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Factors affecting farmers' coping and adaptation strategies to perceived trends of declining rainfall and crop productivity in the central Rift valley of Ethiopia

Zenebe Adimassu[1*] and Aad Kessler[2]

Abstract

Background: Farmers apply several and often different farmer-specific strategies to cope with and adapt to the perceived trend of declining rainfall and crop productivity. A better understanding of the factors affecting farmers' coping and adaptation strategies to counteract both trends is crucial for policies and programs that aim at promoting successful rainfed agriculture in Ethiopia. The objective of this study was to identify the major factors that affect farmers' coping and adaption strategies to rainfall variability and reduction in crop yield in the central Rift valley (CRV) of Ethiopia. A survey was conducted among 240 randomly selected farmers within six kebeles in the CRV using structured and pretested questionnaires. Multivariate probit (MVP) regression model was used to identify these key factors that affect farmers' coping and adaptation strategies to the declining trends of rainfall and crop productivity.

Results: Generally, this study identified several factors that affect farmers' choices of certain strategies, which can be grouped in four major factors: (1) livestock and landholdings, (2) availability of labour and knowledge, (3) access to information, and (4) social and cultural factors. Farmers with better resources, labour, knowledge, access to information and social capital had better coping and adaptation strategies to the declining rainfall and crop productivity.

Conclusions: To conclude, improving farmers' asset accumulation, access to information and knowledge are needed. Moreover, strengthening social capital and labour sharing institutions in the CRV is crucial to increase farmers' capacities to cope with and adapt to environmental changes such as rainfall and crop yield variability.

Keywords: Access to information, Asset accumulation, Determinants, Rainfall variability, Social capital

Background

Rainfed farming in Ethiopia is the main contributor to crop production, but highly variable due to its exposure to rainfall variability (Ford et al. 2015; Conway and Schipper 2011; Deressa et al. 2009). This high crop yield variability characterizes rainfed farming system in Ethiopia in general and in the central Rift valley (CRV) in particular (Seleshi and Demaree 1995; Conway and Hulme 1993). A declining trend in rainfall and crop productivity is also perceived by an overwhelming majority of the farmers in the CRV (Adimassu et al. 2014; Garedew et al. 2009). As a result various coping and adaptation strategies were employed by farmers as responses to the declining rainfall and crop productivity (Adimassu et al. 2014). The distinction between coping and adaptation strategies is mainly in terms of time scale. Coping strategies are short-term and unplanned in response to unexpected crop failure and yield losses and just for survival, while adaptation strategies are long-term and planned responding to expected and continued decline or uncertainty in future crop productivity and food production (Smit and Wandel 2006; Vogel 1998; Osbahr et al. 2008).

The most important coping strategies applied by farmers in the CRV include selling livestock, accessing relief aid

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from governmental organizations (GOs) and/or Non-governmental organizations (NGOs), obtaining credits (especially applicable to the well-to-do farmers), and migration to towns and more productive areas (Adimassu et al. 2014). Similarly, the most important adaptation strategies include changing crop varieties, adjusting planting date, dry plowing/planting, diversifying income through off-farm activities and expansion of Enset (*Ensete ventricosum*), Chat (*Catha edulis*) and Eucalyptus (*Eucalyptus globulus*) (Adimassu et al. 2014). These all strategies are crucial to cope with the shortage of food and income resulted from the variability of rainfall and crop productivity. However, expansion of eucalyptus might have negative ecological impact by depleting water and soil nutrient (Mekonnen et al. 2006). It has been reported that eucalyptus leaves have phenolic acid, tannins, flavonoids and these chemicals inhibit the growth of crops and trees (Zhang and Fu 2009). Moreover, eucalyptus released toxic allelochemicals into the soil system and reduced germination and growth of crops (Lisanework and Michelson 1993). This indicates that not all coping/adaptation strategies are environmentally friendly. This suggests the need to create awareness among farmers and other stakeholders on the advantages and disadvantages of coping and adaptation strategies.

Farmers' coping and adaptation strategies to environmental changes are influenced by several socio-economic and biophysical factors (Adimassu et al. 2015; De Jalon et al. 2014; Kassie et al. 2013; Adimassu et al. 2012; Deressa et al. 2009; Seo and Mendelsohn 2008) which are often site and household specific due to diverse conditions (Tiwari et al. 2008; Conway and Schipper 2011). For example, accessibility to and usefulness of climate information (Roncoli et al. 2001), the policy and institutional environment (Agrawal et al. 2008), and the financial capacity of households (Ziervogel et al. 2006) were found to influence farmers' coping and adaptation strategies to changes in rainfall and crop productivity.

A better understanding of why farmers opt for certain coping and adaptation strategies is crucial for policies and programs that aim at promoting sustainable rainfed agriculture (Le Dang et al. 2014). Nevertheless, such information is very limited, particularly in the CRV of Ethiopia. Therefore, this study aims to understand the major factors that affect farmers' decision-making concerning how to cope with and adapt to rainfall and crop productivity decline.

Methodology

Description of the study areas

This study was conducted in the CRV of Ethiopia in six villages (or kebeles[1]). Beressa, Drama, Dobi, and Mikaelo kebeles are found in Meskan districts (Woredas[2]). Worja and Woyisso kebeles are found in Adamitulu Jido-Kombolcha (AJK) Woreda. Both districts are located in the CRV of Ethiopia but in a different administrative regional states. Meskan is found in the Southern Nations, Nationalities and People Regional (SNNPR) State[3] while AJK is in the Oromia Regional State. Meskan is located 135 km to the Southwest of Addis Ababa whereas AJK is 160 km south of Addis Ababa (Fig. 1). The elevation of the study areas ranged from 1600 m above mean sea level at Ziway to above 2300 m above mean sea level at Butajira.

Rainfall in Meskan is represented by the Butajira weather station and rainfall of AJK by the Ziway weather station. The Meskan Woreda receives more rainfall than the AJK Woreda (Fig. 2) given its higher altitude and location on the slopes of the CRV. The average annual rainfall of Meskan is 1130 mm and that of AJK 750 mm. Figure 2 shows that the annual rainfall is quite variable for both sites. The coefficients of variability (CV) of annual rainfall of the main rain-season (Meher) are 23 and 25 % in Meskan and AJK Woredas, respectively. The coefficients of variability of annual rainfall of the minor rain season (Belg) are 41 and 46 % for Meskan and AJK Woredas, respectively. Rainfall variability in the CRV is much higher than other parts of the country (Degefu and Bewket 2014; Seleshi and Demaree 1995; Cheung et al. 2008). For example, the CV of Belg rainfall for West and North West Ethiopia ranges between 23 to 28 % while the CV for Meher is between 11 and13 % (Seleshi and Zanke 2004; Cheung et al. 2008). Similarly, the CV of Belg rainfall in Central Ethiopia is 16–24 % while the CV for Meher rainfall is 14–16 % (Kassie et al. 2013; Cheung et al. 2008; Seleshi and Demaree 1995).

There are two major farming systems in the study areas: enset-based and cereal-based. Enset (*Ensete ventricosum*) dominates the enset-based farming system. In the cereal-based farming system, farmers rotate cereals such as maize (*Zea mays*), sorghum (*Sorghum bicolor*), and teff (*Eragrostis tef*) with pulses such as field pea (*Pisum sativum*), faba bean (*Vicia faba*), and haricot bean (*Phaseolus vulgaris*). Farmers in Meskan practice intercropping of these cereals with chat (*Catha edulis*) and enset. They also plant trees around their homesteads and outfields for multiple purposes, including construction, fuel wood, fruits, and cash generation. The main tree species grown around Meskan homesteads are fruit (e.g. avocado and mango) and high-value cash crop trees (e.g. chat), whereas non-fruit trees (e.g. *Acacia* sp.) are grown in the outfields.

[1] Kebele is the lowest administrative unit in rural Ethiopia.

[2] Woredas is the local administrative unit above Kebele.

[3] Regional state is Ethiopian administrative structure below Federal Government.

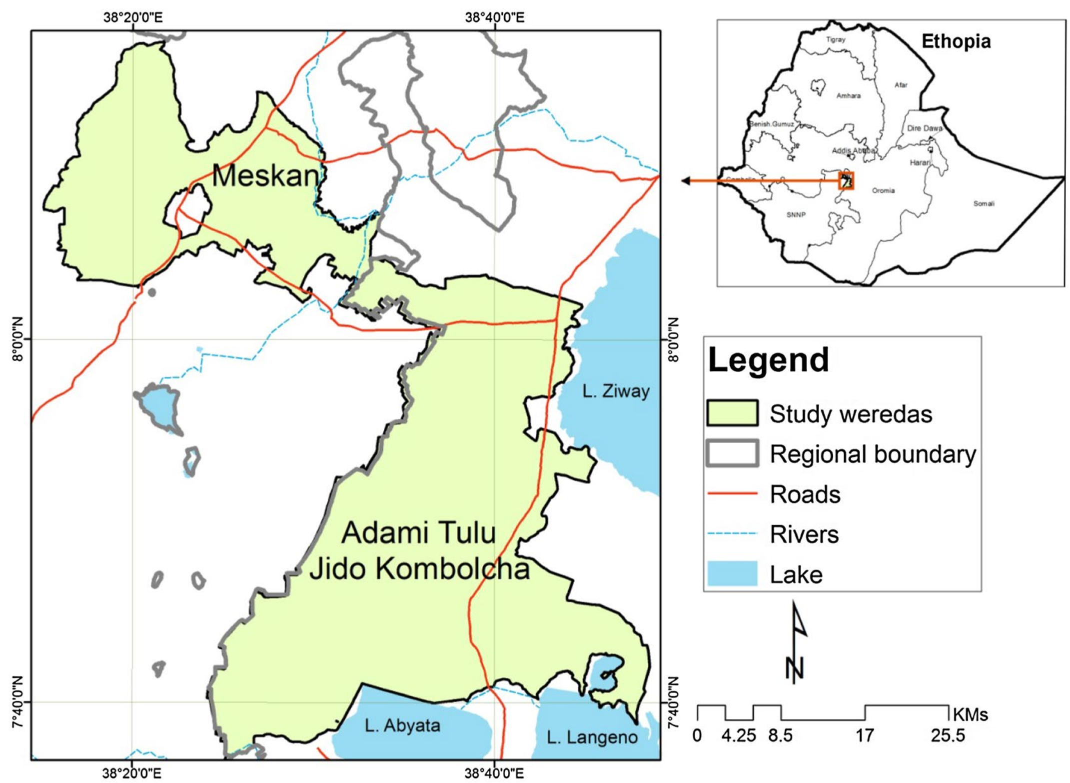

Fig. 1 Map of the study Woredas (districts) in the central Rift valley of Ethiopia

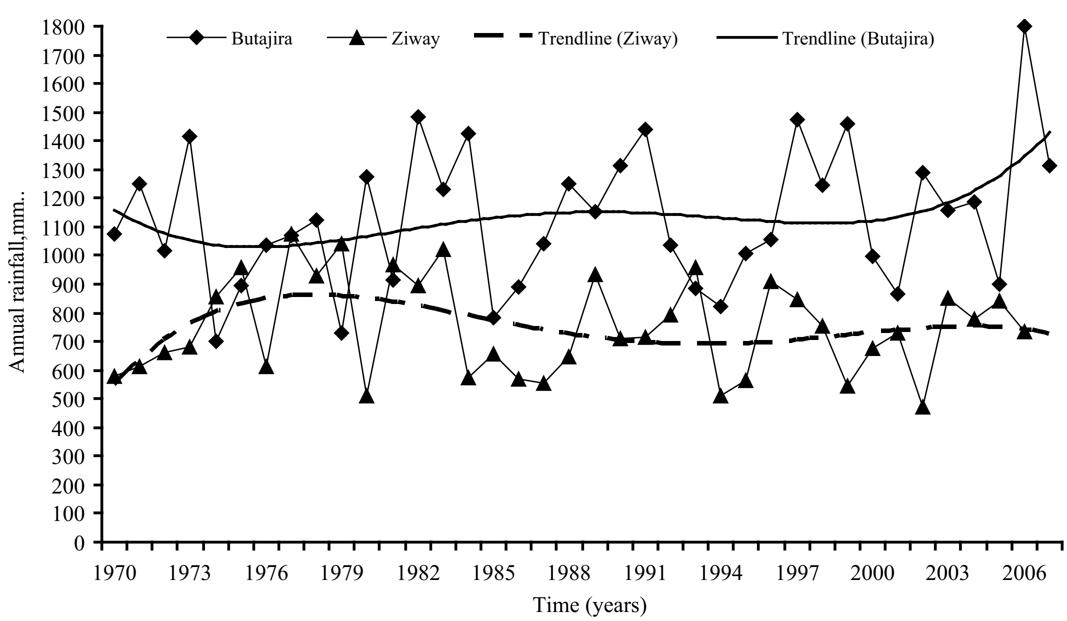

Fig. 2 Trend of annual rainfall in Butajira and Ziway, central Rift valley of Ethiopia

According to the local administration, Dobi and Michaelo are food secure kebeles while Beressa, Drama, Woyisso and Worja are categorized as food insecure kebeles. The food insecure kebeles have been supported by the Productive Safety Net Program during food shortage.

Data collection and analysis

Quantitative and qualitative information was obtained using different data collection methods such as key informant interviews, focus group discussions, formal household surveys, and secondary data collection. General perceptions gathered from the informal survey were propped by in-depth individual household questionnaire interviews. A survey was therefore conducted among 240 farmers randomly selected within the six kebeles, during October 2009 to April 2010 using structured and pretested questionnaires. The lists of households were obtained from respective kebele administrations and the heads of the households were invited for household survey. The questionnaire contained several questions about farmers' perceptions on the trend of crop productivity and rainfall over years. Since farmers may have short recall time, major events such as regime changes and drought (food shortage) were used as reference to facilitate their recall. It also included farmers' adaptation and coping strategies to counter yield failure and food shortage. Informal surveys such as informants' interviews and focus groups discussion were used to formulate the questionnaire for the formal survey and understand in-depth some of the emerging findings from formal survey. Daily rainfall records of two weather stations (Butajira and Ziway) were obtained from the Ethiopian Meteorology Services Agency (EMSA) and the Ethiopian Institute of Agricultural Research (EIAR). The main reason why only two stations were used is because these are the only stations available around the study kebeles in which farmers' perception of rainfall can be compared.

Descriptive statistics were used to summarize farmers' perceptions regarding the trend of rainfall and crop productivity as well as their coping and adaptation strategies. Three major steps were used to analyze the data regarding the factors that affect farmers' coping and adaptation strategies. The first step was reduction of the variables using Explanatory Factor Analysis (EFA) while the second step was the use of correlation analysis to check for the multicollinearity of dependent variables (adaptation and coping strategies). The third step was the use of multivariate probit (MVP) regression model. Explanatory factor analysis (EFA) was used to reduce the number of variables. A varimax orthogonal rotation was used to produce a rotated component matrix that facilitated the interpretation of variables that composed each factor. In such a matrix, the loading for each of the variables is given. A high loading represents a variable that is influenced strongly by the factor. Therefore, only variables with a minimum factor loading value of 0.4 were selected for inclusion in the MVP regression (Adimassu et al. 2012; Kessler 2006; Field 2005). After the explanatory variables were reduced and the dependent variables were checked for multicollinearity, the MVP regression model was employed to identify the factors that affect farmers' coping and adaption strategies to the perceived decline in rainfall and crop productivity. Description of dependent variables (coping and adaptation strategies) and independent variables (household characteristics) used in EFA and MVP regression models are shown in Table 1.

To analyse the interdependent decisions of adaptation and coping strategies by farmers, Multivariate probit (MVP) regression was applied (Greene 2012). Coping and adaptation strategies by farmers in Ethiopia are multivariate in nature so that the appropriate modelling procedure should not be univariate, but must instead take into account the interactions and possible simultaneity of the coping and adaptation decision. This is because farmers are more likely to adopt a mix of strategies to deal with a multitude of agricultural production constraints than adopting a single coping or adaption strategy (Kassie et al. 2013). Farmers might consider a combination of coping and adaptation strategies as complementary and others as competing. Failure to capture unobserved factors and inter-relationships among investment decisions regarding different coping or adaption strategies will lead to bias and an inefficient estimate (Greene 2012; Rencher 2002).

Explanatory factor analysis

In the explanatory factor analysis model, p denotes the number of variables (X_1, X_2,…,X_p) and m denotes the number of underlying factors (F_1, F_2,…,F_m). X_j is the variable represented in latent factors. Hence, this model assumes that there are m underlying factors whereby each observed variables is a linear function of these factors together with a residual variate. This model intends to reproduce the maximum correlations.

$$X_j = a_{j1}F_1 + a_{j2}F_2 + \cdots a_{jm}F_m + e_j \quad (1)$$

The factor loadings are a_{j1}, a_{j2},…,a_{jm} which denotes that a_{j1} is the factor loading of jth variable on the 1st factor. The specific or unique factor is denoted by e_j. The factor loadings give us an idea about how much the variable has contributed to the factor; the larger the factor loading the more the variable has contributed to that factor (Kessler 2006; Field 2005). Factor loadings are very similar to weights in multiple regression analysis, and they represent the strength of the correlation between the variable

Table 1 Description of dependent variables (coping and adaptation strategies) and independent variables (household characteristics) used in EFA and MVP regression models

Dependent variables	Description of variables	Effect
Adaptation strategies		
Enset expansion (ENSEXP)	Dummy (1 yes, 0 no)	
Chat expansion (CHATEXP)	Dummy (1 yes, 0 no)	
Eucalyptus expansion (EUCALEXP)	Dummy (1 yes, 0 no)	
Change in crop variety (CCVA)	Dummy (1 yes, 0 no)	
Adjusting planting date (APLDATE)	Dummy (1 yes, 0 no)	
Dry plowing/planting (DRYPLT)	Dummy (1 yes, 0 no)	
Diversifying off-farm income (DIVI)	Dummy (1 yes, 0 no)	
Coping strategies		
Accessing credit (CREDIT)	Dummy (1 yes, 0 no)	
Selling livestock (LIVE)	Dummy (1 yes, 0 no)	
Accessing relief (RELIEF)	Dummy (1 yes, 0 no)	
Migration (MIGATE)	Dummy (1 yes, 0 no)	
Independent variables		
Gender	Gender of household head (0 female, 1 male)	+
Age	Age of the household head (years)	+
MSTAT	Marital status of the household head (1 married, 0 otherwise)	+
Educ	Education of household head (1 literate, 0 illiterate)	+
FEXPR	Farm experience of household head (years)	+
RLGN	Religion of household head (1 christians, 2 muslim)	±
ETHINI	Ethnicity of the household head (1 meskan, 2 dobi, 3 oromo)	±
NFAML	Number of family members	±
FAMADE	Number of family members in terms of adult equivalent	+
EAFM	Number of economically active family member	+
EDFM	Number of economically dependent family member	
OX	Number of oxen per household	+
COWS	Number of cows	+
OLIVES	Number of other livestock (e.g. Heifer, bull)	+
SHANDGOT	Number of sheep and goats	+
DONKEY	Number of donkeys	+
TLU	Number of livestock in terms of Tropical Livestock Unit (TLU)	+
TLU_CAPITA	TLU per capita	+
TLU_ADE	TLU per adult equivalent	+
Radio	Does the household have a radio? (1 yes, 0 no)	+
MOBILEPH	Does the household head have a mobile phone? (1 yes, 0 no)	+
DSTWOREDA	Distance from the house to Woreda (District) town (walking minutes)	−
DSTMARKT	Distance from the house to nearby market (walking minutes)	−
TOTLANDS	Total landholding per household (ha)	+
LAND_CAPITA	Landholding per capita	+
LAND_EAFM	Landholding per economically active family member	+
LAND_ADEQ	Land per adult equivalent	+
RLINKBL	Number of relatives in the kebele	±
RLOUTKBL	Number of relatives outside the kebele	±
FRINKBL	Number of friends in the kebele	±
FROUTKBL	Number of friends outside the kebele	±
VIISITDA	Number of times that the Development Agent (DA) visited a household	+
MEMCELL	Does a household head member of 'Cell'? (1 yes, 0 no)	±
MEMLIQA	Is household head member of 'Liqa'? (1 yes, 0 no)	±

Table 1 continued

Dependent variables	Description of variables	Effect
MEMEDIR	Is household head member of 'Edir' (1 yes, 0 no)	+
SENBETE	Is household head member of 'Senbete'? (1 yes, 0 no)	+
TRAINING	Did household head get training from over the last year? (1 yes, 0 no)	+

+ or (−) signs indicate the expected effect on coping and adaptation strategies

TLU Tropical Livestock Units (1 TLU 250 kg live weight), with oxen/bulls 1.1 TLU, cows/horses/mule 0.8 TLU, donkey 0.65 TLU, heifer 0.36 TLU, calf 0.2, chicken 0.01 TLU and sheep/goat 0.09 TLU (Sharp 2003)

and the factor (Field 2005). Factor analysis uses matrix algebra when computing its calculations. The basic statistic used in factor analysis is the correlation coefficient which determines the relationship between two variables.

Multivariate probit model

In multivariate Probit model, each subject has a covariate vector that can be any mixture of discrete and continuous variables. Each subject produces J distinct quantal responses or is classified with respect to J dichotomous categories. Specifically, let $y_i = (y_{i1,\ldots}, y_{iJ})'$ denote the collection of observed dichotomous (0/1) responses in J variables on the ith subject, $i = 1, \ldots, n$, x_{ij} be a $k_j \times 1$ vector of covariates, $k = k_1 + \cdots + k_J$, and x_i can be a $J \times k$ matrix

$$Xi = \begin{pmatrix} X'_{i1} & 0 & 0 \\ 0 & X'_{i2} & 0 \\ - & - & - \\ - & - & - \\ \bar{0} & \bar{0} & \bar{X}'_{iJ} \end{pmatrix} \tag{2}$$

The MVP regression simultaneously models the influence of the set of explanatory variables on each of the different coping and adaption strategies while allowing the error terms to be freely correlated (Greene 2012; Rencher 2002). In contrast to MVP regression, univariate probit models ignore the potential correlation among the unobserved disturbances in the regression equations as well as the relation between the different coping/adaptation strategies. For this particular study, the MVP regression model is described by a set of binary dependent variables *Y ij ** as follows:

$$y_{ij}* = X_{ij}ß + \varepsilon_{ij} j = 1 \cdots m \tag{3}$$

$$y_{ij} = \begin{cases} 1 \text{ if } y^*_{ij} > 0 \\ 0 \text{ otherwise} \end{cases} \tag{4}$$

where *Yij** for j = 1, 2,..., m represents an unobserved latent variable of the coping/adaptation strategy j applied by farmer i, X is a matrix of independent variables reflecting household characteristics, ß is a vector parameter estimate and ε_{ij} is the error terms. Error terms have a standard normally distribution with mean vector zero and a covariance matrix with diagonal elements equal to 1.

Results and discussion

Descriptive statistics of variables

The descriptive statistics of dependent variables (adaptation and coping strategies) and independent variables (household characteristics) are presented in Table 2. For all coping and adaptation strategies the minimum values were 0 while the maximum values were 1. This shows that dependent variables are binary variables (0/1). The mean values ranged from 0.15 (adjusting planting dates) to 0.50 (expansion of eucalyptus tree). As shown in Table 2, the independent variables are either binary or continuous numbers. For example, gender (GENDER) is a binary variable (0: female and 1: male) while age is a continuous variable. The minimum and maximum age limit of respondents were 16 and 82 years, respectively, with mean of 45 years and standard deviation of 13.21 years.

Characteristics of sample households

Table 3 shows the major characteristics of the sample farmers in the CRV of Ethiopia. As shown in the Table, a majority (87 %) of the farmers were male-headed. The average age of respondents (mostly household heads) was 45 years with a standard deviation of 13.21 years. The average number of family members of farmers was 6.2 with a standard deviation of 2.33. This result is greater than the national average of 5.2 persons per household (CSA 2008). The minimum land size was 0.13 ha while the maximum land size was 8 ha. The average land size per household was 1.1 ha while the average land size per capita was 0.19. This average land size is similar to the national average of 1 ha (CSA 2008). Similarly, the livestock holdings per household and per capita were 3.7 and 0.60 TLU, respectively. Both land size and livestock number are the most important assets of farmers in the study areas.

Table 2 Descriptive statistics of dependent and independent variables

Strategies/independent variables	Minimum	Maximum	Mean	Standard deviation
Adaptation strategies				
Enset expansion (ENSEXP)	0	1	0.22	0.49
Chat expansion (CHATEXP)	0	1	0.30	0.45
Eucalyptus expansion (EUCALEXP)	0	1	0.50	0.50
Change in crop variety (CCVA)	0	1	0.21	0.41
Adjusting planting date (APLDATE)	0	1	0.15	0.14
Dry ploughing/planting (DRYPLT)	0	1	0.26	0.12
Diversifying off-farm income (DIVI)	0	1	0.29	0.31
Coping strategies				
Accessing credit (CREDIT)	0	1	0.15	0.13
Selling livestock (LIVE)	0	1	0.63	0.48
Accessing relief (RELIEF)	0	1	0.36	0.45
Migration (MIGATE)	0	1	0.58	0.46
Independent variables				
GENDER	0	1	0.80	0.25
AGE	16	82	44.9	13.21
MSTAT	0	3	1.1	0.41
EDUC	0	3	0.89	1.01
FEXPR	2	65	29.35	13.13
RLGN	1	4	1.81	0.52
ETHINI	1	3	1.82	0.90
NFAML	1	16	6.20	2.33
FAMADE	1.02	14.03	5.51	2.05
EAFM	1	10	3.36	1.69
EDFM	0	8	2.84	1.86
OX	0	6	1.42	1.06
COWS	0	15	1.32	1.42
OLIVES	1	12	1.49	1.63
SHANDGOT	0	16	2.38	2.88
DONKEY	0	6	0.43	0.76
TLU	0	26.62	3.70	2.97
TLU_CAPITA	0	3.46	0.63	0.50
TLU_ADE	0	3.75	0.71	0.55
RADIO	0	1	0.61	0.48
MOBILEPH	0	1	0.15	0.34
DSTWOREDA	0	240	86.00	56.80
DSTMARKT	0	150	43.54	31.35
TOTLANDS	0.13	8	1.1	0.91
LAND_CAPITA	0.30	1.33	0.19	0.15
LAND_EAFM	0.06	4	0.38	0.37
LAND_ADEQ	0.03	1.61	0.21	0.17
RLINKBL	1	5	3.77	1.42
RLOUTKBL	1	5	1.80	1.10
FRINKBL	1	5	3.40	1.42
FROUTKBL	1	5	1.45	0.84
VIISITDA	0	3	1.80	1.76
MEMCELL	0	1	0.62	0.49
MEMLIQA	0	1	0.31	0.46
MEMEDIR	0	1	0.85	0.35

Table 2 continued

Strategies/independent variables	Minimum	Maximum	Mean	Standard deviation
SENBETE	0	1	0.13	0.33
TRAINING	0	1	0.60	0.50

Table 3 Major characteristics of the sample households

Household characteristics	Mean	Std. deviation
Men headed households (%)	87.00	–
Age of household head (years)	44.90	13.21
Number of family members	6.20	2.33
Land size per household (ha)	1.10	0.91
Land per capita (ha)	0.19	0.15
TLU per household	3.70	2.67
TLU per capita	0.60	1.20

Farmers' perception on rainfall and crop productivity in the CRV of Ethiopia

Farmers in the CRV generally claim that crop productivity has declined over the last 20 years due to the decrease in rainfall in the area. Figure 3 presents farmers' perceptions of crop productivity and rainfall trends over the last decades in the CRV. A majority of the farmers in the CRV (63 %) perceive that crop productivity has reduced over the last decades. Similarly, a majority of the farmers in the CRV (67 %) reported that annual rainfall has decreased over years. However, farmers' perception on the trends of rainfall is not confirmed by the observed data from weather stations in the study areas (Fig. 2). This might be due to the fact that water availability for agricultural crops has decreased over the last decades because of an expansion of the agricultural area to marginal lands and consequently higher overall water demands to grow more crops for the growing population (Adimassu et al. 2014; Meshesha et al. 2012).

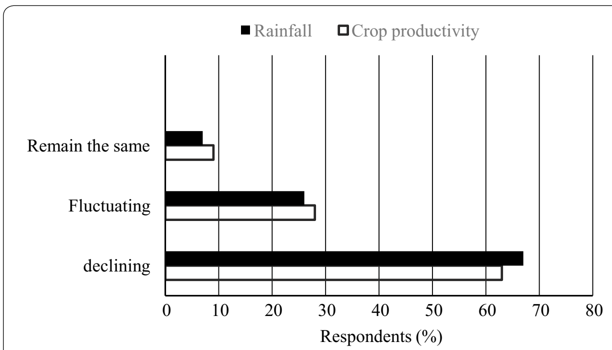

Fig. 3 Farmers' perception on the trends of crop productivity and rainfall over years in the central Rift valley of Ethiopia

Nearly one-third of the respondents reported that crop productivity (28 %) and rainfall (26 %) have fluctuated over years. The percentage of farmers who perceived that crop productivity and rainfall remained the same were 9 and 6 %, respectively. Generally, a majority of the respondents believe that crop productivity has declined or fluctuated due to the fluctuations in annual rainfall. A similar study in the Nile basin of Ethiopia showed that a majority of farmers do also blame the rainfall variability for the decline in crop productivity (Simane et al. 2014; Kassie et al. 2013; Deressa et al. 2009).

Major coping and adaptation strategies in the CRV of Ethiopia

Table 4 presents the percentage of farmers' applying either of the adaptation and coping strategies considered in this study. As shown in Table 4, farmers in the CRV applied seven adaptation and four coping strategies to the declining trend in rainfall and crop productivity. About half of the respondents expanded the area planted with eucalyptus as an adaptation strategy. This is mainly because eucalyptus is tolerant to rainfall variability and there has been a high demand for eucalyptus wood in the area. One-third of the respondents have diversified their off-farm income to adapt to the perceived changes.

A majority of the respondents (63 %) sell livestock to cope with the unexpected crop failure and more than half of the respondents (58 %) migrate to towns (Ziway and Butajira) and more productive areas such Arsi highlands. Similarly, more than one-third of the respondents (36 %) accessed relief aid from Governmental Organizations (GOs) and/or Non-governmental/organizations. Such types of coping strategies are common also in other parts of the country such as the Nile Basin areas (Deressa et al. 2009) and Kobo areas (Kassie et al. 2013).

Household variables extracted using factor analysis

Table 5 presents the rotated component matrix for the household characteristics using EFA. From the thirty-eight household characteristics considered, three were discarded due to their low factor loadings (MEMEDIR, TRAINING, and DSTFTC). As depicted in Table 5, EFA extracted the following seven main components which explained 64 % of the total variance in the sample.

Table 4 Major coping and adaptation strategies of farmers in the Central Rift Valley of Ethiopia

Coping/adaptation strategies	% of households (n = 240)
Adaptation strategies	
Enset expansion (ENSEXP)	22
Chat expansion (CHATEXP)	17
Eucalyptus expansion (EUCALEXP)	48
Change in crop variety (CCVA)	
Adjusting planting date (APLDATE)	26
Dry plowing/planting (DRYPLT)	26
Diversifying off-farm income (DIVI)	29
Coping strategies	
Selling livestock (LIVE)	63
Accessing credit (CREDIT)	15
Accessing Relief (RELIEF)	36
Migration (MIGATE)	58

The total % of households are greater than 100 % because households applied multiple coping and adaptation strategies

The first component *(*C-I*)* includes nine household characteristics mainly livestock holding (TLU, TLU, TLU_CAPITA, OLIVES, COWS, OX, SHANDGOT, DONKEY). The second component (C-II) comprises four household characteristics related to land holding (LAND_ADEQ, LAND_CAPITA, LAND_EAFM, TOTLANDS). The third component (C-III*)* includes family size (NFAML, FAMADE) and family labour availability (EDFM, EAFM). The fourth component (C-IV*)* comprises six household characteristics related to human capital including AGE, FEXP, EDUC, GENDER, MSTAT and MOBILEPH). The fifth component (C-V) includes social relationship of household heads including FRINKBL, FROUTKBL, VISITDA and MEMCELL. The sixth component (C-VI) comprises household characteristics related to religion (RLGN, SENBETE), access to market (DSTMARKT) and use of radio for accessing information (RADIO). The last component (C-VII) comprises a mixture of different socio-cultural characteristics including membership in local institutions (MEMLIQA), ethnicity (ETHINI) numbers of relatives inside (RLINKBL) and outside (RLOUTKBL) the kebele.

Correlations among coping and adaptation strategies

Table 6 presents the correlation coefficients among the adaptation and coping strategies in this study, which test if both type of strategies are independent or not. Phi Coefficient (r_{ϕ}) is used to measures the strength of relationship between two dichotomous variables. As shown in Table 6, the correlation coefficients are very low (ranged from 0.007 to 0.345), implying that binary responses among coping and adaptation strategies are independent. This supports the use of a Multivariate Probit (MVP) regression model in the analysis of these data.

Factors affecting farmers' coping and adaptation strategies

Factors affecting farmers' coping strategies

Table 7 presents how the different variables considered in this study affect the households' choice for certain coping strategies. Some of the most important and significant effects (correlations) are discussed in this section.

There was negative and significant ($p < 0.05$) correlation between migration (MIGRATE) and livestock holding (TLU_ADE and TLU_CAPITA). This means that farmers with more livestock are less likely to migrate during food shortage. Similarly, households with large landholdings are more likely to access credit as compared to households with a small landholding, because of having the potential to payback their credit for the next harvest. Households with higher landholdings per capita are also less likely to migrate because of being able to harvest more yield as compared to households with small landholdings. Households' access to credit and relief services were significantly ($p < 0.01$) and negatively affected by their distance from the Woreda town. Households further away from the Woreda capital (DSTWOREDA) have less access to credit and relief during food shortage. The results in Table 7 also show that marriage affected farmers' coping strategies, particularly migration. Married household heads are less likely to migrate during crop failure and food shortage, showing their sense of responsibility to stay home and feed the family.

Farmers' access to the market (DSTMARKT) on its turn was negatively and significantly ($p < 0.10$) correlated with the households' access to credit and migration. Farmers with better access to markets have better access to credit. Similarly, households living closer to the local market are more prone to migrate and carry out non-farm activities.

Religion of the household heads also affected the type of coping strategies significantly in this study, with Muslims being more likely to access credit than Christians. Similarly, ethnicity of a household was quite decisive as well, with the Oromo ethnic group having better access to credit and relief services during food shortages than Meskan and Dobi ethnic groups. This indicates that provision of access to credit and relief services is not transparent at local level.

Factors affecting farmers' adaptation strategies

Table 8 presents how the different variables considered in this study affect households' choice for certain adaptation strategies. Some of the most important and significant effects (correlations) are discussed in this section.

Table 5 Rotated component matrix for the household characteristics in the Central Rift Valley of Ethiopia (n = 240)

	Components						
	C-I	C-II	C-III	C-IV	C-V	C-VI	C-VII
TLU	0.938						
TLU_ADE	0.890						
TLU_CAPITA	0.882						
OLIVES	0.840						
COWS	0.830						
OX	0.765						
SHANDGOT	0.659						
DONKEY	0.534						
DSTWOREDA	0.485				−0.413		
LAND_ADEQ		0.924					
LAND_CAPITA		0.907					
LAND_EAFM		0.872					
TOTLANDS	0.402	0.808					
MEMEDIR							
NFAML			0.959				
FAMADE			0.950				
EDFM			0.637				
EAFM			0.624	0.459			
AGE				0.755			
FEXPR				0.718			
EDUC				−0.696			
GENDER			−0.411	0.518			
MSTAT				0.518			
MOBILEPH				−0.463			
FRINKBL					0.678		
FROUTKBL					0.657		
VISITDA					0.445		
MEMCELL					0.415		
RLGN						0.703	
SENBETE						−0.699	
DSTMARKT					−0.466	0.578	
RADIO						−0.514	
MEMLIQA							0.713
RLOUTKBL							0.638
ETHINI		0.411					−0.562
RLINKBL							0.429
TRAINING							
DSTFTC							

Extraction method: principal component analysis, rotation method: varimax with Kaiser normalization, and rotation converged in eight iterations. Kaiser–Meyer–Olkin measure of sampling adequacy: 0.76

Livestock holding (expressed in TLU, OLIVES, COWS, OX and DONKEY) was positively and significantly correlated with farmers who changed crop varieties as adaptation strategy to rainfall variability. These types of households are risk averse to experiment, because their livestock can be used as insurance when there is crop failure. The adaptation strategy of diversifying income (DVINC) was negatively and significantly correlated with the distance from Woreda town (DSTWOREDA). This means households closer to town are more likely to diversify their income as compared to households further away, mainly because non-farm job opportunities are better around towns.

There was positive and significant relationship between land size of households and expansion of eucalyptus trees

Table 6 Correlation matrix among farmers' adaptation and coping strategies

	ENSETEXP	CHATEXP	EUCALEXP	CCVAR	APLDATE	DRYPLT	DIVINC	CREDIT	SELCAT	RELIEF	MIGATE
ENSETEXP											
CHATEXP	0.1952										
EUCALEXP	0.3220	0.2601									
CCVAR	−0.2747	−0.1400	−0.1485								
APLDATE	−0.1253	−0.1477	−0.0198	0.2382							
DRYPLT	0.0361	0.0074	0.1053	−0.0355	−0.585						
DIVINC	−0.1632	0.0600	0.0053	−0.1092	−0.0642	−0.0342					
CREDIT	−0.3103	−0.1675	−0.2947	0.1894	0.0083	−0.020	0.0725				
SELCAT	0.0324	−0.1057	−0.1101	0.1628	0.0533	−0.0164	−0.1205	0.1674			
RELIEF	−0.3445	0.1910	−0.1757	0.0744	−0.0255	−0.0502	0.1645	0.1550	−0.1457		
MIGATE	−0.2882	0.0079	−0.1582	−0.0511	−0.0204	0.0074	0.1800	−0.0644	−0.3321	0.1116	

as adaptation strategy: more land means more possibility to plant more eucalyptus trees areas, which are more resistant to rainfall variability as compared to annual crops such as wheat and teff. Similarly, more landholding per capita (LAND_CAPITA) and adult equivalent (LAND_ADEQ) triggers farmers to change crop varieties as adaptation strategy, mainly replacing local varieties by new varieties. Farmers with more land are less risk averse and therefore able to experiment with new crop varieties as compared to small-scale farmers. The size of livestock and landholdings are directly or indirectly related to the household's financial endowments and positively influence farmers' capacities to cope and adapt to rainfall variability and reduction in crop yield. This implies that farmers with better financial resources have a better coping and adaptation capacity. These results support other studies elsewhere which find that wealthier households are better able to act quickly to offset climate risk than poorer households (Hunnes 2015; Adger 2004; Downing et al. 2005; Ziervogel et al. 2006).

Gender and age also had an effect, with significantly more male and old household-heads expanding *Enset* and *Chat* plantations to adapt to rainfall variability. Moreover, literate household-heads diversified income significantly more because of having better access to information regarding non-farm jobs as compared to illiterate household-heads. The results also show that household-heads with longer farm experience were more inclined to adjust their planting dates of crops and as such adapt to rainfall variability. Studies in Ethiopia have indeed shown a positive relationship between number of years of experience in agriculture and farmers' investments in improved agricultural technologies (Shiferaw and Holden 1998; Kebede et al. 1990).

Households with a higher number of relatives in the kebele and those who were members of cell[4] showed to be more likely to expand enset planting in order to adapt the perceived trends of declining crop productivity. Members of Senbete[5] on their turn were more likely to plant *enset* and eucalyptus but less likely to plant *chat*. Households who were members of liqa (MEMLIQA) were less likely to change their crop variety, adjust planting dates and diversify income. The reason might be because these households are more of religious and spend their time in preaching and other religious matters. The results also show that Christian households were more likely to expand *enset* and less likely to expand *chat* as compared to Muslim households. Variables such as number of relatives, membership in liqa and senbete are directly or indirectly related to social and cultural capitals.

Ethnicity affects households' adaptation strategies in different ways. For example, Meskan and Dobi ethnic groups were more likely to expand enset and chat as compared to the Oromo ethnic group. However, Oromo ethnic groups were more likely to expand eucalyptus and change crop varieties to adapt the perceived trend of rainfall and crop productivity.

Distance to market influenced the expansion of enset and chat. Both crops are relatively drought resistant and chat is a high-value plant cultivated for cash generation. The results of this study are in line with studies in other parts of the country and elsewhere in Africa. For example, a study in the Nile basin of Ethiopia showed that access to market affected the adaptation strategies of farmers (Bryana et al. 2009; Bowles and Gintis 2002; Adesina et al. 2000). Earlier studies also show that farmers with better access to information through agricultural experts invest more in adaptation to environmental

[4] A cell is a political structure at lower level with 5 members.

[5] Senbete and liqa are voluntary and mutual aid community (religious) associations peculiar to Orthodox and Muslim religion followers, respectively. The members gather together so as to pray and discuss their problems and further share information.

changes such as soil erosion in Ethiopia (Bekele and Drake 2003; Kassie et al. 2008).

Although the results in Tables 7, 8 show the determinants of farmers coping and adaptation strategies, further analysis is required for simple presentation of these factors. Accordingly, the results can be categorized into four major groups of factors (Fig. 4).

The first category comprises household factors related to the size of livestock and landholdings. These variables directly or indirectly related to household's financial endowments and positively influence farmers' capacities to cope and adapt to rainfall variability and reduction in crop yield. This implies that farmers with better financial resource have better coping and adaptation capacity to rainfall and crop production variability. These results support other studies elsewhere which find that wealthier households are better able to act quickly to offset climate risk than poorer households (Hunnes 2015; Adger 2004; Downing et al. 2005; Ziervogel et al. 2006). The second category is related to *labor availability and knowledge* of rural households, and includes gender, education, age, family size, and farm experience. Studies in Ethiopia

Table 7 Results of a Multivariate Probit (MVP) analysis of factors affecting farmers' coping strategies

Variables	Coping strategies			
	CREDIT	SELCAT	RELIEF	MIGRATE
TLU	−0.009 (0.116)	0.015 (0.195)	−0.153 (0.202)	−0.242 (0.192)
TLU_ADE	−0.734 (0.568)	−0.488 (0.960)	0.874 (0.992)	*−0.862 (0.941)*[b]
TLU_CAPITA	0.678 (0.589)	0.563 (0.995)	−0.583 (1.029)	*−0.812 (0.976)*[a]
OLIVES	−0.001 (0.044)	0.025 (0.075)	0.006 (0.078)	0.018 (0.074)
COWS	0.003 (0.096)	0.027 (0.161)	0.094 (0.167)	0.244 (0.158)
OX	0.039 (0.132)	−0.052 (0.223)	0.139 (0.231)	0.355 (0.219)
SHANDGOT	−0.001 (0.015)	−0.005 (0.025)	0.022 (0.026)	0.035 (90.024)
DONKEY	0.069 (0.082)	0.018 (0.139)	0.026 (0.143)	0.102 (0.136)
DSTWOREDA	*−0.002 (0.000)*[c]	0.001 (0.001)	*−0.003 (0.001)*[c]	−0.001 (0.001)
TOTLANDS	*0.143 (0.073)*[a]	−0.103 (0.124)	−0.058 (0.128)	−0.049 (0.121)
LAND_CAPITA	−0.607 (2.940)	−1.131 (4.966)	1.316 (5.133)	*−10.076 (4.868)*[b]
LAND_EAFM	−0.091 (0.248)	−0.024 (90.419)	0.309 (0.433)	−0.546 (0.410)
LAND_ADEQ	−0.031 (3.019)	1.400 (5.099)	−1.729 (5.271)	*−10.089 (4.999)*[b]
NFAML	*0.160 (0.066)*[b]	0.010 (0.112)	−0.067 (0.116)	0.049 (0.110)
FAMADE	*0.222 (0.075)*[c]	0.047 (0.127)	0.102 (0.132)	−0.055 (0.125)
GENDER	0.033 (0.054)	0.083 (0.091)	−0.130 (0.094)	0.074 (0.089)
AGE	−0.001 (0.002	−0.002 (0.003)	0.003 (0.004)	0.001 (0.003)
MSTAT	−0.022 (0.052)	−0.113 (0.087)	0.258 (0.090)[c]	*0.190 (0.086)*[b]
EDUC	−0.009 (0.021)	−0.023 (0.035)	−0.017 (0.036)	−0.011 (0.034)
FEXPR	0.000 (0.001)	0.002 (0.002)	*−0.005 (0.003)*[b]	−0.003 (0.002)
MOBILEPH	0.072 (0.059)	0.063 (0.100)	0.056 (0.104)	−0.019 (0.098)
FRINKBL	0.004 (0.019)	0.045 (0.032)	−0.047 (0.034)	−0.006 (0.032)
FROUTKBL	0.001 (0.015)	−0.015 (0.026)	0.026 (0.027)	−0.009 (0.025)
VIISITDA	0.009 (0.007)	−0.013 (0.012)	0.001 (90.012)	*−0.019 (0.011)*[a]
MEMCELL	−0.002 (0.043)	*0.245 (0.072)*[c]	−0.108 (0.075)	0.008 (0.071)
RLGN	*0.097 (0.043)*[b]	0.036 (0.072)	0.004 (0.074)	0.106 (0.071)
SENBETE	−0.070 (0.072)	−0.020 (90.121)	−0.089 (0.125)	−0.040 (0.118)
DSTMARKT	*−0.002 (0.001)*[a]	−0.002 (0.001)	0.002 (0.002)	*−0.003 (0.001)*[b]
RADIO	−0.009 (0.040)	−0.005 (0.068)	0.008 (0.070)	−0.135 (0.067)
MEMLIQA	0.035 (0.055)	*−0.236 (90.094)*[c]	0.126 (0.097)	0.039 (0.092)
RLOUTKBL	0.014 (0.015)	*0.050 (0.026)*[a]	−0.007 (0.027)	−0.026 (0.026)
RLINKBL	0.045 (0.025)	0.020 (0.042)	−0.022 (0.043)	−0.008 (0.041)
ETHINI	*0.198 (0.033)*[c]	0.022 (0.055)	*0.205 (0.057)*[c]	0.022 (0.054)

[a, b, c] Means statistically significant at 10, 5 and 1 % probabilities

Values in the parenthesis are standard errors

Table 8 Results of a multivariate probit (MVP) analysis of factors affecting farmers' adaptation strategies

Variables	Adaptation strategies						
	ENSEXP	CHATEXP	EUCALEXP	CCVAR	APLDATE	DRYPLT	DIVINC
TLU	0.104 (0.148)	0.096 (0.162)	0.046 (0.180)	*0.344 (0.168)*[b]	−0.119 (0.156)	−0.117 (0.163)	−0.125 (0.188)
TLU_ADE	0.315 (0.726)	0.230 (0.798)	0.899 (0.883)	0.730 (0.822)	0.498 (0.766)	1.126 (0.799)	0.301 (0.923)
TLU_CAPITA	−0.281 (0.753)	−0.418 (0.827)	−0.973 (0.915)	−0.720 (0.853)	−0.625 (0.794)	−1.175 (0.829)	−0.154 (0.957)
OLIVES	−0.060 (0.057)	0.021 (0.062)	−0.013 (0.069)	*0.124 (0.064)*[a]	0.029 (0.060)	0.007 (0.063)	0.035 (0.072)
COWS	−0.054 (0.122)	−0.068 (0.134)	−0.004 (0.148)	*0.230 (0.138)*[a]	0.104 (0.129)	0.120 (0.134)	0.070 (0.155)
OX	−0.092 (0.169)	−0.109 (0.186)	−0.082 (0.205)	*0.367 (0.191)*[a]	0.112 (0.178)	0.090 (0.186)	0.092 (0.215)
SHANDGOT	−0.004 (0.019)	−0.009 (0.021)	−0.001 (0.023)	0.025 (0.021)	0.031 (0.020)	0.008 (0.021)	0.003 (0.024)
DONKEY	−0.166 (0.105)	−0.095 (0.115)	−0.067 (0.128)	*0.248 (0.119)*[b]	0.082 (0.111)	0.092 (0.115)	0.067 (0.133)
DSTWOREDA	*0.003 (0.001)*[c]	−0.001 (0.001)	−0.001 (0.001)	0.000 (0.001)	0.001 (0.001)	0.001 (0.001)	*−0.002 (0.001)*[c]
TOTLANDS	−0.031 (0.093)	−0.156 (0.103)	*0.217 (0.114)*[a]	0.066 (0.106)	−0.063 (0.099)	−0.059 (0.103)	−0.006 (0.119)
LAND_CAPITA	1.541 (3.757)	−2.159 (4.128)	2.849 (4.567)	*7.273 (4.256)*[a]	−0.084 (3.961)	−1.126 (4.135)	5.307 (4.777)
LAND_EAFM	0.191 (0.317)	0.034 (0.348)	0.062 (0.385)	0.204 (0.359)	−0.434 (0.334)	−0.190 (0.349)	0.583 (0.403)
LAND_ADEQ	−1.780 (3.858)	2.683 (4.238)	−1.287 (4.690)	*7.250 (4.370)*[a]	1.385 (4.068)	1.729 (4.246)	−6.196 (4.905)
NFAML	−0.076 (0.085)	−0.133 (0.093)	−0.050 (0.103)	−0.032 (0.096)	0.077 (0.089)	0.027 (0.093)	0.062 (0.108)
FAMADE	0.098 (0.096)	0.172 (0.106)	0.160 (0.117)	0.048 (0.109)	−0.069 (0.102)	−0.012 (0.106)	−0.033 (0.123)
GENDER	*0.215 (0.069)*[c]	0.118 (0.076)	*0.145 (0.084)*[a]	−0.064 (0.078)	0.056 (0.073)	*0.119 (0.076)*[a]	-0.010 (0.087)
AGE	*0.007 (0.003)*[c]	*0.005 (0.003)*[b]	0.004 (0.003)	0.001 (0.003)	−0.004 (0.003)	0.005 (0.003)	−0.003 (0.003)
MSTAT	−0.001 (0.066)	−0.059 (0.073)	0.033 (0.080)	−0.028 (0.075)	−0.052 (0.070)	−0.078 (0.073)	0.109 (0.084)
EDUC	0.015 (0.027)	0.009 (0.029)	0.032 (0.032)	0.014 (0.030)	0.010 (0.028)	*0.067 (0.029)*[b]	*0.096 (0.034)*[c]
FEXPR	−0.003 (0.002)	0.000 (0.002)	−0.003 (0.002)	0.000 (0.002)	*0.004 (0.002)*[b]	−0.002 (0.002)	−0.001 (0.002)
MOBILEPH	−0.090 (0.076)	0.080 (0.083)	−0.101 (0.092)	−0.062 (0.086)	0.036 (0.080)	−0.099 (0.083)	0.080 (0.096)
FRINKBL	*0.047 (0.025)*[a]	0.010 (0.027)	−0.026 (0.030)	0.028 (0.028)	−0.002 (0.026)	−0.024 (0.027)	0.029 (0.031)
FROUTKBL	−0.004 (0.031)	0.018 (0.035)	−0.018 (0.038)	−0.002 (0.036)	0.025 (0.033)	0.003 (0.035	−0.059 (0.040)
VIISITDA	0.001 (0.009)	0.006 (0.010)	0.007 (0.011)	0.013 (0.010)	−0.003 (0.009)	0.002 (0.010)	0.005 (0.011)
MEMCELL	*0.104 (0.055)*[a]	0.030 (0.060)	0.010 (0.066)	−0.036 (0.062)	0.017 (0.058)	0.022 (0.060)	−0.051 (0.069)
RLGN	*−0.139 (0.054)*[b]	*0.099 (0.060)*[b]	0.007 (0.066)	−0.071 (0.062)	−0.021 (0.057)	0.066 (0.060)	0.063 (0.069)
SENBETE	*0.355 (0.091)*[c]	*−0.188 (0.100)*[a]	*0.375 (0.111)*[c]	*−0.271 (0.104)*[c]	−0.095 (0.096)	0.065 (0.101)	0.061 (0.116)
DSTMARKT	*−0.005 (0.001)*[c]	*−0.003 (0.001)*[c]	0.001(0.001)	0.001 (0.001)	0.000(0.001)	*−0.002 (0.001)*[a]	0.002 (0.001)
RADIO	0.232 (0.051)[c]	0.088 (0.057)	*0.177 (0.063)*[c]	-0.077 (0.058)	0.017 (0.054)	0.001 (0.057)	0.034 (0.065)
MEMLIQA	0.048 (0.071)	0.068 (0.078)	0.047 (0.086)	*−0.150 (0.080)*[a]	*−0.171 (0.075)*[b]	−0.159 (0.078)	*−0.013 (0.090)*[b]
RLOUTKBL	*−0.059 (0.020)*[c]	−0.011 (0.022)	0.006 (0.024)	*0.046 (0.022)*[b]	0.023 (0.021)	−0.017 (0.022	0.034 (0.025)
RLINKBL	*0.047 (0.020)*[b]	0.018 (0.022)	−0.024 (0.024)	0.030 (0.022)	0.011 (0.021)	−0.012 (0.022)	0.027 (0.025)
ETHINI	*−0.179 (0.042)*[c]	*−0.306 (0.046)*[c]	*0.276 (0.051)*[c]	*0.092 (0.047)*[a]	−0.031 (0.044)	−0.068 (0.046)	−0.028 (0.053)

[a,b,c] Means statistically significant at 10, 5 and 1 % probabilities, respectively. Values in the parenthesis are standard errors

have indeed shown a positive relationship between number of years of experience in agriculture and the adoption of improved agricultural technologies (Shiferaw and Holden 1998; Kebede et al. 1990). The third category encompasses factors related to households' *social and cultural characteristics* such as marital status, religion, membership in different socio-political groups, and ethnicity. This shows that households' with better social and cultural capital have better capacity to coping with and adaptation to climate related risks such as reduction in crop yield due to rainfall variability. Similar, results elsewhere show that farmers' with better social and cultural capitals invested more in land improvement activities (Adesina et al. 2000; Bowles and Gintis, 2002). The last category are factors related to *access to information* which include distance to Woreda town, distance to market places, access to information through radio, and support from development agents. Earlier studies also show that farmers with better access to information through agricultural experts or radio invest more in adaptation to environmental changes such as land degradation in Ethiopia (Bekele and Drake 2003; Kassie et al. 2008).

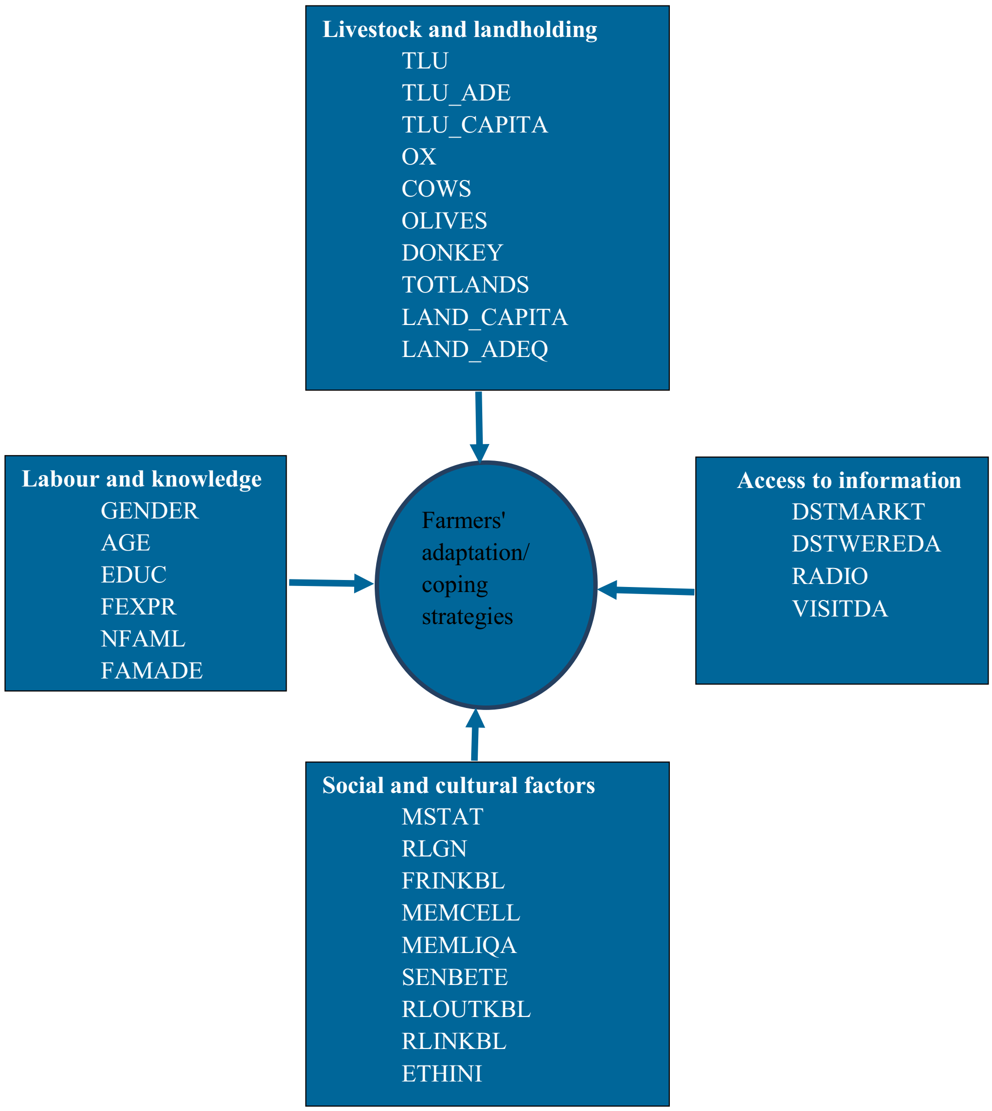

Fig. 4 Summary of factors that affect farmers' coping and adaptation strategies in the central Rift valley of Ethiopia

Conclusion and recommendation

Farmers in the CRV of Ethiopia employ several coping and adaptation strategies to the perceived trend of declining rainfall and crop productivity. These strategies are household and site specific due to variations in household characteristics and site condition. This study identified several factors that affect farmers' choices of certain strategies, which can be grouped in four major factors: (1) livestock and landholdings, (2) availability of labour and knowledge, (3) access to information, and (4) social and cultural factors.

Households with bigger livestock and landholdings, both measures of wealth and access to financial resources, have a better capacity to cope with and adapt to environmental changes. This implies that there is a need for improving farmers' financial capacity in order to invest in certain coping and adaptation strategies. Given this result and limited financial resources of farmers in the CRV, there is a need to include asset accumulation strategies while projects are planned at national and regional levels. Moreover, options such as the provision of credit and enhancing farmers' asset accumulation strategies should be considered while planning national adaptation strategies.

In theory, three stages are identified during asset accumulation strategies. In the first stage, current resource inflows must exceed current outflows. In this case, people often reallocate resources from consumption, but they may also increase resource inflows without reducing consumption, for example, by working more. The latter constitutes a reallocation of time and effort from leisure to labor. In the second stage of asset accumulation, resources may be converted from some easy-to-spend form to a more difficult-to-spend form. For example, cash may be converted to resources in a bank account or to cash held by a trusted friend. Although asset accumulation can occur without this second stage (if resources are saved and maintained in liquid forms). In the last stage, for saving to lead to asset accumulation, individuals must resist pressures to dissave.

The result also shows that availability of family labour and knowledge were the major factors that affect farmers' choice of different coping and adaptation strategies in the CRV of Ethiopia. Generally, farmers with more family labour and better knowledge had more coping and adaptation strategies to the trends of rainfall and crop productivity. This suggests that farmers should have access to formal and informal education to increase their coping and adaptation capacities. Besides, there is also a need to strengthen labour sharing institutions in the country to enhance farmers' adaptation strategies.

The study has also shown the importance of access to information, which is crucial to enhance farmers' awareness and knowledge of coping and adaptation strategies for their particular conditions. This information can be provided using communication media such as radio and through development agents. Use of development agents in assisting farmers related to environmental changes and adaptation strategies should be strengthened in Ethiopia in general and CRV in particular. Moreover, improving communication media (e.g. mobile network) and providing information regarding environmental changes and appropriate adaptation strategies is crucial in the CRV of Ethiopia. Finally, it is important to emphasize that subsistence and smallholder farmers are very susceptible to rainfall variability and changes. Hence, holistic efforts are required to build resilience of communities to the range of environmental shocks and stresses.

Authors' contributions

ZA has made substantial contributions in conception design, data collection, data entry, data analysis and interpretation of results. He has spent his time on writing the first draft of the manuscript. Aad Kessler has contributed in editing and writing the draft manuscript. Both authors contributed in reviewing the manuscript at different stages. Both authors have read and approved the final manuscript.

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Competing interests

The author declares that they have no competing interests.

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