Journal of Sustainable Development in Africa (Volume 22, No.1, 2020)
ISSN: 1520-5509
Clarion University of Pennsylvania, Clarion, Pennsylvania

SUSTAINABLE AGRICULTURAL SOLUTIONS FOR OVERCOMING CLIMATE CHANGE:

ADOPTION OF CONTRACT FARMING AS CLIMATE CHANGE ADAPTATION STRATEGIES IN OROMIA REGIONAL STATE, ETHIOPIA

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ABSTRACT

Even though agriculture is the major livelihood base for many populations in Ethiopia, it is rainfed and affected by climate change and variabilities. This study aims at exploring the factors affecting smallholder farmers' (SHFs) contract farming (CF) as adoption of climate change adaptation strategies (CCASs) employed in Kofele and Adama districts of Oromia Regional State. Data were collected from 368 randomly chosen SHFs, used multinomial logit model and complimented it with FGDs, KIIs, field observations and case histories to explore the adoption of CF as CCASs in the study areas. The results revealed that age of household head, educational status of household head, family size, livestock holding, access to credits, access to agricultural technologies and metrological information significantly affected the adoption of various CCASs. The result depicted that promoting sustainable agriculture, fair and well-structured CF, good agronomic practices, livelihood diversifications, soil and water conservations (SWC) are better helpful to combat CCASs.

Keywords: Agronomic practices, Climate change adaptation, Contract farming, Multinomial Logit Model, Sustainable agriculture

INTRODUCTION

Agriculture is the major livelihood base (i.e. more than 80%) for many populations in Ethiopia (CSA, 2008). It is rainfed and predominantly affected through climate change[1] and variabilities (Getachew, 2010). According to CRGE (2011) and CSA (2008), agriculture is the main stay of the country's economy and believed to continue as the dominant sector to bring about sustainable economic growth in the country. However, Ethiopia in general and the study areas in particular are located within tropical Africa, this makes it vulnerable to influences of climate change and variabilities (Inter Academy Council (IAC), 2004; Dixon et al., 2001; Houghton et al., 2001). These changing climates and climate variabilities manifest itself in rainfall fluctuation, poor on set, late and early cessation and temperature changes compounded with poor agronomic practices and in appropriate input utilizations including poor technology adoption. This in turn affected smallholder framings production and productivity, mainly reducing crop yield that threaten livelihood of those engaged in such agriculture (Deressa et al., 2010). Though, CF as CCASs is expected to curb climate change and variabilities, it provides opportunities for SHFs to participate in value chain and access the global markets (FAO, 2015).

Moreover, climate has changed and will continue to do so in the coming decades and these needs to understand how smallholder[2] farmers (SHFs) are striving to perceive and adapt to the changing climate (Deressa et al., 2010). This is very important in understanding further SHFs' adaptations and plan to adapt to climate change and climate variabilities. A study by Amare and Simane (2017) underscored that despite considerable policies and strategies set to facilitate adaptation strategies to curb climate change adverse impacts of climate change, the negative impacts continued to hamper the agricultural sector. This is highly affecting sustainable agriculture in developing countries like Ethiopia. Empirical studies such as (Reidsma et al., 2009; Kurukulasuriya and Mendelsohn, 2008; Stern, 2006) focused on the study of impacts of climate change and suggested some policy implications. Nevertheless, they failed to address what specific driving forces or determining factors that initiated the local SHFs to adopt CCAS pertinent to their location (i.e. socioeconomic, institutional and environmental conditions of the study locations). Given the difference in socioeconomic, institutional and environmental settings, the adoption of climate change adaptation requires understanding of location specific realities of the SHFs situations.

[1] Climate change refers to a change in one or more climatic elements or stimuli such as rainfall, temperature, relative humidity manifested through drought, floods, snowfall, and change in planting of sowing date and so on.

[2] This paper uses the term "smallholder farmers" and "farmers" interchangeably and it uses it for the sampled households and it represents the "participant and non-participant" farmers in contract farming.

[2] The term smallholder farmers are used quite loose, to denote two characteristics, having limited farming area and not having the resources to invest in expanding the farming practice on their own. These households are typically average to poor households in a community. According to this study, they have farmlands less than five hectares.

As discussed earlier, apart from studies conducted by Asrat and Simane (2018), Amare and Simane (2017) and Deressa et al. (2010) on adoption[3] of CCASs specific to Blue Nile, the scope of their work or research is limited to the Nile basin and it lacks comprehensive coverage. Due to limited scientific investigations in this aspect, there is a need to consider areas with commercial agriculture (i.e. Malt Barley and Sugarcane Contract Farming Areas). Thus, it is paramount important to look into the adoption choices of SHFs in CF[4] areas and deal with sustainable solutions for sustainable agricultural activities with respect to adoption of CF as CCASs helps to draw some lessons from the current study.

Therefore, the objective of this study is to examine what driving forces or determinant factors that are affecting sustainable agriculture and SHFs adoption of CCAs SHFs employed the changing climate and the variabilities in the study areas. Moreover, to analyze sustainable agricultural solutions or CCASs, SHFs of Kofele and Adama districts of Oromia Regional State, Ethiopia are relied sustainable agricultural solutions on to curb climate change and variabilities.

A CONCEPTUAL FRAMEWORK

To address climate change and variabilities there should not be a one shoes fits for all It depends on the context, location, type of agricultural practice and available technologies that have the potential to address climate change and variabilities. This study focuses on the study of sustainable agricultural solutions to curb climate change and climate variabilities by taking into account CF as CCASs and exploring its factors in the adoption process. CCASs depend on understanding of the sustainable livelihood context of farmers. Farmers' understanding on adoption of various CCASs laid a foundation for grasping the contribution o sustainable adaptation options, overall farmers' livelihood and its relationships with agribusiness firms. Moreover, this requires understanding of farmers' sustainability itself, livelihood activities and CCASs or choices in their locality based on their local context. As evidenced in (Prowse, 2012; USAID, 2012; Minot, 2011; Bijman, 2008; Eaton and Shepherded, 2001) CF practices as a sustainable livelihood strategy, agronomic practices, soil and water conservation, shift in livelihood and livelihood diversification creates opportunities to access factors of production such as land, capital, labour and time, which are the cornerstones for the farmers' in climate change adaptation processes. However, the CCASs employed by the farmers serve to build their adaptive capacity and contribute the transformation of structures and processes. Therefore, this study modified and relied on the sustainable livelihood Framework (SLF) employed by Carney (1998) and that of Ziervogel (2003) to understand adoption of CF practices, the climate change adaptations and livelihood of farmers' in the study areas.

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[3] Adoption here refers to a mechanism to employ and use various climate change adaptation strategies in the context of location where the adoption options based on local or own resources and making the adoption practices their own.'

4 CF refers to contract farming signifying the Malt Barley and Sugarcane contract farming or outgrower schemes at Kofele and Adama districts, respectively. The sampled smallholder farmers in these two districts are engaged in CF schemes.

The main aim of this study is to understand the decisions of farmers in adoption of various CCASs with special focus on CF in two districts of Oromia Regional State of Ethiopia:- Kofele and Adama districts that are engaged in Malt Barley and Sugarcane CF, respectively. Thus in the context of this study, the success of farmers' depends on the way adoption took place and integrated or aggregated practice included in climate change adaptations put in place and the livelihood assets such as finance, technical knowledge, new production techniques, technologies and skills were channeled towards facilitation of climate change adaptation (Deressa et al., 2011 and 2010). In addition, the adoption of CCASs related resource utilization, improper application of agronomic practices, pre-harvest and post-harvest loss affect the effectiveness of climate change adaptation. On top of these, there are other factors such as institutional set ups, organizations, soil and water conservation practices, incentives, policies and legislations that shape adoption of various CCASs, as farmers' livelihood and climate change adaptation options are hampered by resource utilization (Getachew, 2012). Moreover, the institutions and processes that operate from the lowest level (household) to the national level and at all spheres from NGOs, private to the public determines access to livelihood assets, livelihood activities, livelihood strategies and outcomes that likely influences adoption of climate change and climate variability induced hazards.

Different CCASs as a solution i.e. CF and all the necessary assets or inputs as described above would be helpful for overcoming climate change hazards successfully through various adaptation mechanisms. The various livelihood choices as a result of CCASs employed, further enhances the adaptive capacities of households, individual farmers, institutions both government and NGOs. It also supports private agribusiness firms and SHFs to achieve their goal on sustainable ground and plays a significant role in building up virtuous circle of the continuum. As depicted in figure 1 below and clearly indicated in Ford et al. (2006), the nature and concerns of farmers, their location, structure and culture impacts successful implementation of CCASs. The comparative advantages and the new Oromia Agricultural Transformation Agency (OATA) strategies (cluster formation) induced commercialization of agriculture play a tremendous role in this regard (OATA, 2016) with respect to CCASs. For example, adoption of sustainable new technologies those have the capacity to boost agricultural production, improve the existing markets creating new markets that benefits both the agribusiness and farmers' from CF practices (Ayelech, 2012 and 2010) and facilitate CCASs.

Fortunately, one of the advantages of the understanding adoption of CCASs in the face of climate change adaptations is to enhance the adaptive capacities of farmers and increase their potential abilities to address, plan for and curb the changing climate and reduce the influences of factors that hinders the successful implementation of CCASs. It is through these gained experiences and a better ways of handling problems related to adoption of CCASs that are making a plain ground for providing solutions for the changing climate. The adaptive capacities that are the major characteristics of the human system including economic wealth, social capital, infrastructure, social institutions, and experiences supports and address challenges resulted from climate change and climate variabilities. Furthermore, the wide range of technologies such as: new varieties of improved seeds, combine harvesters (Threshers), Aybar BBM, irrigation technologies and so on, determines the successful implementations of CF schemes, coping mechanisms or adaptations to climate change and variabilities in the study areas. These factors facilitate or constrain the ability of farmers, cooperatives or a community to deal with climate related hazards (Robards and Alessa, 2004; Adger, 2003a; Smith et al., 2003; Barnett, 2001; Handmer et al., 1999). These determinants are interdependent and influenced by human and biophysical conditions and process operating at various scales from local to global level, by which thinking globally and acting locally has been exemplified in this paper.

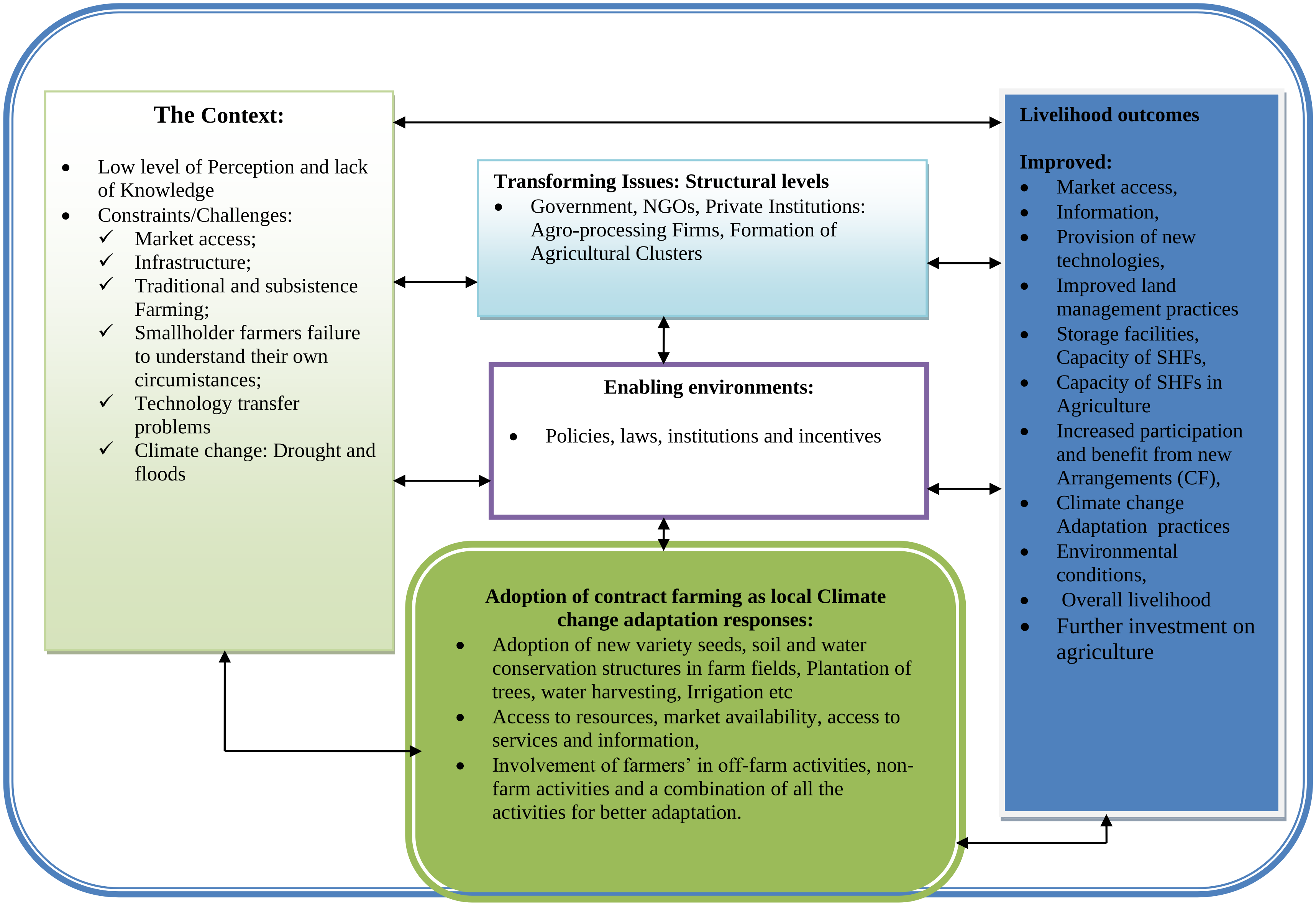

Figure 1: A conceptual framework on adoption of climate change strategies and livelihood choices
Source: Modified from Carney (1998) and Ziervogel and Calder (2003)

MATERIAL AND METHODS

Descriptions of the study areas

This study was undertaken in two Districts: Kofele district is one of the districts located in West Arsi Zone of Oromia Regional State of Ethiopia. It is located in $6^0$50' N - $7^0$09' N latitude and $38^0$38' E - $39^0$04' E longitude. It consisted of a total area of 72,000 hectares with a total population of 17,9508, out of which 90,000 were males and 89,508 were females (CSA, 2007). Agriculture is the main stay of the economy of the district. More than 95% of its population engaged in agricultural activities such as crop production, livestock rearing and other agricultural related activities. It is only limited percent of population (i.e. around 5%) were engaged in different forms of income generation activities of off-farm and non-farm activities in their areas. Malt Barley is becoming the major commercial crop at Germama Peasant Association (PA). The district is known with altitude ranging between 2400-2500m with annual mean temperature of 22^0C, providing wider range of opportunities for the production of different types of crops including Malt Barley. The maximum rainfall of June, July, and August months are with 1200mm, the driest months are January and February. The coldest months are December and November with 12°C and 5°C average and minimum temperature, respectively. While April *(Ebla)* is the hottest month with 15°C average annual temperature and 22°C maximum temperature. On average, the district gets annual mean rainfall of 1200mms.

Adama district is also another study district found in the Eastern Shewa of Oromia Regional State of Ethiopia. Wonji Shewa is one of sugar producing factory located in the rift valley at Adama district. It is found in between $8^0$20’0”N - $8^0$28’0” N latitude and 39012’0”E - 39016’0”E East longitude. The topography of the factory lies within 1500-2300 mean above sea level (m.a.s.l) and dominated by the rising and falling plains that involve extensive ridges all along the western boundaries (Tadesse et al., 2013). Most of the portion of the factory is situated in sub-tropical agro-climatic zone. Very flat and regular land characterizes Wonji-Shewa having a general slope varying between 0.02-0.05 percent (Dinka et al., 2013). The hilly terrain surrounded the plain topography in the area except in the Southeastern part, where the water drains towards the North direction. Prior to the introduction of irrigation in the area, Wonji area was rich in vegetation cover. However, due to the competition for agriculture, livestock grazing and the Sugarcane farm, the forest cover has been changed into shrub and bushes with some remnant Acacia trees. It is one of the densely populated districts in East Shewa zone (CSA, 2007). The total population of Adama district was around 155,321. Among these, 16.9% of the population lives in urban areas, while 83.1% are rural population (CSA, 2007). The district has more than 43 PAs. Wonji-Shewa is the only Sugarcane out grower schemes found within upper Awash River Basin, Central Rift Valley of Ethiopia.

A study by Dinka et al. (2013) long-term weather data of Wonji meteorological station indicated that Wonji is characterized by erratic rainfall pattern with average annual rainfall of 832mm. The mean annual, minimum and maximum temperature exhibits 15.2^0C and 27.6^0C, respectively. The rainfall in the area shows a considerable spatio-temporal variation, where most of the rainfall for the area is in summer season from June to September.

However, there is a considerable monsoon rainfall in the month of March or April because of the Inter-tropical Convergence Zone (ITCZ).

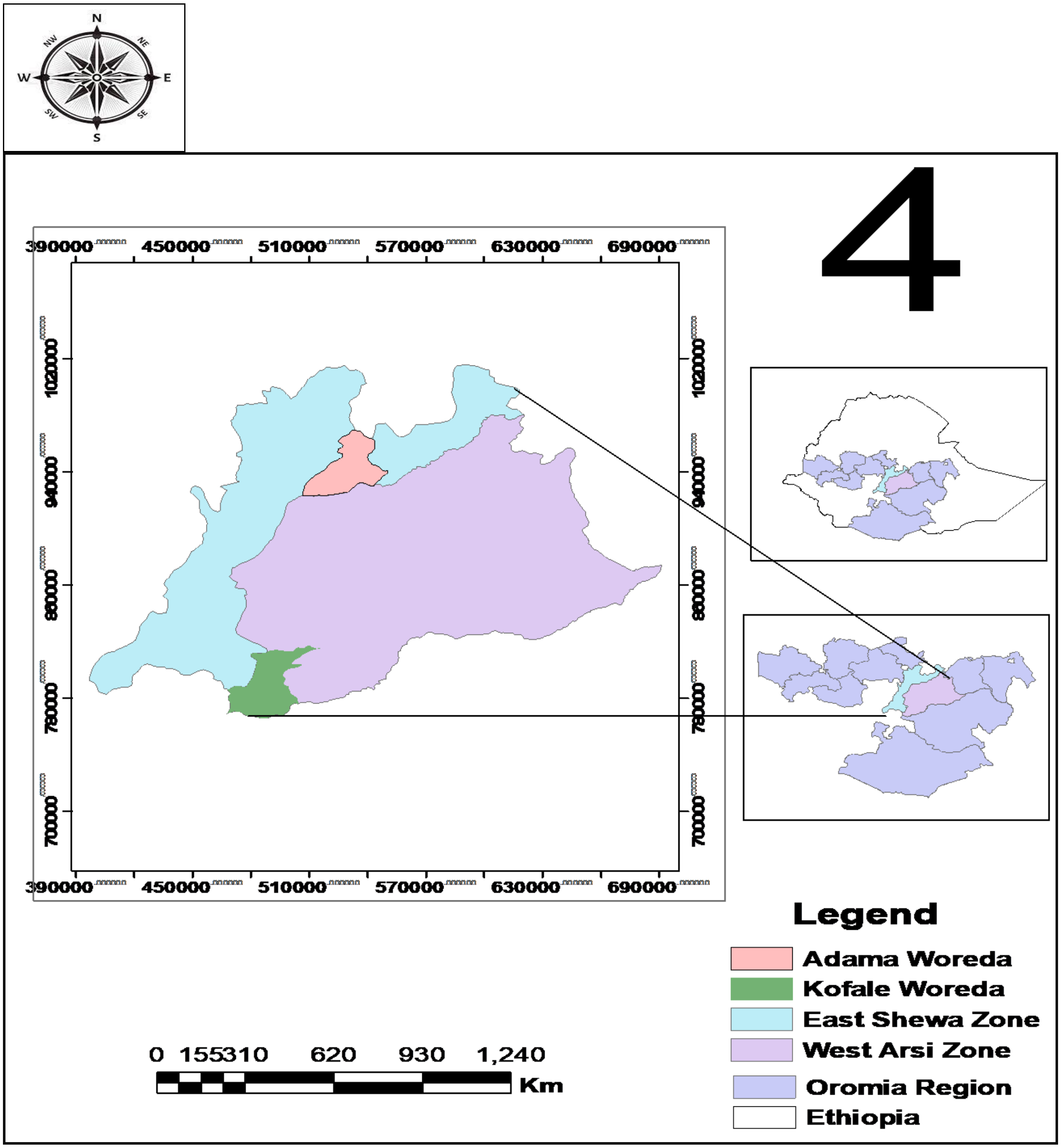

Figure 2: Map of the Study areas

(Source: Own Construction, 2018)

Rainfall and temperature situations of Adama and Kofele districts

As indicated in figure 3 below, the trends of mean annual rainfall of Kofele from 2000-2017 G.C varies from 120mm to 150mm (NMAE, 2018). The lowest mean annual rainfall was observed in 2012 G.C with 70mm of rainfall, the highest and maximum rainfall in 2016/17 G.C with more than 150mm. The computed result, which is the highest amount of rainfall concieded with the discussions made with the FGDs on overall rainfall situations during field survey and they confirmed that there was snow fall and serious flash floods (i.e. between 2014 and 2017 G.C) in the study area. The survey collected on overall rainfall situations further confirmed that there were irregularities in rainfall pattens in the area and this was resulted in extreme floods and droughts, which clearly indicated that there is climate change and variability,which infact is affecting the agricultural production in the study area.

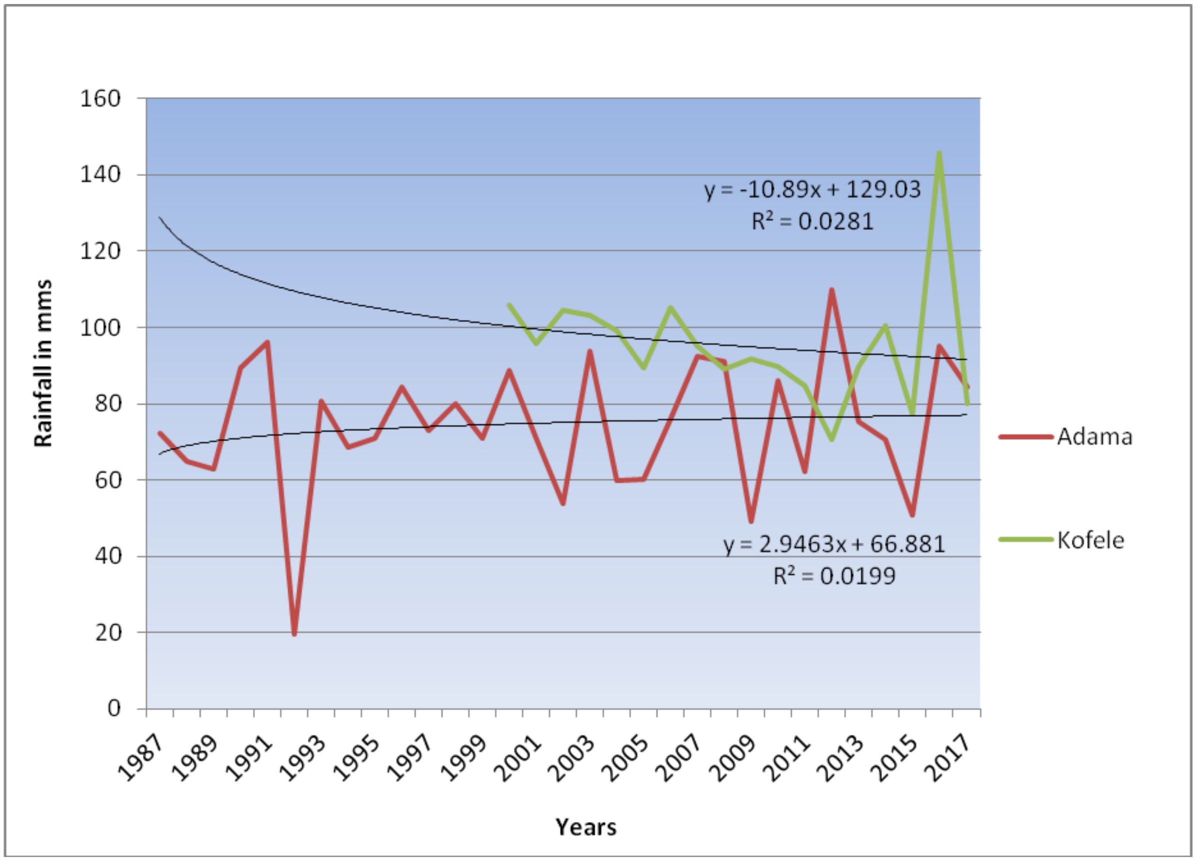

Figure 3: Trends in Mean Annual Rainfall at Adama and Kofele Districts

(Source: Authors construction, 2018)

Regarding the trends in temperature, the metreological data obtained from the national metrological agency computed from daily temperature and monthly records indicated that the temperature situation also exhibited an ossilation or long term variability (-0.9^{0}C in 2011 and -0.2^{0}C in 2012 G.C) and sharply increased and fluctuated after 2014 G.C in mean and minimum annual temperature from time to time (NMAE, 2018). It was not consistent, which in turn affects agricultural production and productivity in the study area. The FGDs and KIIs further confirmed that there are change in climatic elements such as rainfall and temperature leading to climate change, climate variabilities resulting in recurrent drought and sometimes heavy floods. In addition, the regression result between mean annual rainfall and time where an increase in one year period for Adama district revealed an increase of mean annual rainfall by 2.9463mms and a decrease of 10.89mms in mean annual rainfall for Kofele district (See Figure 3). This clearly indicated that the rainfall amount and pattern in Kofele district were decreasing and this seriously affected the agricultural production in the area. This of course consstent with the discussions made with FGD where the time and the amount of rainfall is generally changing from 2000-2017 G.C.

Figure 4: Trends in Maximum Mean and Minimum Temperature at Kofele District

(Source: Computed from NMAE Data, 2018)

Similarly, as depicted in figure 4 and 5, the trends in mean annual rainfall and mean annual temperature at Adama and Kofele districts obtained from Ethiopian metrological agency suggested that the rainfall was irregular and revealed differences in distribution across years from 1987-2017 G.C (National Metrological Agency of Ethiopia (NMAE), 2018). In between 2000-2017 G.C, the temperature in Kofele has shown a decreasing trend. For example, the regression result for minimum and mean annual temperature for Kofele revealed a decrease by 0.717^0C and 0.756^0C, respectively. However, the regression result for maximum annual temperature in one year period for Kofele indicated an increase by 0.5693 ^{0}C. The trends in maximum and mean annual temperature in and around Adama district exhibited a decrease of maximum and mean annual temperature by 0.084^0C and 0.043^0C, respectively. Conversely, the trends in minimum annual temperature from 1987-2017 G.C revealed an increase of temperature in and around Adama district by 0.4309^0C. This computed mean annual temperature is consistent with the discussions made with FGDs and the KIIs interview made with district agricultural experts, where the minimum annual temperature decreased for Adama and its environs decreased because of Sugarcane contract farming microclimate, which reduced the temperature in the area (see figure 4 above). This is to mean that the use of irrigation because of sugarcane plantation, the climate in the area is modified due to decrease in temperature.

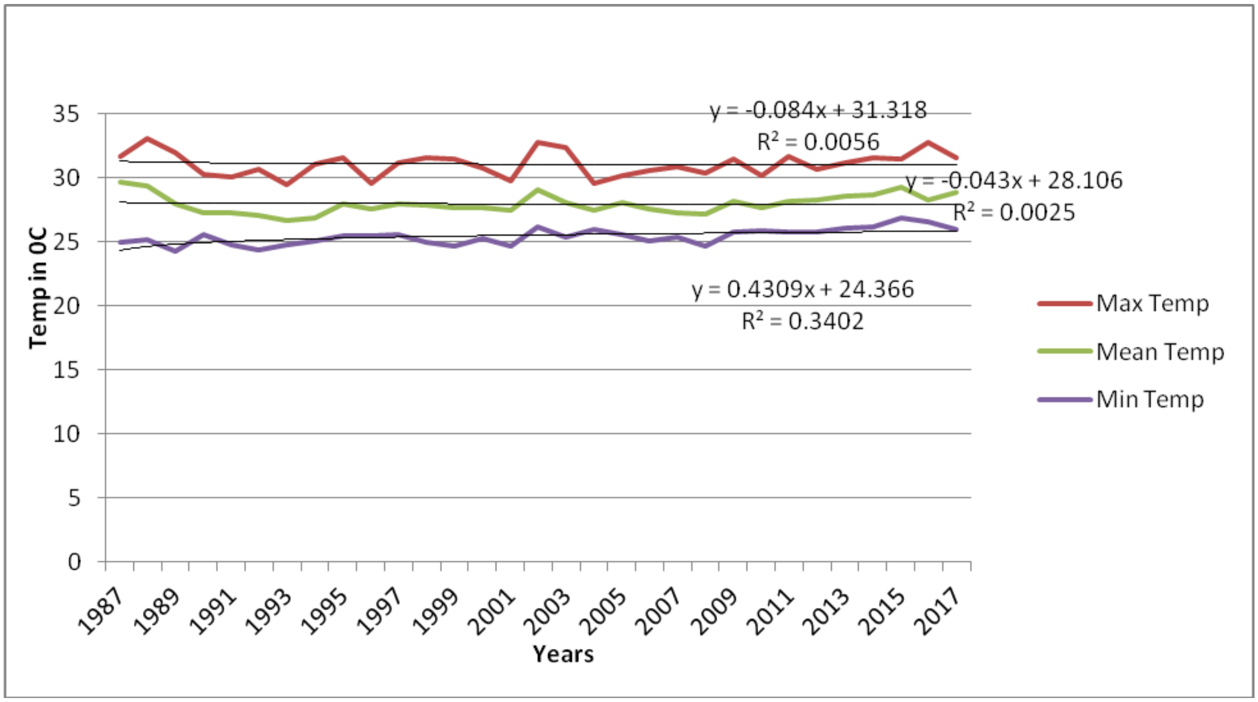

Figure 5: Trends in Maximum, Mean and Minimium Temperature at AdamaDistrict

(Source: Computed from NMAE Data, 2018)

Research Methods: Sampling procedures and data collection

Primary data were collected from the selected farmers using quantitative was administered through household survey. In the qualitative study, Six Focus group discussion that consisted of ten participants each, twenty key informant interview were conducted, three field observation and case histories were undertaken in the study PAs.

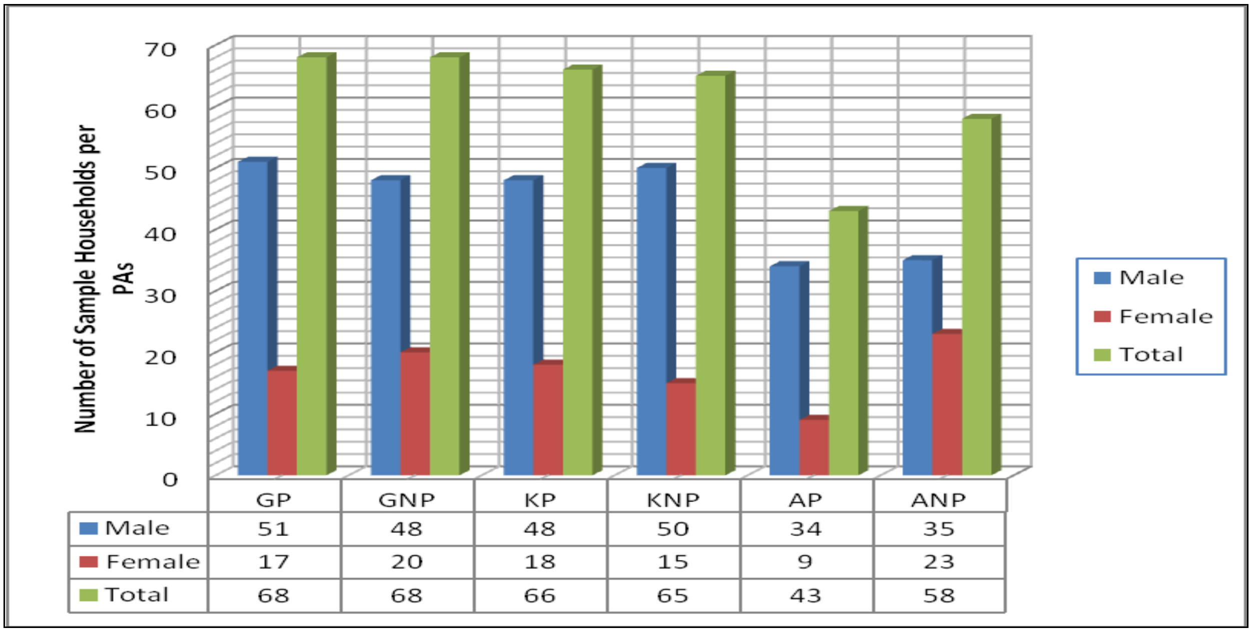

Figure 1: A graph of sampled household heads

(Source: Kofale and Adama District Agricultural Office, 2018)

A multistage random sampling technique was employed to select a sample of 383[5] SHFs from the districts. Three PAs were purposively selected from the districts in these two Zones (i.e. one PAs from West Arsi Zone, Kofale district). The proportionate sampling technique war employed and randomly selected the participant and non-participant SHFs from the lists obtained from PAs. From Germama PA, 136 sample SHFs engaged in Malt Barley production, two PAs from Eastern Shewa Adama district namely: Kuriftu Hida and Adulala Hake Haroreti) with 131 and 116 respondent SHFs, respectively, were selected randomly from the lists taken from the PAs. Accordingly, the PAs were selected based on their crop production history, where households at Germama started Malt Barley Contract Farming at Kofale district in 2006 E.C, Kuriftu Hida and Adulala Hake Haroreti villages started Sugar cane contract farming in 1975 G.C and 2008 G.C, respectively. Consequently, the heads of households engaged in contract farming was the unit of analysis in the study.

Sampling procedure and sample size determination

The two districts: Kofele and Adama were purposively selected because of their engagement in Malt Barley and Sugarcane contract farming arrangement. Three Hundred Eighty Three (383) households in the districts were considered as the survey population. However, 3.92% of the households did not responded to the questionnaires and the data was analyzed based on 96.08% of the households. The units of analysis were heads of households engaged

[5] The plan was to collect household survey data from 383 sample SHFs who are participants and non-participant in contract farming practices in the study areas. However, in the actual field survey the data were collected from 368 smallholder farmers who were available during the field survey as per their appointment with the data enumerators.

in contract farming arrangement in the study areas. Thus, to draw the sample households from the survey population, we relied on Kothari (2004) to estimate the minimum sample size for the study.

Accordingly, to draw the respondent households for the study utilizes the sample size formulated by Kothari (2004):

$$n = \frac{z^2 \cdot p \cdot q \cdot N}{e^2 \ (N-1) + z^2 \cdot p \cdot q}$$

Where: n is the desired sample size for the study; Z is the upper points α/2 of standard normal distribution at 95% confidence level, which is equal to 1.96; e is acceptable error term at a given precision rate (assumed 5%); p is the proportion of households (which is taken as 0.5 or 50%). In most conservative cases, 'n' would be the maximum and the sample would yield at least the desired precision; q is 1-p; N is the total households.

Methods of data analysis

We analyzed the quantitative data obtained by household survey through a Statistical Packages for Social Science (SPSS Version 20) and Stata version 14. The quantitative data gathered through household survey from the participant and non-participant SHFs and substantiated it with the qualitative data such as FGDs, KIIs, field observations and case histories that are transcribed, narrated and used in the analysis.

The descriptive statistic were used to explain the perception of sampled households on rainfall patterns and temperature changes over two decades and the role of CF in climate change adaptation strategies employed by contracted and non-contracted farmers. The multinomial logit model (MNLM) was used to estimate the adoption options in the study areas. Ultimately, marginal effects computed from the MNLM were employed to look into the expected change in the probabilities among the adoption choices made with respect to a unit change in the predictor variables and analyzed the specific climate change adaptation strategies in the study areas.

Econometric model specifications: The multinomial logit model

The logit and probit models are the two most important functional forms employed in adoption modeling. These models have distinct statistical properties as their probabilities are in between 0 and 1. It is obvious that the adoption model on climate change adaptation could be grouped broadly in to two categories based on the number of adoption choices to an economic agent (Greene, 2000) with a choice decision by smallholder farmers with a multivariate decision. This is because, the farmers decide on the adoption of various strategies as a climate change adaptation strategies involves a multiple response that the dependent variable is separate from the independent variable to more appropriately treat factors that affect the choice of adoption of climate change adaptations as a multiple choice decision. Thus in this paper, either multinomial logit or probit model could be employed, since both of them have the power to estimate the effects of independent variables on the dependent variable taking into account multiple choices with unordered response categories (Greene, 2000). However, in this study, the multinomial logit model could have employed as an empirical analysis model because of the computational ease and its superior capacity to predict the adoption choices that households engaged used CF as CCASs in the study areas.

According to Komba and Muchapondwa (2012), the decision to adopt or not to adopt CF and other adaptations mechanisms as CCASs could fall under the general framework of utility maximization employed Greene. Based on Greene (2000), suppose the *i*th respondent encountered with *j* choices; we specify the utility choice *j* as:

$$\mathrm{U}ij = \mathrm{Z}ij\beta + \mathcal{E}ij \qquad (1)$$

Here, if the farmers make choice *j* in particular, then we consider that U_{ij} is the maximum among the *j* utilities. Therefore, the statistical model is derived by the probability that choice *j* is made. This is written as:

$$\mathrm{Prob}(\mathrm{U}ij > Uik) \text{ for all other } K \neq j \qquad (2)$$

Where, U_{ij} is the utility to the *i*th respondent from adoption of climate change adaptation $_{j,}$ *Uik* the utility to the i^{th} respondent from the adoption of climate change adaptations *k*.

Apart from calculating the probability of the utilities, the household's maximizes its utility defined over income realizations. Thus as stated in Brown et al. (2006), the household is simply the optimal allocation of its asset endowment to choose adoption of CCASs that maximizes its utility. To this end, the $\boldsymbol{i}^{th}$ household's choice can be therefore, modeled as maximizing the expected utility by selecting the *i*th adoption of CCASs among *J* discrete adoption factors, given as:

$$\mathrm{Max}j = E(Uij) = fj(xi) + \mathcal{E}ij;\ \text{where } j = 0 \ldots J \qquad (3)$$

In general, for an outcome variable with *J* categories, let the *j*th adoption that the i^{th} household selects to maximize its utility could take 1 if the i^{th} household chooses jth adoption factor and 0 otherwise. Therefore, the probability that a household or a farmer with charactestics x chooses adoption factor *j*, P_{ij} is modeled as:

$$\frac{\exp(X'i\beta j)}{1+\sum_{j}^{J}=0 \exp(X'i\beta j)}, J = 0 \ldots 3 \qquad (4)$$

With the requirement that $\sum_{j}^{J} = 0\ \ Pij\ = 1$= 1 for any *i*, where P_{ij} = probability representing the *i*th respondent's chance of falling into category *j*; *X* = predictors of response probabilities; β_j = Covariate effects specific to ith response category with the first category as the reference.

By computing equation (4), it is possible to normalize and removes an indeterminacy in the model assuming that β_1 = 0,; this arises because the probabilities sum to 1, so only *J* parameter vectors are required to determine the *J* + 1 probabilities (Greene, 2003), so that $\exp(X'_i\beta_1)$_ = 1 implying that:

$$\Pr\left(\gamma\mathrm{i} = \frac{1}{Xi}\right) = Pij = \frac{\exp(X'i\beta j)}{1+\sum_{j}^{J}=1\exp(X'i\beta j)},\ \ for\ j = 0{,}2 \ldots J \quad and$$

$$\Pr\,(\gamma i = \frac{1}{Xi}) = Pi1 \ = \frac{1}{1 + \sum_{j}^{J} = 1 \exp\,(X'i\beta j)}, \qquad (5)$$

Where *y* = A is a polytomous outcome variable with categories coded from 0…*J*. Ultimately, the probability of P_{i1} is derived from the constraint that the *J* probabilities sum to 1. That is:

$Pi1 = 1 \ - \ \sum pij \ldots$, which is similar to binary logit model implying that it can be computed for J log odds ratios and it can be specified as:

$$\text{in}[\frac{Pij}{dpijx}] = x'(\beta - \beta) = x'\beta J if\ J = 0 \qquad (6)$$

Coefficient Interpretation

The MNL model is the extension of the binary logit model, interpreted as binary logit model (Gujarati, 2003). The major difference is that the reference category no longer the other choice as in binary logit model. Probability in the MNL model could be computed similar to that of binary logit model, with the only modification being made for multiple sets of *β* estimates. The meaning of logit (log odds) and odds term is the same in both cases. In the binary case, the comparison is among category 1 and category 2 (i.e. the first versus the last category). In MNL case, the comparison is between category j and J or any category versus the last one.

Hence, the predicted probabilities are better-interpreted using the marginal effects of the MNL model (Greene, 2003). Here, every sub-sector of *β* enters every marginal effect of both probabilities and through weighted average that appears in δ*ij*. By differentiating equation (6) with respect to the covariates, it can be found that the marginal effect of the individual characteristics on the probabilities (Greene, 2003). Thus, the marginal effects (*βij*) of the characteristics on the probabilities can be specified as:

$$\delta\text{ij} = \frac{\partial Pij}{\partial xi} = Pij\,[\beta j\ \sum_{k=0}^{J} Pik\beta k] = Pij\,[\beta j - \ \beta] \qquad (7)$$

Where, δ*ij* is the marginal effect (the coefficient) of the explanatory variable on the probability that alternative j is chosen.

Before running the model, it is very useful to look into the problem of multicollinearity among the continuous variables and confirm the degree of relation between the hypothesized qualitative explanatory variables. The presence of multicollinearity will definitely affect the parameter estimates. If it turns out to be significant, the simultaneous presence of highly variables will reinforce the individual effects of these variables. To detect these problems of multicollinearity among the continuous variables the Variance Inflation Factor (VIF) was used in this study. Each continuous variables is regressed on all the other explanatory variables, the coefficients of determination

R^2 being constructed in each case. If the linear regression exists among the explanatory variables then will result in large value of R^2 in at least one of the tested regressions. A popular measure of multicollinearity associated with VIF is defined as:

$$\mathrm{VIF}(X) = 1/(1 - \mathrm{R2}) \qquad (8)$$

Where X shows the variables regressed on other explanatory variables and R^2 is the coefficient of determination for each independent variable.

Thus, the rise in the value of R^2 revealed an increase in the degree of multicollinearity, which does indeed lead to an increase in the variance and standard errors. Guajarati (1995) underscored that a VIF value greater than 10 (this will happen, if R^2 exceeds 0.90), was used as a signal for presence of severe multicollinearity. Moreover, there may be interaction between dummy variables that can lead to the problem of multicollinearity. For dummy variables if the value of coefficient is greater than 0.75, the value is then collinear. To test this problem, the Coefficient of Contingency (CC) would be computed from the survey data. Then, the CC is calculated as follows:

$$CC = \left[\frac{\sqrt{\chi 2}}{\mathrm{n}+\chi 2}\right] \qquad (9)$$

Where CC is coefficient of contingency, $\chi 2$ is chi-square test and n is the total sample size in the study.

The multinomial logistic (MNL) model essentially depends on the independence of Irrelevant Alternatives (IIA) assumptions in order to get unbiased and consistent estimates from the model (Wooldridge, 2001). This assumption depends on the household's capacity in using certain adoption mechanisms needed to be independent of other choices employed by the same household. However, the validity of this was conducted through Housman test to check whether it is appropriate or not. Thus, Tizale (2007) explained that the estimated coefficients of MNL reveal only the direction of effect of independent variables and it estimate not the actual magnitude of changes and the probabilities. Finally, Stata version 14 was employed to obtain the parameter estimates or marginal effects to measure the expected change in the probability of a particular choice being made with regard to a unit change in predictor or independent variable (Greene, 2000).

RESULTS AND DISCUSSIONS

For agricultural practices to be sustainable and curb climate change and climate variabilities, SHFs needs to engage in modern agriculture that has the capacity to increase agricultural production and productivity. Thus, this section deals with the discussions of the findings pertaining to this study. It tried to explore how adoption of CF as CCASs would immensely help the farmers for overcoming climate change and climate variabilities. Regarding adoption of various adoption strategies to curb climate change, the SHFs employed about six (6) adoption strategies including the no adoption options. Consequently, among all the respondent SHFs that accounted about 16.6%, 20.7%, 29.9%, 16.8%, 5.4% and 10.6% relied that no adoption, adoption of CF, agronomic practices, soil and water conservation strategies, shift in livelihood and livelihood choices (combinations of on-farm, non-farm and off-farm activities), respectively in their locality. Among the adoption of CCASs as depicted in figure 6, agronomic practices, CF, SWC[6] practices and those employed nothing were ranked from 1-4 , respectively. These 1-3 in the rank are the dominant climate change adaptation strategies employed by respondent smallholder farmers' in the study areas.

Agronomic practices[7] are the first most important CCASs and CF is the second one, where CF from its design to its contribution aims at reducing challenges related to agricultural commercialization. This is to say that CF facilitates conditions for the provision of agricultural inputs, market facilitation through basic cooperatives and cooperative unions. The third most crucial climate change adaptation was SWC practices such as half moon, stone bunds, soil bunds, hedges, terraces and drainage was especially done at the hilltops of farmland areas to protect soil erosion because of floods. These SWC practices at Kofele district were very common SWC structures that protect soil erosion from farm fields.

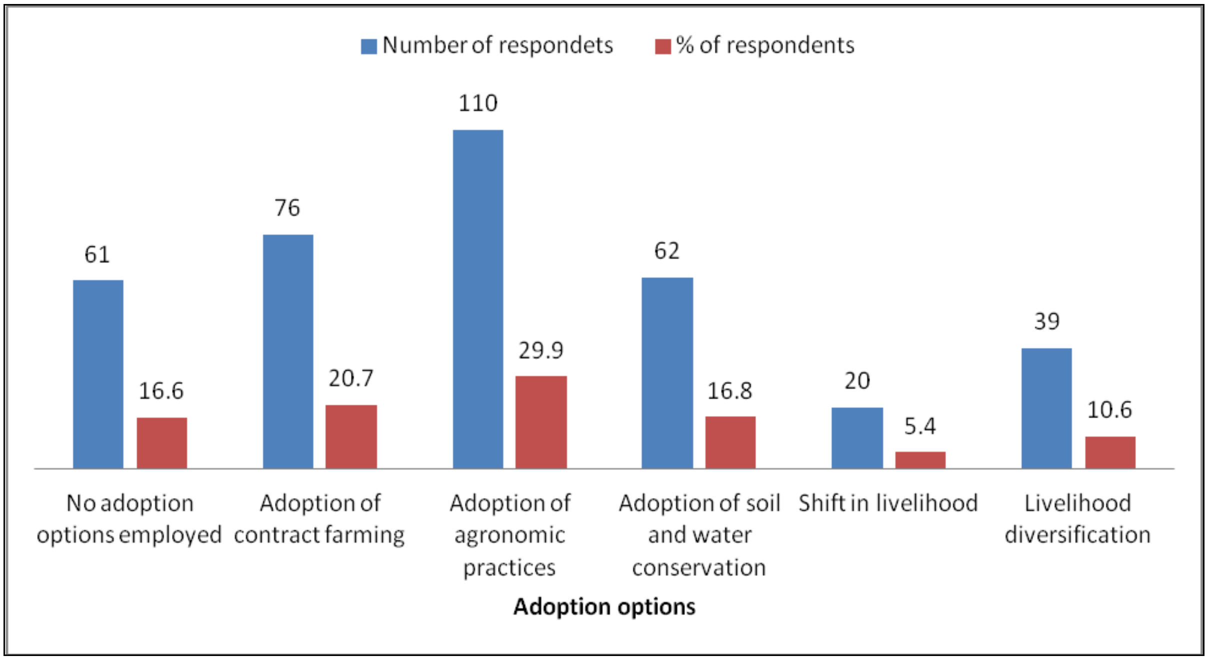

Figure 7: Adoption options employed by Smallholder Farmers

(Source: Computed from survey result, 2018)

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[6] The soil and water conservation practices designated as SWC in the study areas refers to stone bundling, terrace, farm top drainage canals, hedges, fallowing, in farmland canals to drain water from farm fields and so on, which helps to conserve soil and water on farm fields and the surrounding farmland environments.

[7] Agronomic practices as a typical CCAS incorporates those farming practices such as farmland preparation, sowing or planting in rows or conventional ways, weeding, natural or modern fertilizer application, use of pesticides, harvesting, storing agricultural produce and watering of crops from irrigation sources and rainfed. In general, it deals with pre-harvest and post-harvest crop management that aimed to boost agricultural production.

Socioeconomic determinants of adoption of climate change strategies

Adoption of various CCASs employed by participants and non-participant SHFs needs to understand the socioeconomic determinants of the adoption of climate change adaptations in the study locations. As revealed in Table 2 and 3 below, the socioeconomic determinants that are supposed to exert influence on adoption options are age of households, gender of households, educational status of households, family size, Livestock owning situation, farmland size and net peasant associations, access to credits, net income, access to agricultural technologies, access to extension services and access to metrological services.

Age of household heads: Age of household is one of the socioeconomic factors that determine the adoption of CCASs in the study locations. Those farmers who employed the no adaption options, CF, agronomic practices, SWC, shift in livelihood, livelihood combinations or diversifications constituted about mean age of 47.7, 41.1, 42.3, 43.1, 46.9, and 46.4, respectively. From this, one can understand that the respondents with higher mean age preferred to employ no adoption of any strategy, shift in livelihood and depend on various livelihood choices. This is a reflection of the enriched experience in using various CCASs. However, those with lower age groups employed adoption strategies such as CF, agronomic practices and SWC. Above all, the Chi^2 result revealed that there are statistically significant difference among adopters and non-adopters in using various CCASs at $p<0.079$. Therefore, it is paramount important for policy makers to find a way and promote young farmers to employ CCASs to reduce the adoption gaps created as a result of age of respondents in adoption of CCASs focusing on those energetic, abled young farmers to employ various CCASs.

Gender of household heads: Gender of household is another determinant factor that affected the adoption of various CCASs in the study areas. The significant number of respondent households that employed various CCASs were male (i.e. 43.5%) as compared to those female respondents that accounted about 17.8%. This clearly indicated that the female respondents engagement in adoption of various CCASs were less as compared to their male counterparts, where larger proportion of male used various adoption mechanisms to curb climate change and climate variabilities in their study areas. Even though the number of male adopters and female adopters vary greatly, this shows statistically significant difference among the adopter and non-adopter males and females in adopting the CCASs in the area ($p<0.047$). The reason behind this according to the FGDs was that the female respondents engaged less in the adoption process or hire male daily laborer in addressing climate change and climate variabilities through either one of or a combinations of these CCASs discussed above.

Education of household heads: Educational status of respondents plays an immense role in adoption of any CCASs. The mean educational status of respondents ranges between 2.1 to 3.2 grade level with the overall mean of 2.67 grade level. However, those respondents with mean of 3.1 and 3.2 grade level employed CF and shift in livelihood as the best adoption of CCASs. The Chi^2 result further indicated that educational level of adopters and non-adopters of any CCASs were statistically significant at ($p<0.000$). From this, it is possible to concluded that as level of education increases, the probability of participation in CF increases because the respondents with better education have better chance of knowing the benefits and advantages of adoption of CCASs. Hence, this study is consistent with (Strohm and Hoeffler, 2006), where the better the farmers' educational level, the better the respondents' probability to know the benefits of various adoptions and the ways of adopters adopt various CCASs increases.

Family size: Regarding mean family size of the respondent SHFs, the mean number of family of adopters and non adopters was 6.57 persons with standard deviation of 1.49 and 6.51 persons, which is higher than the mean family size of the national average (4.2 persons per household) (CSA, 2007). However, it has been reported that there is significant difference between the family size of adopters and non-adopters ($p<0.016$). As depicted in the table 2, the mean family size of the adopters and non-adopters exhibited significant difference among the types of climate change adaptation strategies employed in the study locations. Above all, all the survey respondents comprised of more than 6 family members and depend on more than one adoption options. For instance, respondent families with larger family size that consisted of 7.1, 6.7 and 6.6 employed CF, agronomic practices and livelihood diversification as CCASs, respectively. This means that those respondent families with larger family size have large labour size and better engage in CCASs and there were no problems of human resource. From these, one can conclude that the large family labour pool facilitates CCASs that specially require labour force.

Livestock rearing: Livestock rearing is one of the important socioeconomic factors that affected the farming system among farming community in the study areas. As indicated in table 2, the survey results revealed that livestock is another major component of socioeconomic pillar of respondents that played a prominent role in adoption of CCASs in the study areas. To this end, the adopters and the non-adopters of the strategies portrayed a mean of 6.23 TLU[8] in using the different CCASs. The Chi^2 result further indicated that there is significant statistical difference among the adopters and non-adopters in using livestock as one of the socioeconomic factor affecting the overall adoption mechanisms ($p<0.000$). This means that, the better the presence of the heads of cattle, the better the respondents adapt and employ various adoption strategies in their locality.

Farmland size: As revealed in table 2, the adopters and non-adopters of different CCASs get hold of 1.73 hectares of farmland. Thus, the farmland sizes in the study locations were larger than the national average of farmland size, which is below 1 hectare (Amare and Simane, 2017). However, the Chi^2 revealed that the farmland holding situation among the adopters and non-adopters of any climate change adaptation strategies indicated significant statistical difference at 1% level *($p<0.000$).*

Net income of households: This one of the continuous variable that is computed or transformed to the natural log of income and it was the aggregate income (on-farm, off-farm and non-farm income) obtained from the difference between total income and total expenditure. The mean income was about 9.72 that was estimated above 12000

[8] Total Livestock Units (TLU) is measurement unit that helps to measure live heads of cattle with animal category and its conversion factor. Thus, according to Strock et al. (1991): Calf=0.25 TLU, Heifer=0.75 TLU, Cow/Ox=1.00 TLU , Horse=1.10 TLU, Donkey =0.70 TLU, Sheep/Goat=0.13 TLU, Chicken=0.013 TLU, Bull=1.00 TLU and Mule=0.70 TLU

Ethiopian Birr (ETB). The study revealed that income affected the adoption of CCASs employed by the adopters and non-adopters. The Chi^2 result further revealed that income obtained from various sources significantly affect the adoption of CCASs and it was statistically significant at 1% ($p<0.000$) is consistent with the study done by Deresse et al. (2010), whereby the greater the income, the better the SHFs employed various adoption mechanisms of climate change strategies. Thus, broadening income base of SHFs immensely facilitates adoptions of various CCASs in the study locations.

Member of peasant association: Being a member of peasant association helps the farmers or respondents to access the basic resources in the area. According to this study, most of the respondents at Germama (Malt Barley CF), Kuriftu Hida and Adulala Hake Haroreti (Sugarcane outgrowers) had employed different CCASs such as including no adoption of any options. Hence, the three (3) PAs have used CF, agronomic practices and SWC. Those respondents sugarcane out growers revealed that small proportions of respondents employed shift in livelihood and livelihood diversifications as CCASs. The Chi^2 result further result revealed that it is statistically significant among the adopters and non-adopters at 1% level ($p<0.000$).

Access to credits: Access to credits as an institutional, factor plays an important role in adoption of CCASs. It facilitated and supported the overall adaptation processes. As pointed out in Amare and Simane (2017) and Deressa et al. (2010), access to credit helps to access to agricultural inputs and technologies that aimed to increase agricultural production and productivity. Moreover, it helps respondents in ensuring agricultural productivity through modern agricultural technologies such as farm inputs: fertilizers, improved seeds, modern farm mechanizations (combine harvesters, threshers) that have a power to boost agricultural production. Thus, significant proportions of respondents have access to credit (i.e. 55.8%). It was only 5.5% of the respondents did not have access to credits and did not adopt all the other climate change adaptation mechanisms except agronomic practices and SWC. The rest of the adopter have got access to credits and employed CF, agronomic practices, SWC, shift in livelihoods and livelihood choices as the major adoption of CCASs. The Chi^2 further indicated that these were statically significant among the adopters and non-adopters of climate change adaptation strategies at 1% level ($p<0.000$). The policy implications here are that in order to help those non-adopters because of not accessing resources, there is a need to design and include a mechanism to put in place financial provisions.

Access to agricultural technologies: Access to agricultural technologies is also one of the pillars of agriculture that increase the production and productivity of farmers. Hence, 49.5% of participant respondent households indicated that they have access to agricultural technologies such as agricultural inputs including fertilizers, improved seeds, agro-chemicals, farm implements and other related technologies. However, only small proportions of participant households that accounted about 7.1% did not rely on agricultural technologies to increase their production. In the survey result, having access to agricultural technologies immensely helped the respondents to relay and adopt a combination of all CCASs. The Chi^2 result further indicated that there is statistically significant difference among the adopters and non-adopters in accessing agricultural technologies and adapting to climate change at 1% level of significance ($p<0.000$).

Access to extension services packages: Access to credit and other financial lending facilities are very essential to enhance the ability of the households in times of financial need. The overall extension package includes inputs, technical support and trainings, supervision etc, which have the capacity to enhance agricultural production and productivity. It is of course an important element in extension service packages and agricultural technology adoption in the view of increasing agricultural production and productivity (Deressa et al., 2010). The need for access to extension service packages was helped the sampled households in ensuring agricultural productivity through modern agricultural technologies such as farm inputs: fertilizers, improved seeds, modern farm mechanizations (combine harvesters, threshers) that have a power to boost agricultural production. In the light of climate change adoption strategies, 60% of the respondents that have access to extension service packages have adopted CF, agronomic practices, SWC, shift in livelihoods and livelihood diversifications including the o adoption options. It was 1.3% of the respondents that have no access to credits adopted only agronomic practices as CCASs. The Chi^2 further confirmed there are statistically significant difference among adopters and non-adopters in accessing to extension service packages and adaptation to climate change in the study areas ($p<0.002$). Therefore, the policy makers should work on strengthening the provision of extension service packages for smallholder farmers engaged in CCASs and promote the use of various agricultural inputs that enhance the capacity of farmers.

***Access to metrological information*:** Access to metrological information could better help to understand climate change processes, plan and implement CCASs. Accordingly, the majority of the respondents that accounted about 57.8% who have access to metrological information better adopted CF, agronomic practices, SWC, shift in livelihood and livelihood diversifications[9] employed no adaptation options as CCASs in their study locations. This study is consistent with a study done by Deressa et al (2010) on climate change adaptation in Southern and Eastern Ethiopia indicated that better access to climate change information could have significant effect on the likelihood of various climate change adaptation strategies including use of various crop varieties. Likewise, in this study we found that access to metrological information such as temperature, rainfall, humidity, wind and other climatic elements significantly and positively affect the adoption of various adaptation strategies, which is statistically and significantly different among adopters and non-adopters of climate change adaptations at 1% level ($p<0.032$).

[9] Livelihood diversification in this context describes the use of various livelihood choices or combinations such as agriculture based, off-farm activities, non-farm activities employed by a smallholder farmer. It is expected that livelihood diversifications broaden the income bases of farmers' and immensely help as CCASs.

Table 1: Descriptions, definitions and values of variables employed in the empirical model

Variable	Definition	Values and units of measurement
Dependent variable		
Adoption of options	Adoption options	It is a categorical variable which takes a value of 1= not adopting any adoption strategy, 2= contract farming adoption, 3= adoption of agronomic practices, 4= adoption of soil and water conservation practices, 5= adoption of shifting in livelihoods and 6= livelihood diversifications
Independent variables or Predictors		
AgeHHHs	Age of household heads	It is a continuous variable measured in years
GenderHHHs	Gender of household heads	It is a dummy variable which takes value of 1 for male and 2 for female
EducHHHs	Educational level of household heads	A categorical variable that takes 1= Illiterate; 2 for Grade 1-4; 3=Grade 6-8; 4=Grade 9-10; 5=Grade and 6=Above Grade 12)
Family Size	Number of Persons in a family	A continuous variable refers to Total number of people who are currently living within a family
HeadsCattle	Number of cattle owned by household heads	A continuous variable measured in Total Livestock Units using conversion factor
Access Credit	Access to credit and financial services	A dummy variable that takes 1 if the household heads have access to credits and 2 for not receiving credits
Access Market	Distance to markets from home	Walking Distance to the Nearest Market from home in hours
Size of farmland	Hectares of cultivated land	A continuous variable measured in hectares
Agronomic Practices	Relying on agronomic practices	A dummy variable that takes 1 for relying on Agronomic Practices 2 Otherwise
Access MetroInfo	Access to metrological information	A categorical variable that takes 1 for having access to metrological information and 2 Otherwise
SWCPractices	Soil and water conservation practices	A categorical variable that takes 1 for employing Soil and Water Conservation Practices; 2 Otherwise
ShiftLH	Shift in livelihoods	It is a categorical variable that takes 1 for shifting in livelihood; 2 otherwise.
LHChorDiver	Livelihood choices or livelihood combinations or diversifications	It is a categorical variable that takes: 1=On-farm; 2=Off-farm; 3=Non-farm; 4=On farm+ non-farm + Off farm incomes

Source: Based on Survey Result, 2018

Table 2: Difference of continuous explanatory variables between adopters' and non-adopters' respondents based on one way ANOVA

Continuous variables	Adaptation options							
	No adaptation	**Contract farming**	**Agronomic practices**	**Soil and water conservation**	**Shift in livelihood**	**Livelihood diversification**	**Average mean**	**Sig.**
Mean age of HHs	45.7	41.1	42.3	43.1	46.9	46.4	44.25	0.079
Mean of education of HHs	2.9	3.1	2.1	2.2	3.2	2.5	2.67	0.000
Mean of family size	6.5	7.1	6.7	6.2	6.3	6.6	6.57	0.016
Mean of Livestock in TLU	4.9	10.3	5.4	5.4	4.9	6.4	6.23	0.000
Mean of farmland size	1.4	2.2	1.6	2	1.4	1.8	1.73	0.000
Mean of net income	9.8	9.9	8.5	9.8	10.1	10.2	9.72	0.000

Source: Computed survey result, 2018

Table 3: Difference of dummy explanatory variables between adopters' and non-adopter respondents

Dummy variables	Adaptation options								
	No adoption	Contract farming	Agronomic practices	Soil and water conservation	Shift in livelihood	Livelihood diversification	%	Chi^2	Sig.
PAs									
Germama	30	68	19	19	-	-	22.6	293.333	0.000
Kuriftu Hida	13	-	45	53	-	20	21.8		
Adulala Hake	18	8	65	9	1	-	16.8		
Gender of HHs									
Male	43	57	76	45	16	24	43.5	3.344	0.047
Female	18	17	34	17	4	15	17.8		
Access to credits									
Yes	53	61	110	62	14	35	55.8	39.944	0.000
No	8	15	-	-	6	4	5.5		
Access to Agricultural technologies									
Yes	37	67	109	59	4	21	49.5	116.061	0.000
No	24	9	1	3	16	18	7.1		
Access to extension services									
Yes	61	76	102	62	20	39	60	19.181	0.002
No	-	-	8	-	-	-	1.3		
Access to metrological information									
Yes	59	67	106	56	20	39	57.8	12.249	0.032
No	2	9	4	6	-	-	3.5		

Source: Computed from survey result, 2018

Factors affecting adoption of climate change adaptations strategies in the study locations

This section of the finding focuses on the multinomial logit model (MNLM) parameter estimates on adoption of different climate change adaptation strategies employed by respondent smallholders in the study areas. One of the major purposes of MNLM was to estimate the coefficients and provide only the direction of effects of predictors and the estimates represent neither the actual magnitude of changes nor the probabilities (Tizale, 2007). In addition, the parameter estimates or the marginal effects that measures the expected change in the probability of a particular choice made with respect to a unit change in independent variable (Greene, 2000).

In the MNLM analysis, the no adoption option was taken as a base category in this analysis. The multicollinearity test was conducted through variance inflation factor (VIF), which is the inverse of Tolerance (T). The VIF result revealed that, the VIF is less than the value of 10 that indicates all the explanatory variables have with less multicollinearity problems between dummy variables. Based on these, both the continuous and dummy variables were included in the MNL model. However, before running the estimation of MNL the Hausman test was conducted to check for the validity of independence of the irrelevant alternative (IIA) conditions. Thus, the result indicated that both the tests accepted the null hypothesis of independence of adoptions of CCASs, suggesting that the use of MNL parameter estimate is the appropriate statistical model for this study. Furthermore, the likelihood ratios revealed by the Chi^2 statistics are highly significant with $p<0.000$, suggesting that the model has a strong explanatory power in explaining the adoption options employed by smallholder farmers in the study locations.

The results of MNL model revealed that being member of peasant association, age of household heads (HHHs), gender of HHHs, education status of HHHs and family size significantly affect the adoption choices made. Moreover, livestock holding, size of farmland, access to agricultural technologies, access to credits, distance to markets and access to metrological information significantly affect the adoption of various CCASs in the study locations.

Member of peasant association

Peasant association (PA) or locations of the respondent households positively and negatively affect the adoption of CCASs. With respect to Malt Barley CF (i.e. Germama PA), the location of the PA significantly affects the agronomic practices (such as farmland preparation, keeping planting or sowing date, fertilizer applications, use of appropriate agro-chemical, early harvesting, late harvesting etc), SWC, shift in livelihoods and livelihood diversifications (i.e. farm, off-farm, non-farm activities) with 1% significance level. In the same token, this study revealed that the respondent's decision to adopt climate change adaptation strategies have a significant impact on sampled HHHs engaged in sugarcane outgrower schemes. Thus, they adopted CF and shift in livelihood (i.e. from agriculture to trade, daily laborers and the like). However, the sugarcane producing HHHs did not decide to adopt livelihood diversifications as a mechanism to adapt to climate change in the area because of the limited benefits obtained from sugarcane production schemes. This study is consistence with the studies by Lobell et al. (2008) and Asrat and Simane (2017a) where agronomic practice significantly affects CCASs employed to curb climate change problems on agriculture. Thus, this has negative impact on the respondents where livelihood diversification activities were not practical in the eyes of SHFs at Wonji Shewa sugarcane outgrower schemes.

The SHFs decision of sugarcane outgrower scheme to adopt CF was most probably due to better provision of agricultural inputs, presence of irrigation water, technical assistance and better supervisions in place. However, there were no similar studies conducted on the decisions of farmers to adopt CF as a CCASs and confirmed whether CF practices positively or negatively affect climate adaptations employed to curb climate changes. However, there are studies that revealed the farmers decision to adopt agronomic practices, SWC and livelihood diversifications as a CCASs that positively contributed towards adaptation to climate change (Amare and Simane, 2017; Deressa et al., 2011).

Age of household heads

This study shows that age of HHHs negatively and significantly affected the adoption decisions of the respondent SHFs. Even though the probabilities to adopt various CCASs expected to increase as age of experiences increases, in this study the adoption decision was less as the age of respondents' increases. This was for the reason that any agronomic practices and SWC requires energy and labour of the adopter (i.e. labour intensive), which were the major challenges in the study locations. The discussions made with FGDs clearly revealed that as the age of the household heads increases, the chance of employing various CCASs decreases because of decrease in labour force and weakened energy required to engage in any agricultural activities.

Gender of household heads

Gender is one of the determinant factors that negatively and significantly affect the adoption of climate change at 1% significance level. This means that the male-headed households adopted CF as CCASs compared to those female-headed households in the study areas. The discussions made with FGDs during fieldwork clearly indicated that female-headed households were limited in number and they were economically less empowered in the society, handle more household chores, less access to information and less constrained with labour. The results of MNL model of adoption of climate change revealed that being male-headed households reduced the adoption of CF by 25.3%. Some empirical studies on CCASs such as Amare and Simane (2017), Asrat and Simane (2018), Asrat and Simane 2017b, Guteta and Abegaz, 2015b, Deressa et al., 2011 and Buyinza and Wambede, 2008) is consistent with this study and confirmed that gender of household heads negatively and significantly affect the adoption of CCASs.

Educational status of household heads

Education of household heads plays a positive and significant role in adopting CCASs employed by sampled HHHs in the study areas. This study shows that most of sampled HHHs adopted CF because of the provisions of agricultural inputs, technical assistance, extension workers assistance, agricultural experts support, and availability of water and irrigation water facilities in the case of sugarcane outgrower schemes. From this, it is possible to point out that as the level of education increases, the SHFs decision to adopt CCASs increases. These was due to the SHFs better know how, experiences and access to various information related to market, use of different agricultural technologies (improved varieties of seeds), agricultural practices and use of extension service packages increases. However, level of education of households positively and significantly affect the adoption of CF, agronomic practices, SWC and livelihood diversification or combinations as CCASs. This study is congruent with the study conducted by (Asrat and Simane, 2018; Amare and Simane, 2017; Deressa et al., 2009; Asrat et al., 2004), where education of household heads positively affect the adoption of agronomic practices, SWC and livelihood diversification as CCASs. This was due to that fact that the higher the level of education of the HHHs, the better the knowledge and capacity to understand and apply agronomic practices, SWC and the more they diversify their livelihood.

Family size

Family size is one aspect of the adoption process in this study. This study revealed that family size positively and significantly affected adoption of CF and SWC as CCASs at 1% and 5%, respectively. This is because, CF and SWC practices are labour intensive and require the participation of those abled and working population who are the member oh households. The empirical studies by Deressa et al. (2010) confirmed that the households with large family size have better labour endowments and thus have better opportunities in adapting the changing climate. According to Kassie et al. (2009), large family size attributed to labour endowments that help to engage family labour in labour intensive activities CCASs such as CF, agronomic practices and SWC practices. Thus, all the studies mentioned here are consistent with our study.

Livestock owning situation

Livestock as measured in Total Livestock Unit (TLU) positively and significantly affect the adoption of CCASs at 1% significant level. Owning livestock increased the probability of adoption CF as CCASs by 25.4%. This revealed that apart income from CF, the income obtained from selling livestock and livestock products immensely support the SHFs to adapt to the changing climate in the area. Empirical studies by Asrat and Simane (2018) and Simane (2016) is in agreement with this study finding and revealed that the household heads with larger number of livestock increases the probability of adoption of CCASs.

Size of farmland

This is the size of cultivated land or farmland covered with crops in the study areas. This study revealed that size of farmland positively and significantly related adoption of CCASs. Sizes of farmland are positively and significantly affect adoption of CCASs through CF and livelihood diversification. The probable reason for size of farmland that affects CF as CCAS was the having larger farmland size helps to produce many hectares of agricultural production especially in the case of Malt Barley production at Kofele district. This further increase the income earned from CF schemes and could help to adapt to climate change relate problems. In the same token, as indicated in the study result size of farmland improves and helps to diversify livelihood bases and adapt to climate change in the area. On the other hand, SHFs with larger farmland size mostly invest their time on agricultural land not on SWC. This negatively affected the adoption of SWC as CCAS by 92.8%. Incongruent to this study, Deressa et al. (2010) emphasized that the size of farmland negatively attributed to climate change adaptations where the focus was not on the size of farmland, but the fertility aspect (i.e. fertility of the farmland) that determine the adoption of CCASs.

Access to agricultural technologies

Access to agricultural technologies is positively and significantly associated with CF, agronomic practices shift in livelihoods and livelihood diversification as adoption of CCASs. On the other hand, access to agricultural technologies was inversely related to SWC. In the case of Malt Barley such as access to Threshers or combine harvesters, improved variety of Malt Barley (i.e. Traveller) engaged in producing high quality Malt Barley increased the income of SHFs by more than 50%, which in turn improved the CF and agronomic practices as adoptions of

CCASs. In addition, access to agricultural technologies saves time and enhances agricultural production and productivity. From this, it is possible to conclude that those HHHs with better access to agricultural technologies could better adopt CF, agronomic practices, shift in livelihood, diversify their livelihood, and better adapted to climate change. Thus, this study is compatible with previous empirical studies such as (Asrat and Simane, 2017b; Simane et al., 2016; Asrat et al., 2004) and confirmed that access to agricultural technologies could better help SHFs to adapt climate change and increases the sustainability of the adaptation strategies employed by SHFs. Regarding access to technologies, one of the case informant in Kofele district Germama PA stated that:

> *More recently, the use of Threshers that manually operated helped us a lot in harvesting our Malt Barley on time as compared to the year before we entered to CF scheme or arrangement. We collected our production very easily and prepare it for Assella Malt Factory* (Case informant: 46 Years old, MHHH, Germama PA).

Form the explanations of this informant; one can understand that having access to modern agricultural technologies its use immensely facilitated SHFs agricultural activities. Moreover, it help better adapt to the changing climate and climate variabilities in the areas. The case informants in Wonji Shewa Sugarcane outgrower schemes tried to compare the access to agricultural technologies before they entered to outgrower scheme and during also indicated that:

> *Our access and use of agricultural technologies is far better now than before. We are now planting Sugarcane in rows. We are transporting our agricultural produce to the factory through vehicles. Before this, we took load it on pack animals like Mule and Donkey* (Case informants: 56 and 60Years old FHHHs, from Kuriftu Hida and Adulala Hake Haroreti PAs).

Table 4: Estimates of parameters of multinomial logit model of adoption of climate change adaptation strategies

Explanatory variables	Contract farming		Agronomic practices		Soil and water conservation		Shift in livelihood		Livelihood combinations	
	Coefficients	***P* level**	**Coefficients**	***P* level**	**Coefficients**	***P* level**	**Coefficients**	***P* level**	**Coefficients**	***P* level**
Peasant Associations										
2	0.0129955	0.517	1.183671***	0.033	2.939551***	0.000	0.357544***	0.016	0.1750311***	0.003
3	0.7546546**	0.068	21.34745	0.933	18.66115	0.990	1.047849***	0.000	-5.966589***	0.000
Age of HHs	-0.0198401	0.298	-.031494***	0.042	-0.0297911**	0.079	0.0151361	0.517	-0.0000768	0.997
Gender of HHs	-0.2538523***	0.028	-0.0216117	0.961	0.0858937	0.861	-0.4658927	0.489	0.5004286	0.299
Education of HHs	1.317647***	0.000	0.6993155***	0.001	0.496814**	0.065	0.4231221	0.286	0.1850158***	0.001
Family size of HHs	0.3561363***	0.013	0.0611546	0.601	0.1166779**	0.078	-0.1713208	0.421	0.1187263	0.406
Livestock in TLU	0.2549433***	0.000	0.0009287	0.981	-0.0189754	0.663	0.0086845	0.879	0.0551417	0.226
Size of farmland	2.016815***	0.000	-0.01825	0.957	-0.9286473***	0.012	0.0425807	0.941	0.9664089***	0.012
Access to agricultural technologies	1.629544***	0.008	3.792444***	0.000	-1.725638***	0.012	1.610364***	0.014	0.8237067**	0.091
Access to credits	0.781943	0.262	-15.77094**	0.087	-15.88145**	0.091	0.7792333**	0.052	0.1067912	0.883
Distance to market	-0.1207115	0.495	0.2121142	0.131	-0.1943557	0.246	-.1799953***	0.007	-0.3122482	0.101
Access to metrological information	-1.344071	0.263	0.0178087**	0.086	1.192355	0.247	-14.24949	0.994	-14.73547	0.993
_cons	-7.638643***	0.002	22.61266**	0.082	19.11217***	0.009	9.888764	0.996	11.25555***	0.000

Number of obs. = 368

LR χ^2 (60) = 451.57

Prob > χ2 = 0.0000

Log likelihood = -389.39436

Pseudo R^2 = 0.3670

Base category: No adoption of any strategy

*****, **,* Significant at 1%, 5% and 10% probability level, respectively.**

(Source: Authors estimation, 2018)

Table 5: Marginal effects computed from multinomial logit model of adoption of climate change adaptation strategies

Adoption Options	Contract farming		Agronomic practices		Soil and water conservation		Shift in livelihood		Livelihood combinations	
	Coefficients	***P* level**	**Coefficients**	***P* level**	**Coefficients**	***P* level**	**Coefficients**	***P* level**	**Coefficients**	***P* level**
Peasant Associations										
2	0.2339866 ***	0.000	0.0219705**	0.050	.0408789***	0.004	0.0294766***	0.000	0.0770816***	0.003
3	-0.0991232 ***	0.000	-0.0166766	0.103	-0.0067291***	0.005	-0.1230147***	0.001	-0.4242189***	0.065
Age of HHs	0.0018631***	0.015	-0.0006367	0.561	-0.0023742	0.151	-0.0012374	0.410	0.0008333	0.345
Gender of HHs	-0.0131142	0.670	-0.0095046	0.843	-0.0198876	0.647	-0.0272532	0.296	0.0717557**	0.033
Education of HHs	0.0970296 ***	0.000	0.0991232 ***	0.000	-0.0159345	0.471	0.0197157	0.183	-0.0209477	0.279
Family size of HHs	0.0202086***	0.010	0.0064406	0.586	-0.0219705**	0.050	-0.0095419	0.235	0.0098154	0.319
Livestock in TLU	0.0149579***	0.000	-0.0047581	0.241	-0.0067291***	0.074	-0.0012334	0.540	0.0022964	0.467
Size of farmland	0.1089628***	0.000	0.1230147***	0.000	0.0691458***	0.022	-0.0196029	0.342	0.0313224	0.237
Access to agricultural technologies	-0.0581702	0.109	0.4242189***	0.003	0.0305625	0.735	0.0719962***	0.001	0.2339866 ***	0.000
Access to credits	0.4847181***	0.006	-1.204738	0.991	-0.8406071	0.994	0.1231191	0.971	0.5739343	0.979
Distance to the market	-0.0166766	0.103	0.0439761***	0.001	-0.0081059	0.545	-0.002526	0.807	-0.0204021	0.121
Access to metrological information	-0.128173***	0.000	0.0333671	0.155	0.0408789***	0.037	-0.0358224	0.224	0.0770816 ***	0.000

***, **,* Significant at 1%, 5% and 10% probability level, respectively.

(Source: Authors estimation, 2018)

Access to credits

Regardless of the expectations of SHFs, households with better access to credits affected negatively and significantly by the decisions of SHFs to adopt CCASs such as agronomic practices and shift in livelihood. Even though access to credits did not have any significant effect on CF, livelihood diversification has negatively associated with agronomic practice and shift in livelihood as an adoption of climate change strategies in the study areas. This clearly revealed that the sampled households were access to credits not due to adaptation to climate change, rather because of previous extension services in place. To this end, this empirical study was consistent with the study done by Tessema et al. (2013), where access to credits affected SHFs engaged in CF before adopting climate change adaptation in their locality because of their prior investment. Thus, the policy implications should promote access to credits as one of the important ingredients of climate change adaptation and if available, it could facilitate adaptation through filling the financial gap created because of financial problems in the study locations and locations with similar climatic conditions.

Distance to Market

Empirical evidences such as Tessema et al. (2013); Amare and Simane (2017) clearly portrayed that distance to market increases the chance of adaptation as it may create opportunities to get access to new technologies and other agricultural inputs. However, distance to market was negatively related to shift in livelihood in the study areas. This may imply that the sampled households are expected to travel longer distance to get the market and this reduces the time to spent on farmland or other agriculture related activities in the study areas. However, it probably creates an opportunity for SHFs to share and gain experiences from other farmers related to agricultural technology, agronomic practices and improve ways of agricultural production techniques.

Access to metrological information

Access to metrological information such as access to rainfall, temperature, humidity, flood and drought is positively and significantly associated with adoption of agronomic practices as CCASs. Having access to metrological information associated with CF and agronomic practices that could help in pre-harvest and post-harvest crop management where SHFs respond to any change in the metrological discrepancies or challenges such as heavy rainfall, drought, flood and pest infestation. Consequently, the policy implications here is that there should be institution that continuously make available metrological information through various meanses including media out let (radio, television, cell phones) where SHFs can easily access them in their locations (disseminations of time specific metrological information).

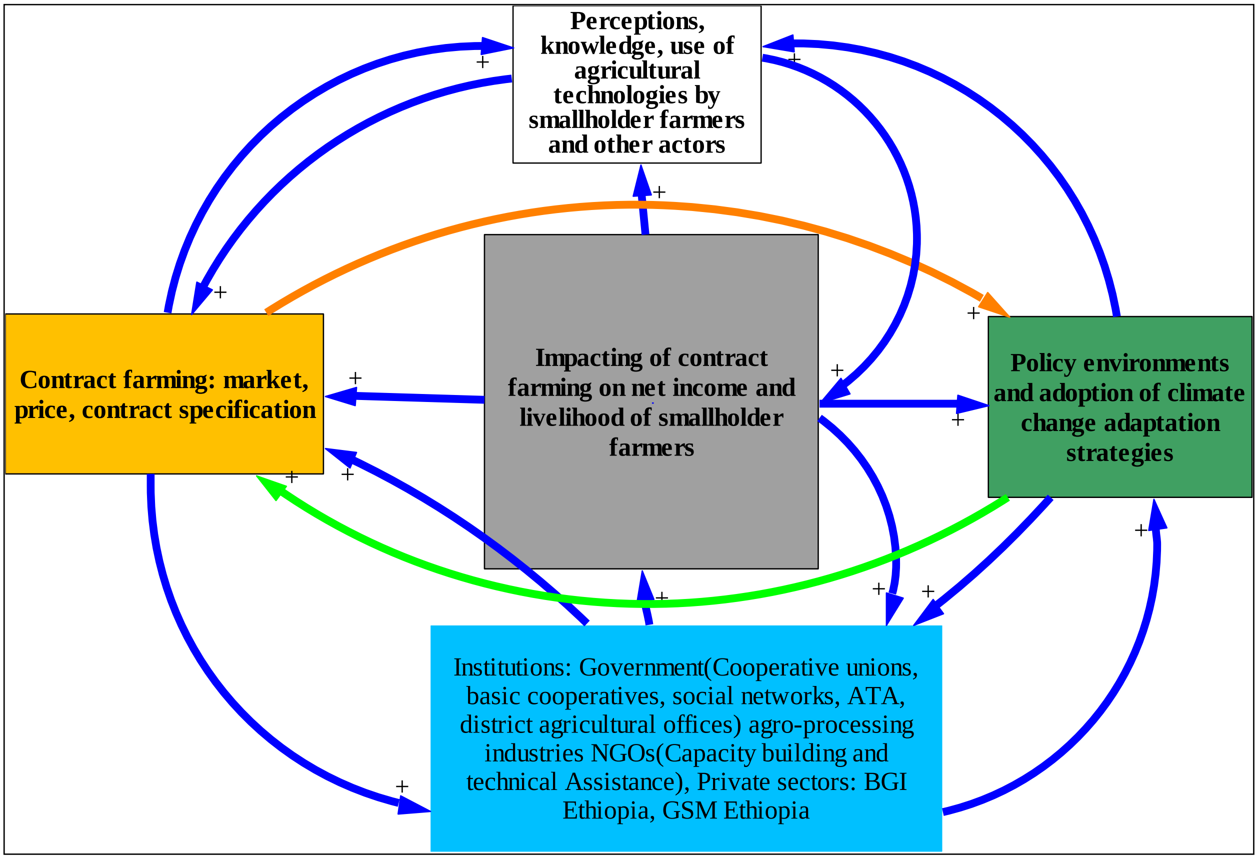

Figure 8: A diagrams of contract farming, agronomic practice, agricultural technologies and climate change adaptation nexus

(Source: Authors construction, 2018)

The current agricultural commercialization is the result of the interplay between perceptions of smallholder farmers and private sectors, NGOs, contract farming situations, institutions and climate change adaptations employed in the in the changing climatic condition, which ultimately are governed through the use of CF: agronomic practices and agricultural technologies in the whole agricultural production. The arrows with orange color and green arrow shows that CF has a direct link with CCASs, where agricultural input such as fertilizers, agro-chemicals, improved seeds, extension service packages including technical advice and supports from development agents and agricultural experts affected the success of CF and climate change adaptations SHFs employed in the study areas. These have a strong bearing on the nexus between the two these factors, which facilitates agronomic practice and technology transfer.

Moreover, the plus signs (+) at the head of the blue arrow revealed that the relationships among the factors in figure 8 are very strong and positive in affecting one another. For example, as indicate above the presence of strong, committed and informed institutions work towards successful CF practices i.e. in search of markets and fair contract design) that could serve as an input in adoption of CCASs, ease agronomic practices and transfer of agricultural technologies.

CONCLUSIONS AND POLICY RECOMMENDATIONS

CF as responses to CCASs are paying more attention to environmental sustainability (FAO, 2018). Hence, understanding adoption of CCASs requires understanding the livelihood contexts of SHFs and the overall socioeconomic, institutional and environmental conditions. The CCASs SHFs' employed to address climate change in the study areas are not *a one shoe for all approach*. It tried to employ a locations specific CCASs that have the capacity to curb climate change and climate variabilities in the study locations. In relation to this study, the SHFs' knowledge and perception revealed that the local climate is changing and manifesting itself in late onset, early cessations, recurrent, drought and flash flood affecting the livelihood of sampled SHFs' engaged in Malt Barley and sugarcane CF. Moreover, the rainfall is becoming irregular and there are extreme fluctuations in temperatures. Consequently, all these changes and variabilities in climate stimuli necessitated respondent SHFs to adopt various CCASs such as CF, agronomic practices, SWC, shift in livelihood and livelihood diversifications in their locality. From the adoption choice made, adoption of agronomic practices, contract farming, SWC and livelihood diversification are the most and widely employed adaptation strategies in the study areas.

Therefore, in line with the findings, it is very crucial to inculcate the following into policy recommendations.

- It is paramount important for policy makers to find a way and promote young farmers to employ CCASs to reduce the adoption gaps created as a result of age difference in adoption of CCASs focusing on those energetic, abled youth farmers to employ various climate change adaptation strategies.
- Broadening the income base of SHFs help to build the adaptive capacities of farmers and immensely facilitates adoptions of various climate change strategies in the study locations;
- In order to help those non-adopters because of not accessing resources, there is a need to design and redesign adaptation mechanisms to curb climate change and climate variabilities and put in place financial provisions or access to financial resources;
- The policy makers should work on strengthening the knowledge base through education, field trainings; provisions of extension service packages, good CF management, proper implementation of agronomic practices that have the capacity and initiate SHFs to engaged in CCASs and promote the use of various agricultural inputs that enhance the capacity of SHFs to enhance their production and productivity;
- The policy makers should promote a fair and well-designed CF as an instrumental business model and as one of the important ingredients of CCASs; and
- Creating access to metrological information through various means including media out let (radio, television, cell phones) that could have the capacity to improve SHFs' planning, crop management and paves the way for better climate change adaptations, where SHFs' can easily access them in their locations (i.e. disseminations of time specific metrological information).

- Above all, understanding adoption option in climate change adaptation in the light of agricultural commercialization is paramount important to conduct further researches. Moreover, the link between adoption of CCASs, commercial agriculture, agronomic practices and its disseminations serve as a decisions making tool or ground for policy makers and agricultural experts working in the field of agriculture, climate change and livelihood improvements.

ACKNOWLEDGMENT

It is a pleasure and gratitude to praise God in the accomplishment of this research article. I would also give my heartfelt thanks to my supervisor, Engdawork Assefa (Ph.D) in providing his valuable comments in this paper. Finally, I extend my precious thanks to Addis Ababa University and Jigjiga University in funding this research paper.

AUTHORS' CONTRIBUTIONS

Getachew Megersa generated the idea, designed the study and carried out data collection, data analysis, and write-up. Engdawork Assefa played a role of reading and revisited the manuscript. Both authors read and approved the manuscript.

REFERENCES

Adger, W. N. (2003a). Social Aspects of Adaptive Capacity to Climate Change: In Huq, S., Smith, J. and Klein, R. T. J., *Climate Change, Adaptive Capacity, and Development.* Imperial College Press, London: 29-50.

Amare, A & Simane, B. (2018). *Does adaptation to climate change and variability provide household food security? Evidences from Muger sub-basin of the upper Blue-Nile, Ethiopia, A journal of ecological process: No. 4:Vol.1: 6: https://doi.org/10.1186/s13717-018-0124-x. Accessed by Date 10/22/2018.*

Asrat Paulos & Simane Belay. (2018). Farmers' perception of climate change and adaptation strategies in the Dabus watershed, North-West Ethiopia. *Journal of Ecological Process,* No 7: Vol 7: *https://doi.org/10.1186/s13717-018-0118-8, Accessed by Date:10/22/2018.*

Ayelech, T.M. (2010). *Contract farming in Ethiopia: An overview with focus on sesame*, Agenda Setting Workshop, The DGIS-WUR programme. June 26, Addis Ababa, Ethiopia.

Ayelech, T.M. (2012). *Contract Farming: Business Models that Maximize the Inclusion of and Benefits for Smallholder Farmers in the Value Chain,* Wageningen University, Published. The Netherlands.

Barnett, J. (2001). Adapting to Climate Change in Pacific Island Countries: The Problem of Uncertainty. *World Development*, 29, 977-993.

Bekele W, Drake L. (2003). Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area. *Ecol Econ*.; 46: 437–51.

Brown D, Stephens E, Ouma J, Murithi F, Barrett CB. (2006). Livelihood strategies in the rural Kenyan highlands. Afr J Agric *Resource Econ;* 1(1): 21–36.

Carney, D. (1998). *Approaches to Sustainable Livelihoods for the Rural Poor Poverty Briefing* Overseas Development Institute, London.

Climate Resilient Green Economy Strategy (CRGE). (2011). Report of the Ethiopian Government: 200. Ministry of Finance and Economic Development, Addis Ababa, Ethiopia.

CSA. (2007). *The Federal Democratic Republic of Ethiopia Statistical Abstract for 2003,* Federal Democratic Republic of Ethiopia, Addis Ababa, Ethiopia.

CSA. (2008). *Population and Housing Census: Summary and Statistical Report of the 2007,* Federal Democratic Republic of Ethiopia, Population Census Commission, Addis Ababa, Ethiopia.

Deressa T, Hassan R, Ringler C. (2010). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *J. Agric Sci*. 50(1):1–9.

Deressa T, Hassan RM, Ringler C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *J. Agric Sci*.: 149:23–31.

Dinka, O.M., Loiskandl, W., Furst, J., and Musyoka, J.N. 2013. *Seasonal Behavior and Spatial Fluctuations of Groundwater Levels in Long-Term Irrigated Agriculture: the Case of a Sugar Estate*, Department of Civil Engineering, Faculty of Engineering and the Built Environment, Tshwane University of Technology, P/Bag X680 Pretoria 0001, Republic of South Africa.

Dixon, J., Gulliver, A. & Gibbon, D. (2001). *Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World.* Rome and Washington, DC: FAO and World Bank.

Eakin, H. (2005). Institutional change, climate risk, and rural vulnerability: cases from Central Mexico. *World Development* 33 (11): 1923–1938.

Eaton, C. & Shepherd , A.W. (2001). Contract farming; partnerships for growth: *FAO Agricultural Services Bulletin.* Rome, FAO.

FAO. (2018). Enabling regulatory frameworks for contract farming: FAO legislative study #111, Published by Food and Agriculture Organization of the United Nations, Rome, 2018.

FAO. (2015). *Inclusive business models-Guidelines for improving linkages between producer groups and buyers of agricultural produce,* by Kelly, S., Vergara, N. & Bammann, H. Rome, Italy

Ford, J., Smit, B. & Wandel, J. (2006). Vulnerability to Climate Change in the Arctic: A Case Study from Arctic Bay, Nunavut. *Global Environmental Change*, 16 (2), 145-160.

Getachew, M. (2012). Adaptation to Climate Variability among the Pastoralist and Agro-Pastoralist Communities in Jigjiga District, Somali Regional State, Ethiopia, MA Thesis, June 30, 2010, Addis Ababa University, Ethiopia; Published in *VERLAG* Publishing gmhp.ltd.

Greene W. (2003). *Econometric analysis*, vol. 4. New York: Macmillan Publishing Company.

Greene W. (2000). *Econometric analysis*. 4th ed. New Jersey: Prentice-hall Inc.

Gujarat, D.N. (2003). *Basic Econometrics, The McGraw-Hill, 1002*. 4th edition, New York.

Handmer, J.S., Dovers, S. & Downing, T.E. (1999). Societal Vulnerability to Climate Change and Variability. *Mitigation and Adaptation Strategies for Global Change* 4, 267-281.

Houghton, J. T., Ding, Y., Griggs, D. J., Noguer, M., Van Der Linden, P. J., Dai, X., Maskell, K. & Johnson, C.A. (2001). Climate Change 2001: The Physical Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, 2001. Cambridge, UK: Cambridge University Press.

Inter Academy Council (IAC). (2004). *Realizing the Promise and Potential of African Agriculture. Amsterdam*, The Netherlands: Inter Academy Council.

Kassie M, Zikhali P, Manjur K, Edwards S. (2009). Adoption of sustainable agriculture practices: evidence from a semi-arid region of Ethiopia. *Nat Resou Forum* 33:189–198.

Kirsten, J. & Sartorius, K. (2010). 'Linking agribusiness and small-scale farmers in developing countries: Is there a new role for contract farming?' *Development Southern Africa*, vol. 19, no. 4: pp503-529.

Kofale District Finance and Economic Development Office. (2007). *Socioeconomic profile of Kofale District based on 2005 and 2006 E.C Data*, Kofale District Finance and Economic Development Office, Kofele, Ethiopia.

Komba C, Muchapondwa E. 2012. Adaptation to climate change by smallholder farmers in Tanzania. Economic Research Southern Africa (ERSA) Working paper No 299*: https://econrsa.org/2017/wp-content/uploads/wp299.pdf 7, Accessed 22 Dec 2018.*

Kothari, C.R. (2004). *Research Methodology: Methods and Techniques*, New Age International (P) Ltd., Published by New Age International (P) Ltd., 4835/24, Ansari Road, Daryaganj, New Delhi – 110002:179.

Kurukulasuriya, P, Mendelsohn, R. (2008). A Ricardian analysis of the impact of climate change on African cropland. *Afr J Agric Resour Econ*. 2008; 2 (1):1–23.

Lobell D, Burke M, Tebaldi C, Mastrandrea M, Falcon W, Naylor R. (2008). Prioritizing climate change adaptation needs for food security in 2030. *Science* 319(5863):607–610

Minot, N. (2011). Contract Farming in sub-Saharan Africa: Opportunities and Challenges, International Food Policy Research Institute, Prepared for the policy seminar: -Smallholder-led Agricultural Commercialization and Poverty Reduction: How to Achieve It, Kigali, Rwanda Organized by the AC.

National Metrological Agency of Ethiopia (NMAE). (2018). *Precipitation, Temperature and Relative Humidity Data;* Addis Ababa, Ethiopia

Oromia Agricultural Commercialization Cluster (OACC). (2015). Agricultural Commercialization Cluster Planning Workshop held at Adama in Collaboration between Ethiopian Agricultural Transformation Agency and Synergos, Adama, Ethiopia.

Prowse, M. (2012). Contract farming in developing countries-A Review: Institute of Development Policy and Management, University of Antwerp, Belgium: *A Savoir* No. 12: 23-49.

Reidsma P, Ewert F, Lansink A, Leemans R. (2009). Vulnerability and adaptation of European farmers: a multi-level analysis of yield and income responses to climate variability. *Reg Environ Change*. 2009;9 (1):25–40.

Robards, M. & Alessa, L. (2004). Timescape of Community Resilience and Vulnerability in the circumpolar north. Arctic 57: 415 - 427.

Simane, B., Zaitchik B.F, Foltz J.D. (2016). Agro-ecosystem specific climate vulnerability analysis: application of the livelihood vulnerability index to a tropical highland region. *Mitigation and Adaptation Strategies for Global Change* 21:39–65

Smit, B. & Pilifosova, O. (2003). *From Adaptation to Adaptive Capacity and Vulnerability Reduction,* In: Smith, J.B., Klein, R.J.T., and Huq, S. eds., Climate Change, Adaptive Capacity, Sustainable Development and Equity, Chapter 18. In London: Imperial College Press.

Stern, N. (2006). What is the economics of climate change? *World Econ;* 7(2):1–10.

Stock H, Bezabih E, Berhanu A, Borowiceki A, Shimelis W. (1991). Farming system and farm management practices of smallholders in Harerghe highlands: *Farming system and resource economics in the Tropics*, vol 11. Kiel: Wissenschaftsverlag Vauk.

Strohm, K. & Hoeffler, H. (2006). Contract Farming in Kenya: Theory, Evidence from selected Value Chains and Implications for Development Cooperation, promotion of private sector development in agriculture. Ministry of Agriculture and Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Germany.

Tadesse A, Bosona, T, and Gebresenbet, G. (2013). *Rural Water Supply Management and Sustainability; The Case of Adama Area, Ethiopia,* Department of Energy and Technology, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden.

Tessema Yibekal, A., Aweke Chanyalew, S. and Endris Getachew, S. (2013). *Understanding the process of adaptation to climate change by smallholder farmers: the case of east Hararghe Zone, Ethiopia*. School of Agricultural Economics and Agribusiness, Haramaya University, Dire Dawa, Ethiopia.

Tizale, C. (2007). *The dynamics of soil degradation and incentives for optimal management in Central Highlands of Ethiopia*. South Africa: University of Pretoria.

USAID. (2012). Contract Farming and Policy Options in Ethiopia: *USAID-CIAFS*, 6th Floor, KT12 Building Ethio-China Road, Addis Ababa, Ethiopia, *http://hdl.handle.net/123456789/3047.*

Wooldridge, J.M. (2001). *Econometrics Analysis of Cross Section and Panel Data London:* The MIT Press, Massachusetts.

Ziervogel, G., and Calder, R. (2003). *Climate Variability and Rural Livelihoods: Assessing the Impact of Seasonal Climate Forecasts in Lesotho Area,* Published by: Blackwell Publishing on behalf of The Royal Geographical Society (with the Institute of British Geographers) Vol. 35, No. 4: 403-417.

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