

Farmers' Perceptions and Adaptation Strategies to Climate Change and Variability the Case of Kacha Bira Woreda, Kembata Tembaro Zone, Southern Nations, Nationalities and Peoples Ethiopia

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Abstract
Climate change is global environmental treat to all economic sectors, particularly agricultural sector, geographical location and topography in combination with heavy dependence on reified agriculture result in high vulnerability to adverse impact of climate change and variability. The study was carried in to two villages of Awaye and Burchana of Kacha Birra district, southern Ethiopia. The overall objective of this study was to assess farmers' perceptions and adaptation strategies to climate change and variability in Kach Birra woreda, south Ethiopia. Both primary and secondary data were used. Primary data were collected from household's interviews through structured questionnaire, key informants interview, focus group discussion and field observation from two dominant agro-ecological zones in the woreda. The data were collected from 130 households who were selected through multi-stage sampling techniques. Distractive statistics is used to assess farmers' perceptions, and baseline adaptation, where as binary logit model is used to examine the determinants of adaptation strategies to climate change and variability. Results show that over the past 30 years almost all respondents have perceived increase in temperature, decrease in precipitation and more erratic rainfall patterns and this is confirmed by climatic data records. The most common adaptation options include planting new crop varieties, drought resistant crop variety, diversifying crop, changing planting dates, implementing soil and water conservation practices, making adjustments to crop and livestock management, changing fertilizer applications, engaging in off-farm income-generating activities and migration. The result of the binary logit model highlighted age, family size, land size, education and farming experience as main factors that encourage private adaptations and by contrast, female headed household, access to extension significantly discouraging ones. Future policy making processes should pay due attention to incorporate action plans that strengthen the already existing autonomous adaptation strategies used by these communities.
Keywords: awaye, kachebirra vulnerability logit baseline adaptation

1. INTRODUCTION

Climate change is one of the most serious environmental challenges facing the world at present. It refers to any change in climate over time, whether due to natural variability or as a result of human activity (Kinyangi *et al*., 2009). Global warming shows no signs of decreasing trend and is expected to bring about long term changes in weather conditions (FAO, 2008).

According IPCC (2007), the average global surface temperature has warmed up by 0.8°C in the past century and by 0.6°C in the past three decades. The IPCC has also projected that if greenhouse gas (GHG) emissions and the leading cause of climate change continue to rise, mean global temperatures will increase by 1.4–5.8°c by the end of the 21st century. These changes may prove especially destructive for underdeveloped nations that historically, have been vulnerable to extreme climatic events such as droughts and floods. Increases in the frequency of these events are projected to negatively affect local crop production in regions such as eastern Africa, especially in the lowland and drier areas.

According to Ndaruzaniye (2011), climate change and variability is increasing the frequency and intensity of climate related hazards and hence, the level and patterns of often inter related risks, particularly water and food security, exacerbate levels of vulnerability, mainly for rural communities. The Ethiopia's low level of economic development combined with its heavy dependence on agriculture and high population growth rate make the country particularly susceptible to the adverse effects of climate change. Negative climatic impacts on crop and livestock production could result in a nationwide food shortage and greatly hinder the economy.

Adaptation is widely recognized as a vital component of any policy response to climate change and variability. Studies show that without adaptation, climate change is generally detrimental to the entire livelihood system, but with adaptation, vulnerability can largely be reduced (Smith, 1996). 'The degree to which an agricultural and pastoral system is affected by climate change depends on its adaptive capacity, which is the ability of a system to adjust to climate change and variability to moderate potential damage, take advantage of opportunities or cope with the consequences' (IPCC, 2001).

Thus, the adaptive capacity of a system or society describes its ability to modify its characteristics or behavior so as to cope better with changes in external conditions.

The Kacha Birra farming community in Kembata Tembaro zone, like farmers in any other part of Ethiopia, is suffering from climate upheavals that have become common natural adversities in the country. There has been more erratic rainfall from June to September ('Kiremt') and from February to May ('Belg') rainy seasons. These have been bringing drought and reduction in crop yields and plant varieties; the rainfall especially in destructive heavy downpours, bringing floods and soil erosion in the study area. Also there has been an increase in temperature which influences the physiology of crops, the micro-climate and the soil system on which the farmers cultivate. Water availability has been reported to decrease dramatically in the area under study. As a result, widespread poverty and chronic food insecurity has become the defining feature of the area (CDP, 2012; Tesfaye and Debebe, 2013; Baseline survey, 2014). The present study was conducted at Kacha Birra worada in Kembata Tembaro zone in South Nation National and Peoples Regional State (SNNPR). In the area livelihoods are highly dependent on natural resources; moreover, climate sensitive livelihoods coupled with the existence of food insecurity, weakening of local adaptive mechanisms and variable weather events put them in a most vulnerable position. None of the studies considered farmers' perception and adaptation strategies to climate change and variability. Hence, this study was designed to fill the existing research gap in Kacha Birra worada in Kembata Tembaro zone in South Nation Nationalities and Peoples Regional State of Ethiopia with respect to farmers' perception and adaptation strategies to climate change and variability. The overall objective of this study was to assess farmers' perceptions and adaptation strategies to climate change and variability in the case of Kacha Birra woreda of Kembata Tembaro zone, Ethiopia. This study mainly seeks to answer three specific objectives.

1. To analyze farmers' perceptions towards climate change and variability over the last 30 years.
2. Identify the ongoing adaptation strategies used by farmers in response to climate change and variability.
3. To examine the determinants of farm-level adaptation strategies to changing climatic conditions. What factors influence farmers' decision to adapt climate change and variability?

Materials and methods

3.1. Description of the Study Area

The study woreda Kacha Birra is located in Kambata Tembaro zone, SNNPR and it is situated in the south western part of the zone, which is bounded with Angacha woreda in the north, Kedida-gamela woreda in the east, Hadiya zone in south east and southwest with Wolayita zone in the south west (Figure 1).The woreda lies between 07°12'30.1" - 07°17'08.3" N and 37°47'48"– 37°50'30.6"E degree north and east longitude in Kembata Tembaro zone of SNNPRS. The woreda capital is found 327 Kms away from the country capital Addis Ababa and 117 km away from the regional capital, Hawassa. The woreda with a total land area of 25,944 hectare is further divided in to 20 rural kebeles and 2 semi-urban kebele (CSA, 2005). The woreda has diversified topographic features such as flat, gentle, sloping plains and undulating to rolling plains with substantial proportion of low to moderate relief hills. The altitude of the woreda varies from 1600-2600 meter above sea level. The study area is characterized by two distinct agro-ecological zones, highlands (2300-2500m.a.s.l) and midland (1500-2300m.a.s.l) were considered, for they are important in terms of area coverage and population size. Average temperature (^{0}c) and annual rainfall of the area is ranges between 20^{0}c to 16^{0}c and 800mm to 1200mm rainfall (CDP, 2012 and KBWAO, 2013). The type of the vegetation covers of the study area categorized by *Eucalyptus,* (*E. globluis* and *E. camaldulensis), C.africana, P. fulcatus, M. feruginea and H. abyssinica*. Types of crops which grow in Kacha Birra woreda include maize, tef, wheat, barley, fruits and vegetables. The major types of food crops grown in woina dega are maize, haricot bean, coffee, enset,ginger, sweet potato, taro,banana, teff, pepper and fruits. In addition, in dega wheat, barley, enset, beans and potato are grown. The major income sources for households in the woreda are ginger and coffee (CSA, 2005). With regard to cropping system, except for enset, which is important in both agro-ecology, the two agroecologies are quite different. The highlands are dominated by wheat while the midlands are dominated by high value crops like coffee and ginger as well as maize. The population of Kacha Bira woreda is 115,579 out of which 58,778 are female (i.e. 50.86 %). Zonal population growth rate is 3%. The total number of households in the woreda is 25,780, with an average of 6 family members per household. The average population density is 551 people per km^2. About 52% of the total population is economically active (CSA, 2007).

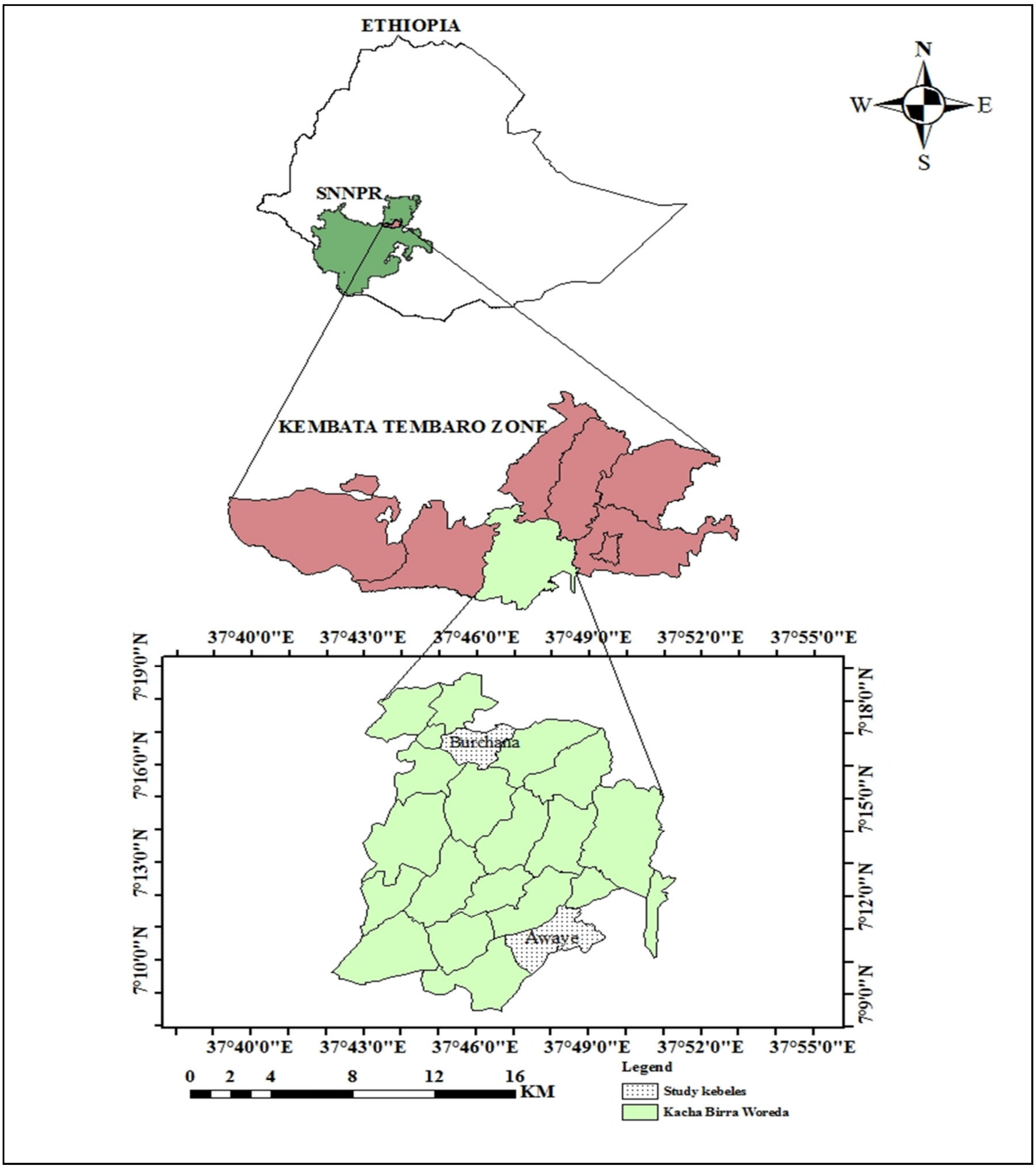


Figure 1: Map of the study area

3.3. Data Source and Data Collection Method

3.4. Data Analyses Techniques

Both qualitative and quantitative techniques (descriptive statics, a one-way ANOVA tests and econometric analysis) were used to analyze the data collected.

The data collected were analyzed and presented using appropriate methods of analysis. The quantitative data were analyzed using various analytical methods such as descriptive statistics (like mean, frequency, percentages and a one-way ANOVA tests and econometric models were employed. Analyses were made using Statistical Package for Social Studies (SPSS) version 16software and Microsoft Excel. The programs were extensively used to produce different kinds of illustrations, statistical tables (more frequently), graphs and charts (wherever necessary) and cross sectional analysis. On the other hand, qualitative data from key informant interviews and focus group discussions were transcribed, categorized, looked for relationships and interpreted. Temperature and rainfall data from meteorological stations were analyzed using Microsoft Office Excel to present patterns and trends of rainfall and temperature in the form of graphs.

Sample design and sample size

Multi-stage sampling techniques where a combination of purposive and random sampling procedures was used to select sample kebels and households. At the first stage, out of 7 woreda in Kembata Tambaro zone, Kach Birra woreda was purposively selected due to the fact that the woreda is affected by climate change and variability like recurrent drought and irregularity nature of rainfall more than all other wored as in the zone. In the second stage, out of 22 kebeles in the woreda 2 kebele were purposefully selected from two agro-ecological zones based on their exposure to climate change and variability. The households in each of the selected kebeles were stratified based on their wealth status in to poor, medium and rich. From each stratum the sample households were selected using random sampling technique. This is done to reduce the biasness of respondents selected to the study. The survey was conducted between January and Februaryin 2014. For the data collection, about 130 farmers were interviewed irrespective of gender, farm size or tenancy status through farm household survey. A fully structured questionnaire was used to gather information on socio-economic characteristics, farmers' perception towards climate change and variability and adaptation strategies. And also explored adaptive strategies of farmers' facing climate change and variability, key constraints they faced to adapt and determinants of adaptation strategies of farmers in the area. Prior to the study, a pretesting of the questionnaire was performed to avoid missing any important information. The enumerators received field training about the study objective farm household survey.

3.4.2. Binary Logit Model Specification

Econometric analysis was done to examine the factors influencing the climate change adaptation strategies. The logistic regression model, the natural logarithm of an odds ratio, was used to examine the household heads' decision on the choice of climate change adaptation strategies. Since the probability of an event must lie between 0 and 1, it is impractical to model probabilities with linear regression techniques, because the linear regression model allows the dependent variable to take values greater than 1 or less than 0 (Agresti, 2007; SPSS 16.0.0). This model is well suited for describing the relationships between categorical response variables (adoption) and one or more categorical or continuous predictor variables (Tarling, 2009; SPSS 16.0.0). This condition calls for the use of logistic regression by identifying both dependent and independent variables. In this study, the Binary Logistic Regression model was employed the effect of socio economic correlates (determinants) that influence decision to use adaptation measure. The Binary Logistic Regression model was used to determine farmers' decision to use adaptation strategies or not .

The standard form of (Greene, 2003). The logistic formulas are stated in terms of the probability that Y = 1(decision to adapt), which is referred to as the probability that:-

Y is 0 is 1 - q_{it} (not adapting)..(1)

$$P(Y_t=1/X_t) = \frac{\exp(X_t B)}{1+\exp(X_t B)} \quad \text{.........................(2)}$$

An equivalent form can be stated thus,

$$\frac{\exp(X_t b)}{1+\exp(X_t b)} = \frac{1}{1+\exp(X_t b)} \quad \text{----------------------- (3)}$$

This can be expressed as, $q_{it} = bx_{it} + u_{it}$ -------------------------------------- (4)

Where qit = an unobservable latent variable for household participating on adaptation strategies

X_{it} = vector of explanatory variables b = vector of parameter to be estimated, uit = error term.

The observed binary (1, 0) for whether household decision to adapt or not to climate change and variability assumed as in the usual logit model (Green, 2003).

Probability that binary assumes the value one is, prob. (q_{it}=1) = exp ($\beta_0+\beta x$)/1+exp ($\beta_0+\beta x$)

$$\frac{e^{\alpha i} + B^{x} it}{1+e^{\alpha i} + (B^{x} it)}$$

Exp is the exponent function, sometimes written as e. So, the equation on the right is just the same thing but replacing exp with e. We can always tell when e stands for exp if you see that there is a superscripted value with the e, suggesting that e is raised to some power. The empirical model for this study was specified here as.

Y = β0 + β1X1 + β2X2 + ...βkXk + ε

Probability of adaptation = β0+ β1age + β2sex + β3fsize + ...

3. 4.3. Definition of Variable Descriptions and Expected Signs

After the analytical framework is established, it is important to define the measurements of the variables as well as the symbols representing them. Accordingly, the major variables expected to have influence on the adoption of adaptation measures are explained below. The dependent variable of the model: The household probability of adaptation decision which is the dependent variable for the logit analysis is a dichotomous variable representing whether or not to use adaptation strategies. It was represented in the model by1 for households that decide to use adaptation strategy and 0 not decided to use. Independent variables: that is hypothesized to affect the farmers' decision of an adaptation practice. For this study, demographic, socioeconomic and institutional variables were used as independent variables. Based on the review of adoption and adaptation literatures and past research findings 10 potential explanatory variables were considered in this study and examined for their effect in practices to climate change and variability. The hypothesized explanatory variables included in the analysis were expressed as follow.

Table 1: Description of variables and their hypothesized relationships

Source: Field survey 2014

Explanatory Variable	**Description**		Expected sign
Age	Continuous	Age of respondent (in years)	+/-
Sex	Dummy	Sex (Female = 1, Male =0)	+/-
Family size	Continuous	Household size (number of families)	+
Edu level	Dummy	education level(illiterate=1, literate= 0)	+
Total farm size	Continuous	Total Land Size (ha)	+
TLU	Continuous	Number of livestock in TLU	+
Ext services	Dummy	Access to extension service yes=1,No=0	+
Clim info	Dummy	if you have =1 otherwise=0	+
Agroz	Dummy	if midland =1 otherwise=0	+/-
Wealth	Categorical	poor=1 medium=2 rich =3	+

3.4.4. Data Diagnosis

Multicolinearity Tests: Before taking the selected variables into the Binary logit model, it is necessary to check for the existence of multicolinearity among the continuous variables and verify the degree of association among discrete variables. The reason for this is that the existence of Multicolinearity affects seriously the parameter estimates. Multicolinearity causes large variance and standard error with a wide confidence interval. Hence, it is quite difficult to estimate accurately the effect of each variable (Gujarati, 1995 and 2003). If multicolinearity turns out to be significant, the simultaneous presence of the two variables will reinforce the individual effects of these variables. And since we cannot obtain their unique estimates, we cannot draw any statistical inference (i.e., hypothesis testing) about them from the given sample. To this end, the variance inflation factor (VIF) was used to test the degree of multicolinearity among the continuous variables and contingency coefficients were also used to check for the degree of association among dummy variables. The values of VIF for continuous variables were found to be small (i.e. VIF values less than 5). To avoid serious problem of multicolinearity, it is quite essential to omit the variable with value 5 and more from the logit analysis. Based on the VIF result, the data have no serious problem of multicolinearity. As a result, all the 10 explanatory variables were retained and entered in to logistic analysis. Similarly, value of contingency coefficient ranges between 0 and 1, and value of variable with contingency coefficient below 0.75 shows weak correlation and value above it indicates strong association of variables. Accordingly, the results of the computation reveal that there was no serious problem of association among discrete explanatory variables. Hence, all the 10 discrete variables were entered into logistic analysis.

RESULTS AND DISCUSSION

A total of 130 households were interviewed from two agro-ecology zone, of which 93.8% of male headed and 6.2% of female headed household. The average age of the respondents was 47.65 years (rangewas27–90 years). The overall average household size of the sampled population was 7.28, the range of family size between 1 and 17. Data on education indicated that 40%, 22%, 17.6% and13.8% and 6.1% respondents had Illiterate, Read& write, Elementary school, and Junior school and High school, respectively. The overall average farm size was 0.58± 0.278 ha (SE) and this is below the national average land holding of 1.02 hectare. Land holdings range between 0.25 to 2 ha (Tabel4). The mean livestock holding is about 3.2 with standard deviation of1.9 (Table 3) Livestock holdings ranged between no holdings to a maximum of 8.04 heads. The mean livestock ownership of the poor is 1.93, medium 4.3 and rich 5.41. However, there is statistically significant difference between the mean of livestock ownership among the three socio-economic groups (Table 3). Farming alone, Farming and off-farm activities 63.1% and 36.9% respondents respectively. The findings suggested that majority of respondents in both agro ecologies are dominated by poor, followed by medium and rich53.8, 31.5 and 14.6 respectively (table 3).

Table3: Number of livestock of the respondents in TLU

Types livestock	Poor		Medium		Rich	
	Mean	SD	Mean	SD	Mean	SD
OX	.6571	.53530	1.2927	.46065	1.8947	.31530
Cow	.7143	.48582	1.3415	.48009	1.6316	.49559
Young	.1714	.31721	.4024	.37864	.5132	.35818
Calves	.0250	.07554	.2134	.10549	.2500	.08333
Goat	.0706	.13766	.2093	.11583	.2668	.13338
Sheep	.0613	.11005	.1617	.13874	.2053	.14577
Chicken	.0241	.03744	.0480	.04273	.0674	.03649
Hours	.1100	.33238	.2683	.47825	.2895	.49766
Donkey	.0943	.31016	.3488	.57364	5.4079	1.30558
Total TLU*	1.93	1.27768	4.3	1.15408	5.41	1.30558
Over all TLU	3.2	1.9				

Source: Owen survey, 2014

Table 4: Basic Characteristics of Household Heads

Variables	Respondents		Total		
	no	*min*	max	mean	SD
Age	*130*	*27*	90	47.65	12.76
Family size	*130*	*1*	17	7.2	2.41
Farmland size	*130*	*0.25*	2	0.58	0.278
Education level	*Midland*		Highland		total
	No	*%*	no	%	%
Illiterate	30	35.7	22	47.82	40
Read& write	22	26.2	7	15.2	22
Elementary school	16	19.0	7	15.2	17.6
Junior school	10	11.9	8	17.39	13.8
High school	6	7.1	2	4.34	6.1
Total	84	100%	46	100%	100%
Occupation					
Farming alone	50	59.8	32	69.6	63.1
Farming and off-farm	34	40.5	14	30.4	36.9
Total	84	100	46	100	100
Wealth status					
Poor	46	54.8	24	52.2	53.8
Medium	28	33.3	13.3	28.3	31.5
Rich	10	11.9	9	19.6	14.6
Total	84	100	46	100	100%

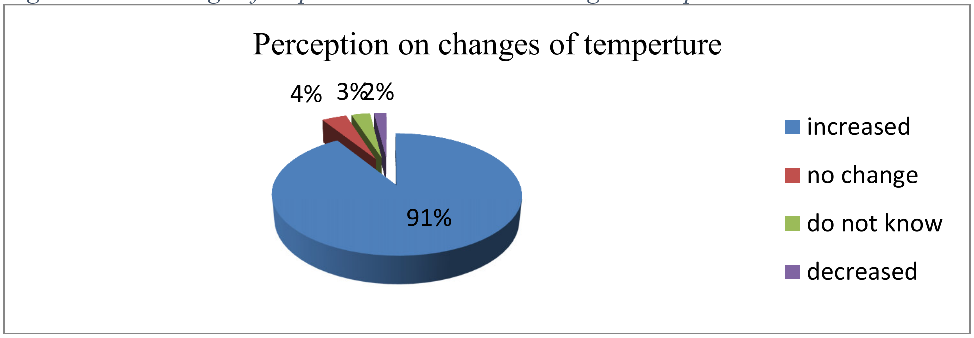
Source: Owen survey, 2014

4.2. Farmers' Perceptions about Climate Change and Variability

4.2.1. Farmers' Perceptions about Temperature

Among the interviewed respondents, 91% perceived increase in temperature where as 2% claimed decrease in temperature in the area over the last 30 years. The remaining 7% did not perceive the change; from this 4% felt no change in temperature and 3% did not say anything about temperature trends over the last 30 years (Figure 3). The results obtained from respondents are in line with the focus group discussion and key informant interviews, which indicate the change in temperature pattern since 1990 (the downfall of the Derg regime) and have shown an increasing trend in amount and intensity.

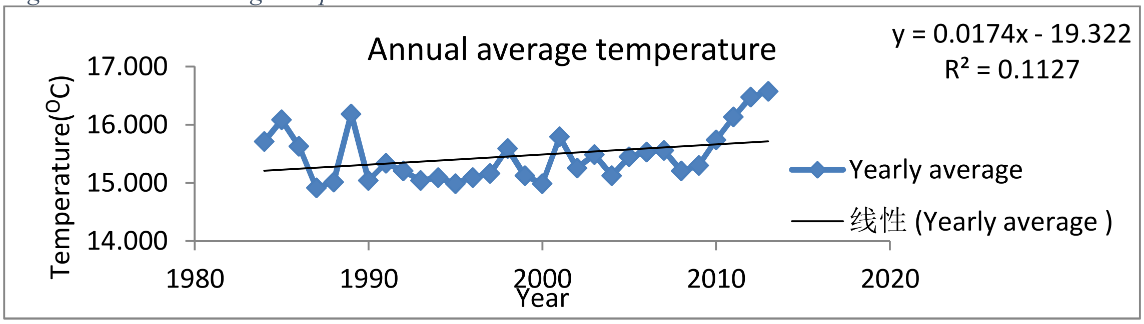
Figure 2: Percentage of respondents observation change in temperature



Source: survey result, 2014

As can be seen in figure 4 an 5 below, the trend analysis of average annual temperature and both annual mean minimum and maximum temperatures follow increasing trends. This is in accordance with the perceptions of most farmers towards temperature. As metrological data, Kach Birra woreda faced the problem of climate change and variability. The average annual temperature of the woreda has increased at a rate of 0.017°c per year or 0.17°c per decade (figure4).

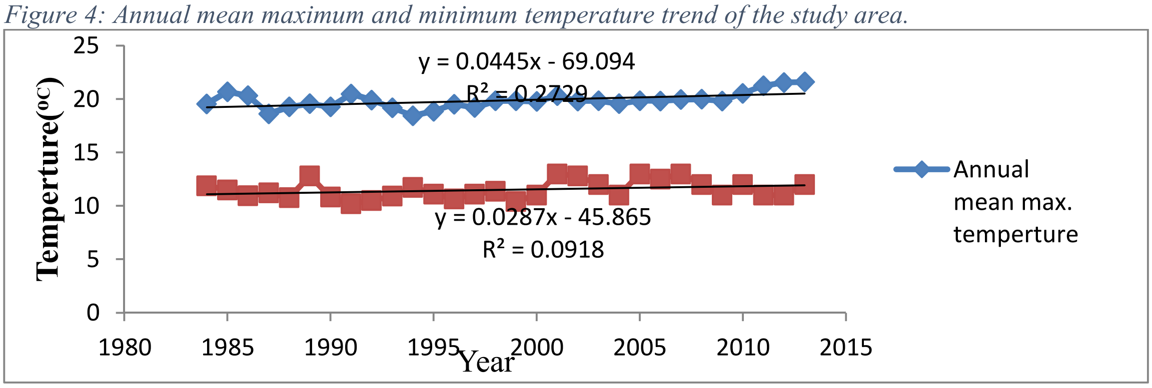
Figure3: Annual average temperature



Source: Computed from NMAS data, (1984- 2013

The analysis of average annual maximum and minimum temperature showed that, the mean maximum temperature is in increasing with coefficient of 0.044°c per decade. While the trend of average minimum temperature showed also an increasing by 0.028°c per decade (figure5). This is in accordance with the perceptions of most farmers towards temperature.

Figure 4: Annual mean maximum and minimum temperature trend of the study area.

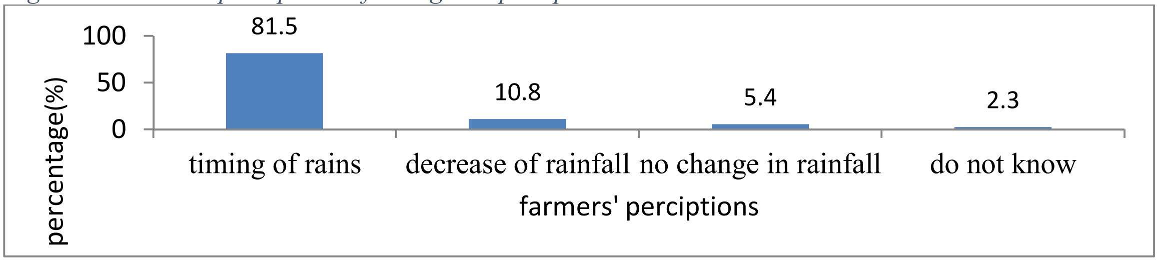


Source: Computed from NMAS data, (1984- 2013

4.2.2. Farmers' Perceptions about Precipitation

All the respondent household heads included in the survey perceived long-term changes in pattern of rainfall amount and distribution. The majority of the respondents (81.5%) noticed a change not in the total amount of rainfall but in the timing of rains, with rains coming earlier or later than expected; 10.8% observed decrease of rainfall; 5.4% claimed as no change in rainfall amount and 2.3% did not pay enough attention to say anything about the precipitation trend of the study area over the last three decades (Figure 6). Such variation in level of perceptions among respondents related with a number of factors influence the likelihood that farmers will perceive climate change. Having fertile soil and access to water for irrigation decreases the likelihood that farmers will perceive climate changes, whereas education, experience and access to extension services increase the likelihood that farmers will perceive climate changes. This suggests that perceptions are not based entirely on actual climate conditions and changes but are also influenced by other factors. This was verified by all participants of Focus group discussants and key informant as there were changes in rainfall timing, amount and distribution in the area over the past 30 years

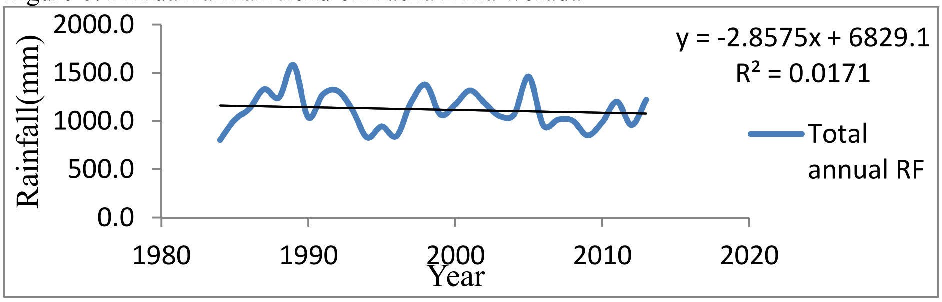
Figure 5: Farmers' perceptions of changes in precipitation



Source: survey result, 2014

Based on the time series analysis, the total yearly rainfall pattern for the past 30 years shows the decreasing treads in amount and a change in the timing of rainfall (Figure 7). The annual total rainfall of Kacha Birra worada ranged betweentheyear1984 and2013ranges from804 to 1581mm. This is in accordance with the perceptions of most farmers towards rainfall.

Figure 6: Annual rainfall trend of Kacha Birra worada



Source: computed from NMAS data, (1984- 2013)

In general, we can conclude that majority of the farmers in the study area feel that there are changes in the long-term average temperature and total rainfall over the last 30 years and this is supported by the observed trends of temperature and precipitation levels of meteorological data.

4.6. Farmers' Adaptation Strategies to Climate Change and Variability

Farmers who observed variability in the climate over the period of 30 years were further asked to describe the farm-level adaptation measures undertaken in response to climate change. The results of the study demonstrated that farm households applied a wide range of adaptation measures in response to the changes in climate. As shown in Fig. 12, the most common adaptation measures were use of soil and water conservation practices (84.6%), different or new crop verities (65.4%), planting drought tolerant crops (63.8%), use fertilizer application (59.2%), shifting planting date (57.7%), crop diversification (45.4%), involvement in off-farm activities (38.5%), livestock management migration (36.9%) and (32.3%) (Table 12).

This implies that farmers in the study area noticed the change in climatic variables and have adopted various adaptation options to counteract the negative impact of climate change and variability in the area. The finding is in line with the studies done in Africa (Gbetibouo, 2009; Nhemachena and Hassan, 2007), City of Cape (Mukheibir and Ziervogel, 2007) and Ethiopia (Bryan *et al*, 2009; Temesgen, 2008).

Table 2: The adaptation strategies for perceived climatic change regarding agro-ecology

Adaptation strategies	midland(Awaye)		highland(Burchana)		Total	
	No	%	No	%	no	%
Soil and water Conservation	69	82.1	41	89.1	110	84.6
Different or new crop varieties	51	60.7	34	73.9	85	65.4
Drought tolerant crops	54	64.3	29	63.0	83	63.8
Fertilizer application	44	52.4	33	71.7	77	59.2
Shifting planting date	48	57.1	27	58.7	75	57.7
Crop diversification	38	45.2	21	45.7	59	45.4
Off-farm activities	34	40.5	14	30.4	50	38.5
Migration	41	48.8	7	15.2	48	36.9
Livestock managements	17	20.2	25	54.3	42	32.3

Source: survey result, 2014

4.9. Determinants of Adaptation Strategies to Climate Change and Variability

Result from the binary logit model show that a total of 10 explanatory variables were found to be significant at 1%, 5% and 10% probability levels. **Age of household head:** has been found to be positively related at 10% significant level with use of drought tolerant crop adaptation strategy not significant for other categories of adaptation strategies. This means that an increase in the age of household heads increases the probability of household decision to use adaptation measure

In other word, as the age of the household heads increases by one year, the probability of household heads to adapt climate change by using the adaptation strategy drought tolerant crop increase by a factor of 1.05 units (Table 6). **Sex:** Sex of household was significant at 10% and negatively associated with adoption to adjust livestock management adaptation strategies not significant for other categories of adaptation strategies. The probability of female household heads to adapt climate change by using the adaptation strategy livestock management strategies decrease by 0.038 compared to male headed households (Table 6). **Total land size:** As expected, that farm size has been found to be positively related at 5% significant level with use of changing planting date adaptation strategies not significant for other categories of adaptation strategies. The conditional odds ratios, shows that as the size of the farm land increase the probability household heads to adapt climate change by using the adaptation strategy changing planting date increases by 5.46 times when compared to those who have small farm size (Table 6).

Education level: the results show that, education of respondents is positively and significantly related with crop diversification and use of drought tolerant crop at a 1% and10% significant level, respectively not significant for other categories of adaptation strategies. The conditional odd ratios for both crop diversification and drought tolerant shows that the probability for households with higher level of education to adapt climate change by using the adaptation strategies of crop diversification and use of drought tolerant crop increases by factor of 5.2 and 2.2 compared with households who has lower education level, respectively (Table 6). **Livestock Holding:** It is positively and significantly associated with soil and water conservation adaptation strategies at 10% of significance level not significant for other categories of adaptation strategies (Table 6). The conditional odds ratios, as the number of livestock holding increases by one unit, the probability of households to adapt climate change by using the adaptation strategy soil and water conservation increases by a factor of 1.28. **Access to climate information:** a climate information source showed a positive and significant relation with improved crop variety and changing planting date at 1%, use of fertilizer application and off-farm at 10% and crop diversification at 5% significant level with use of this adaptation strategy not significant for other categories of adaptation strategies. Contrary to other adaptation strategies, access to climate information which is negatively and significantly related with migration at 1% significance level not significant for other categories of adaptation strategies (Table 6). The conditional odd ratio increases by a factor of 5.67, 18.7, 3.2, 2.93 and 3.76 to adapt climate change by using the adaptation strategies of improved crop variety, changing planting date, use of fertilizer application, off-farm and crop diversification, respectively compared with households who have no access to climate information. This is probably because the availability of climate information helps the households make comparative decisions among alternative adaptation practices. **Wealthier households:** The results indicate that the probability of resource-rich farmers in adapting off-farm, crop diversification and adjust to livestock management decrease by 0.029, 0.018and 0.04 than resource poor farmers, respectively. However, the likelihood of rich farmers in adapting migration as an adaptation option increases by a factor of 8.71 as compared to poor farmers (Table 6). Similarly, the probability of medium farmers in adapting to climate change by using off-farm, change planting date, crop diversification and livestock management decrease by a factor of 0.1, 0.11, 0.044, 0.033 as compared to the poor respectively. Nevertheless, the probability of medium farmers in using migration as adaptation option is 8.5 times more than that of poor farmers (Table 6).

Agro Ecology: Results of regression analysis have showed that making a living and operating in Dega (high land) appears to increase the likelihood of selecting and using fertilizer application and adjust to livestock management as adaptation option at 10% and 1% significance level, respectively relative to the woina daiga (midland). Accordingly, the likelihood of farmers living in dega in adapting fertilizer application and livestock management is 2.45 and 11 times more likely than that of woina dega. Moreover, making living in dega agro-ecology appears to decrease the likelihood of selecting and using adaptation strategies off-farm by 0.32 and migration by 0.12(Table 6). This is due to high severity of climate problem in woinadega relative to dega settlers. Besides, these climatic conditions force the farmers to practiced off-farm and migration as an adaptation option in midland agro-ecology than farmers making their livings in highland. Similarly Temesgen *et al*. (2010) revealed that being making their living in dega agro-ecology increase the likelihood of adapting to climate change as compared to the others.

Table 6. Results of the binary logistic regression regarding factors that affect farmers' adaptation to climate change and variability.

Exv.	Crop var.		So. &wa.co		fertilizer application		Off- farm		Migration		changing planting date		Crop diversification		Dro. tolerant crops		Adj. Livestock management	
	Sig	Ep (B)	Sig.	Exp (B)	Sig.	Exp (B)	Sig.	Exp (B)	Sig.	Exp (B)	Sig.	Exp (B)	Sig.	Exp (B)	Sig.	Exp (B)	Sig.	Exp (B)
Age	.373	.97	.799	.991	.173	.952	.748	1	.348	1.03	.852	.992	.944	1.0	.097*	1.05	.729	1.01
Sex	.24	.10	.310	.338	.821	1.3	.371	.368	.657	1.66	.780	1.39	.283	.196	.895	1.14	.07*	.038
f.size	.02**	1.4	.670	1.06	.180	1.18	.981	1	.220	.866	.332	1.14	.243	1.16	.529	1	.608	1.07
land s	.558	1.6	.242	3.72	.700	1.3	.580	1.48	.183	2.36	028**	5.46	.879	1.10	.185	2.8	.374	1.89
Educ.	.300	.54	.115	.407	.715	1.2	.358	1.63	.882	.923	.380	1.75	.003***	5.2	.088*	2.2	.911	1.07
Livest	.844	1.04	.07*	1.28	.146	1.4	.669	.913	.822	.946	.279	1.33	.855	1.04	.542	.89	.903	.967
Clim info	.017**	5.67	.998	3.30	.063*	3.2	.066*	2.93	.000***	.081	.000***	18.7	.025**	3.76	.115	2.8	.915	.922
w1	.998	.00	.998	.000	.998	.000	.003***	.029	.038**	8.71	.136	.173	.006***	.018	.539	.41	.000***	.004
w2	.998	.00	.998	.000	.998	.000	.026**	.100	.013**	8.5	027**	1.1	.019**	.044	.177	.19	.007***	.033
Agro ecology	.510	1.4	.586	1.40	.09*	2.45	.045**	.32	.000***	.12	.872	1.10	.787	.865	.736	.85	.001***	11
Extension	.501	.46	.982	1.02	.809	1.36	.999	3.3	.522	.414	.215	.199	.214	.226	.235	4.5	.48	.066
Constant	.998	3.2	.998	1.13	.998	5.75	.999	.000	.446	5.93	.491	.195	.133	73.4	.394	.13	.214	37.7

*Note 1: ***, **, * indicate significant at 1%, 5%and 10% significant level, respectively*

Note 2: Crop var = crop Varity, So. &wa.co = soil and water conservation, Dro =drought, Adj = adju st, Expv = explanatory variables, f.size = family size, Educ = education, Livest = livestock, Clim info = climate information, W1= wealth1, W2 =wealth2, extension= extension service

5. Conclusions and Recommendation

5.1. Conclusions

The findings from this study showed that most of the farmers' perceived an increasing trend in temperature and decrease in rainfall volume and the pattern becoming unpredictable. Farmers' perceptions of climate change and variability is in line with the climatic records.

Evidence for farmers' perceived changes is reflected in the adaptations of different farming strategies. Survey results confirmed that the majority of the respondents have adjusted their farming practices to counteract perceived climate change and variability. The main adaptation strategies farmers were using included a different crop variety, implementing soil conservation, diversifying crops, changing planting dates, changing use of chemicals or fertilizers, adjusting to crop management, engaging in off-farm activities, adjusting to livestock management and migration. This study also shows that farmers in different agro ecological zones prefer different adaptation measures. This diversity confirms the need for research at local levels, i.e., in different agro ecological zones, to develop efficient and effective adaptation strategies for the agriculture sector. The study also shows that adaptation is highly location specific and hence, geographical location should be considered while designing adaptation strategies. The adaptation options employed are reactive ones, born out of necessity by the farmers themselves. Adopters believed that the adaptation options they employed are not enough to reduce the impact of current climate change and variability. So, one can safely conclude that livelihood diversification is not only a choice, but it is mandatory in order to survive in the face of eminent climate change and variability. Hence, future policies need to address barriers for the adoption of advanced adaptation measures at the farm level such as providing information and support, introducing climate smart varieties, promoting soil conservation and new adaptation measures based on different agro ecological zones. Despite the need for locally specific adaptation of agriculture to climate change, investment and research are also needed at the macro level. In particular, commodity prices, resource endowments, and environmental impacts depend on regional and international developments but interact with local adaptation measures.

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