6% and 28.8% of them were having a family size ranging from 7 to 9 and 4 to 6, respectively. Therefore, large numbers of the HHs were within the active age group. It is known that these groups are the most productive forces that can play a decisive role in generating appropriate and suitable responses to CC for their locality and these people are ready and fit to take responsibility just to cope with the challenges paused due to CC.

The majority (69.5%) of the households' received no formal schooling. On the other hand, about 23.7% and 6.8% of them completed primary and secondary education, respectively. It is understood that education is considered central in determining the readiness to adopt new ideas, and enables people to realize the diversification or specialization of livelihood activities and technology. Indeed, HHs better literacy level was assumed to have a positive impact on their involvement to use and better accept adaptation mechanisms. Household heads higher levels of education increase the opportunity and access to information, better understanding and application of new technologies as well as better ability to withstand climatic risks (Belay et al. 2017; Hadgu et al. 2015). Furthermore, according to Ndambiri et al. (2013), education improves farmers' capacity to accept, understand, and realize information necessary to make creative decisions on their farmland.

Tab. 3 Descriptive statistics of sex, age, marital status, family size, and educational levels.

Descriptive variables	Description	Frequency (f)	Percentage (%)
Sex	Male	275	84.70
	Female	50	15.30
Age	26–35	77	23.70
	36–45	80	24.60
	46–55	36	11.00
	56–65	102	31.40
	> 65	30	9.30
Family size	1–3	44	13.60
	4–6	94	28.80
	7–9	116	35.60
	10–12	52	16.10
	None	19	5.90
Marital status	Single	19	5.90
	Married	278	85.60
	Divorced	25	7.60
	Widowed	3	0.80
The educational level of respondents	Cannot read and write	226	69.50
	Primary education (1–8)	77	23.70
	Secondary education (9–12)	22	6.80

3.2 Coffee farmers' perception of climate change/variability

About 60.2% of the coffee farmers explained that the trend of temperature in the last three decades was increasing, but 33.1% perceived it is constant and the remaining 6% perceived decreasing (Tab. 4). Similarly, 82.2% of stallholder farmers explained a decrease in rainfall, while 17% did not over the period 1992-2022. Farmers' perception has a greater role in being prepared and withstand in the changing climatic situation (Wagesho and Yohannes 2016).

Before ~20 years, most farmers' land was covered with dense plant forests, and this was also essential to their means of sustenance, especially when it came to producing coffee. However, the forest cover had declined due to the growing human population and their desire to expand land for the production of crops and other uses like building materials and various furniture, charcoal, and wood. The FGD participants also mentioned that although the number of coffee growers has occasionally increased, the yield of coffee has decreased due to diseases and climate change/variability.

Tab. 4 Coffee farmers' perception of rainfall/temperature change trends over the period 1992–2022 (n = 325).

Descriptive variables	Description	Frequency (f)	Percentage (%)
Temperature trend	Increases	196	60.2
	Decreases	22	6.8
	Constant	107	33.1
	I don't know	–	–
Rainfall trend	Increases	–	–
	Decreases	267	82.2
	No change	58	17.8
	I don't know	–	–

A five-point Likert scale rating was employed to gauge the sample respondents' perceptions of a few chosen CC attributes. Farmers who choose to simply agree or strongly agree are thought to perceive change differently than those who do not. The results showed that most respondents (79%) thought there was less rainfall and that it was insufficient to sustain crops during their whole growing season. The findings of this study were similar to those of Tesfaye and Seifu (2016) and Belay et al. (2017), which claimed that 79.1% of farmers believed rainfall could not sustain production. The results of the FGD verified that the rainfall usually ends before or after the crop-growing season. In a similar vein, 90% of the participants noted a rise in the quantity of hot spots. Eighty percent of respondents reported seeing an early end to the rainy season, and eighty-two percent reported that the start of the rainy season was later than usual (Tab. 5). The belg (spring) season production in the woreda, which typically produces a sizable amount of output, abruptly declined. The research reports of Tesfaye and Seifu (2016) corroborate the results, which also showed that farmers acknowledged the rise in crop disease and pest infestation that had previously become an issue.

3.3 Smallholder Coffee farmers adaptation strategies to climate change/variability

The study result revealed that 28 and 24.6% of the HHs use planting coffee under shade and pruning as a prime strategy to cope with CCV by coffee farmers, respectively (Tab. 6). Besides, 17 and 14.4% of coffee farmers used heat-tolerant varieties and diseases, and altered the planting date and location as a strategy, respectively.

Farmers reported planting coffee under shade regulates light penetration to coffee plants (91.5%) and increases coffee yields and quality (79.7%). Others experienced climate adaptation strategies to improve

Tab. 5 A Likert scale-based measurement of small-holder farmers' perception of CC in the Mattu woreda. Note: 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree.

CC signals and pattern of changes	Farmers perception (n = 325)				
	1	2	3	4	5
Rainfall unable to support a full growing period	–	21.00	–	62.90	16.10
Increase in the number of hot days	10.00	–	–	62.80	27.20
Early cessation of rainfall	–	20.00	–	34.40	45.60
Delay of the onset of rainfall	–	10.00	–	7.25	82.75
The community is aware of the effect of CC on coffee yield	27.00	56.70	–	7.30	9.00
Rise of the price of coffee due to low productivity caused by CC	43.30	30.00	3.00	–	23.70
High deforestation to compensate the income and livelihoods losses from coffee	11.80	–	6.20	28.50	53.50
Change of livelihood due to CC	31.00	16.50	–	18.50	34.00
High fluctuation of temperature and rainfall	5.90	–	5.00	24.10	65.00
Crop disease and pests increase over time	–	–	–	32.60	67.40

Tab. 6 Climate variability/change adaptation strategies practiced by coffee-producing rural farmers in Mattu woreda.

Strategies practiced	Frequency (f)	Percentage (%)
Planting coffee under the shade	91	28.0
Close spacing, mulching, and irrigation	36	11.0
Developing an adaptable coffee variety	28	8.5
Use of disease and heat-tolerant varieties	22	6.8
Changing the location and planting date	39	11.9
Pruning	80	24.6
No adaptation	30	9.3

Farmers' coffee yield suddenly decreased as a result of frost and lack of rain. Climate change/variability caused a strong impact on coffee production in the Mattu woreda (Desta and Belayneh 2023).

soil moisture and fertility, increase coffee yields and quality, and reduce soil erosion in the woreda. Local farmers cultivate a variety of coffee varieties, some of which become poor in their resistance to disease and pests and tolerant of drought shock. These coffee varieties have variable yields and remain with the farmer for a long time. The agricultural experts noted that the productivity of coffee occasionally declined because of challenges to the traditional coffee production systems, where the absence of attention is significant in terms of technical assistance and extension, a lack of improved varieties, and an inadequate supply of input for coffee productivity package enhancement. The primary issues facing farmers were the layout of the coffee plantations and the replacement of older coffee trees in the new plantation. Experts retorted that adopting and utilizing new technologies is difficult for farmers. Besides, the extension service, awareness and capacity-building training program, and agricultural input availability are very limited.

3.4 Determinants of choice of climate change/variability adaptation strategies among smallholder coffee farmers

The statistical analysis result implies that the model displays a good fit. The Pseudo R^2 was 0.2279, implying that 22.79% of the variation in the selection of climate variability/change adaptation techniques was explained by the 14 explanatory variables (Tab. 7). There is no multi-collinearity among variables because the tolerance value is >0.25 and the VIF value for each variable is <10.

HH age

HH age is a key explanatory factor with a positive coefficient. When all other factors are held constant, there is a 73.7% increase in the likelihood that farmers will employ close spacing, mulching, and irrigation as an adaptation strategy when the age of the HH head rises (P-value = 0.029). This suggests that as the HH's age increases there will be an increase in the probability

Tab. 7 Variance inflation factor (VIF) analysis results for explanatory variables (n = 325).

Variables	Multi-collinearity statistics		
	R-squared	Tolerance	VIF
Sex	0.273	0.727	1.376
Age	0.386	0.614	1.620
Marital Status	0.272	0.728	1.373
Family size	0.328	0.672	1.488
Educational level	0.334	0.667	1.500
Land Holding Size	0.226	0.774	1.291
Coffee farm experience	0.469	0.531	1.883
Income of HHs	0.347	0.653	1.531
Distance to coffee farm	0.433	0.567	1.763
Climate information	0.637	0.363	2.754
Credit access	0.131	0.869	1.150
Extension Services	0.091	0.909	1.100
Training	0.380	0.620	1.612
Tropical Livestock Units	0.547	0.453	2.207

of implementing close spacing, mulching, and irrigation. This could be related to more experienced farmers having a better sense of CCV and related effects on coffee production.

The study's finding is consistent with the results of Nhemachena et al. (2014), who showed that farming experience raises the likelihood that people will use adaptation strategies. Age influences farmers' decisions to select the type of adaptation strategies to use. But, on the contrary, Deressa et al. (2011) found an undetermined impact of age on adaptation decisions.

Family size

This variable has a positive and significant impact on CCVAS. The likelihood that farmers will use close spacing, mulching, and irrigation as adaptation techniques increased by 75.1% with every unit increase in family size while maintaining the same levels of other variables (P = 0.015). One argument is that having a higher family size allows for the easier adoption of new technologies by providing the necessary labor force.

Landholding size

Land holding size positively and significantly increases the likelihood of farmers' adoption of CCVAS. For instance, if one-hectare increases in farm size, the chance of coffee farmers using disease and heat-tolerant varieties as an adaptation strategy increased by 92% (P = 0.03) holding other variables constant (Tab. 8). Landholding size is mostly linked to better wealth and may lead to better implementation of adaptation strategies.

Therefore, the amount of land allotted for various crop varieties as farmers' likely adaptation strategies increase with the size of the farm. The likelihood of

Tab. 8 Factors determining the selection of climate variability/change adaptation strategies: multinomial logistic regression model result.

Explanatory variables	Dependent variable (adaptation strategies)											
	Planting coffee under shade		Close, spacing, mulching, and Irrigation		Use an adaptable coffee variety		Apply disease and heat-tolerant varieties		Changing the location and planting date		Pruning	
	β	P	β	P	β	P	β	P	β	P	β	P
Sex	.306	.824	.878	.513	1.006	.488	.494	.734	.416	.753	.148	.863
Age	.281	.388	.737	.029*	.268	.409	.185	.422	.219	.334	−.281	.388
Marital status	−.594	.602	1.238	.202	−1.350	.301	.130	.986	.236	.760	.594	.602
Family size	−.825	.104	.751	.015*	−.821	.085	−.140	.647	−.419	.139	.825	.104
Educational level	−1.363	.213	−.804	.249	.888	.163	.110	.831	.141	.775	1.363	.213
Landholding size	−.0840	.859	.071	.842	−.387	.393	.920	.030*	.356	.222	.084	.859
Coffee farming experience	.994	.044*	−1.612	.060	1.184	.270	1.292	.032*	−1.797	.054	1.142	.018*
HHs income	1.215	.025*	−1.275	.071	.177	.743	.264	.509	.041	.920	−1.405	.724
Distance to coffee farmland	.371	.083	−.521	.043*	.036	.827	−.147	.254	−.384	.006*	−.371	.083
Climate-related information	.758	.090	.427	.180	.129	.739	−.362	.145	.577	.024*	−.758	.090
Credit access	.921	.116	.236	.667	−546	.342	.801	.253	−.309	.714	.311	.593
Extension services	−1.004	.404	.146	.899	.794	.505	−.818	.561	.113	.940	−.731	.544
Training	.800	1.677	−2.458	.120	−2.980	.160	−2.875	.270	−1.807	.145	−1.177	.720
Tropical livestock unit	−.379	.046*	.318	.445	.141	.780	.637	.067	.571	.097	−.822	.126

Base category = No adaptation; N = 118; Log likelihood = −153.7985; LR Chi2 (50) = 90.80; Probability > Chi^2 = 0.04**; Pseudo R^2 = 0.2279; *, **, significant at 0.01 (1%) and 0.05 (5 %), probability level of significance.

a farmer's adaptation decision to CC increases with the size of their farm because larger farms are invariably linked to higher wealth, capital, and resources. This result also agrees with the finding of Tessema et al. (2013). However, some research documented that farm size influences adoption in both positive and negative ways, indicating that there is conflicting evidence regarding farm size's impact on technology adoption (Bradshaw et al. 2004).

HH income

HH farm income is another statistically significant variable that exerts influence on planting coffee under shade as a means of CCVAS. Holding other factors constant, the likelihood that farmers would use planting coffee under shade as an adaptation strategy increased by 12.15% (P = 0.025; Tab. 8) with a one Ethiopian birr (ETB) increase in HH farm income. Deressa et al. (2011) reported a positive co-variation between farmers' income and the use of adaptation strategies. When farming becomes their primary source of income, farmers typically invest in options that smooth productivity, like irrigation. This finding is consistent with studies by (Ahmed and Bogale 2021; Mengistu and Haji 2015).

Coffee farm experience

This variable had a strong correlation with practices related to climate adaptation, as indicated by the model's result. The analysis's result shows that the HH's prior experience on the farm had a favorable and significant impact on the use of shade-grown coffee plants as a method of adaptation to CC, increasing their use by 99.4% (P = 0.044). Smallholder farmers' use of disease and heat-tolerant varieties and pruning increased by 12.9% (P = 0.032) and 11.42% (P = 0.018), respectively.

Distance from coffee farmland

The distance of the HHs place of residence from his/her coffee farm plot negatively affected the adaptation strategies for improving coffee production. Farmers are less likely to employ irrigation, mulching, and close spacing as adaptation techniques when it takes them longer to travel from their home to the cultivated area, holding all other variables constant (P = 0.043). Holding all other factors constant, the likelihood of farmers to use location and planting date changes as an adaptation strategy dropped by 38.4% (P = 0.06), due to an increased distance between their home and coffee plot. Minwuye (2017) also argued that the distance of plots from the homestead may influence HH investment in time lost traveling to and from a plot, and plots located far from farmers' residences are a high-risk investment as the chance of losing these plots is higher in the event of land distribution.

Farmers' access to climate-related information

Farmers' decisions to use location and planting date changes as a strategy for climate variability were positively impacted, and this effect was significant at 5% probability levels (P = 0.024). When other factors were held constant, the multinomial logistic regression model's result showed that farm HHs with access to climate information were more likely than their counterparts to use location and planting date changes as a strategy for climate variability. By using climate information practices to adjust planting dates and locations, smallholder farmers can increase yields by 57% while mitigating the effects of climate variability. The study's conclusions were validated by Minwuye (2017).

Livestock size (TLU)

In this study, one important explanatory variable was the farmer's livestock count. Its indication was having a detrimental effect on farmers' decisions to adopt new crop varieties and enhance livestock and crop adaptation strategies. Keeping all other factors equal, the likelihood of adopting coffee under shade as an adaptation strategy drops by 37.9% for every unit of livestock the HH owns. In this instance, livestock was viewed as a resource by the farmers and was crucial because it provided cash for the purchase of better crop varieties. However, having a lot of livestock can make it harder for farmers to adapt to CC because they need a lot of grazing land, which limits their ability to use coffee land for grazing. However, one aspect of agricultural activity that is also impacted by CC is the raising of livestock. As a result, farmers will become less interested in seeking out adaptation strategies to protect their assets from climate-related issues as the number of livestock increases. This result is against the research reported by Tazeze et al. (2012).

4. Conclusions and policy implications

The study examined the smallholder coffee farmers' perception and determinants of the adaptation choices to climate variability/change using cross-sectional data employing a multinomial logistic regression model. Coffee farmers were requested to reflect on their awareness of the changes in climatic elements and the main factors determining the use and selection of CCVAS. About 79% of coffee farmers were aware of the effects of a changing climate on coffee growth, productivity, and quality. The majority of farmers were also aware of the trends in rising temperatures and falling rainfall during the study period. Farmers who perceived changes practiced different adaptation strategies including planting coffee under shade, close spacing, mulching, and irrigation, developing an adaptable coffee variety, adopting disease and heat-tolerant varieties, changing the location and planting date, and pruning. However, we found diverse preferences for adaptation strategies among smallholder farmers. Field-based assessments on farmers' experience of using multiple adaptation choices were done and the result showed that nearly 52% of the farmers were found to use planting coffee under shade and pruning.

The study's conclusions showed that the age, family size, land holding size, income, experience on the coffee farm, distance to the coffee farm plot, availability of information about climate change, training, and TLU of the HHs significantly (positively/negatively) influenced the adaptation strategies chosen by the coffee farmers (P < 0.05). The primary obstacles to coffee farmers using various adaptation strategies were a lack of funding, a labor shortage, and a lack of training regarding the impact of climate change and coping mechanisms as well as extension services.

Therefore, it is recommended to design early warning policy systems that target to make farmers aware of future CCV and potential impacts so as to take proactive measures in different agro-climatic conditions. The government and other stakeholders should assist more vulnerable smallholder coffee farmers in terms of training, financing (credit service), and identifying and suggesting agroecological suitable CCVAS. In this regard, we suggest further research to identify and recommend evidence and agroecology-based, cost and labor-effective, and sustainable adaptation strategies for coffee farmers.

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