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Impact of Climate Change and Variability on Maize (*Zea Mays L*) Production and Factor Affecting Farmers Adaptation Strategies in Hawassa Zuria District, Southern Ethiopia

Timotiwos Michael Didiso (MSc) [1]
Natural Resource Management Expert at Hawassa Zuria District Agriculture and Natural Resource office, Sidama Regional State of Ethiopia (email: timotiwosmichael82@gmail.com)

Demelash Kefale Hunegnaw (PhD) [2]
Instructor and Researcher at College of Agriculture, Hawassa University, Ethiopia (email:demelashk@gmail.com)

ABSTRACT

Climate change is one of the challenges facing the world which is increasingly affecting peoples' food security and livelihood especially in developing countries. The impacts are more pronounced on crop production. In this regard the current aimed at investigating long term climatic trends evaluating the impacts specifically on Maize production and assessing adaptation strategies of the farming community in Hawassa zuria district, Sidama Regional State of Ethiopia. The study used multi stage random sampling procedure in which 331 sample households were considered to collect primary data through interview. Secondary data were also collected from National Meteorology Agency and district agricultural office. Collected data were analyzed by descriptive statistics, Mann-Kendall trend test, Adaptation Strategy Index, Regression and MNL model. According to the survey results about 81% of the respondents stated that, the amount of rainfall in the study area is decreasing, despite long-term data records show that, it is increasing by 2.22 mm annually over the past 33 years. The mean annual rainfall was also found to be less variable with CV value of 14%, which was also confirmed by 85% of the interviewed respondent farmers. The sample households were also perceived that the temperature is increasing through time, which was in line with the long-term data records of NMA indicating mean annual increase in the annual minimum and maximum temperature by 0.062^oC and 0.028^oC respectively. The data from NMA also showed that, the rainfall of the spring (Belg) season was positive and significantly correlated with Maize production, while the correlation with long-term maximum temperature was negative. The study also identified that, the main adaptation measures being practiced by the farmers include using; improved crop varieties, crop-livestock mixed system, micro irrigation, soil and water conservation, adjusting planting date and income diversification activities. The marginal effects of MNL model results also indicated that, the adaptation strategies used by farmers were significantly ($p< 0.05$) influenced by; age of household head, family size, farm land size, and monthly income and livestock ownership. Therefore, to increase and sustain farmers Maize productivity under changing climatic conditions; improving the Maize production through: developing drought resistant Maize varieties, improving farmers' perception of climate information, and promoting farm-level adaptation measures such as the use of new agricultural technologies and adjusting planting date must be strengthened in the study area.

Key words: Adaptation strategies, Climate change, Climate variability, MNL and Maize.

1. INTRODUCTION

Climate change includes major changes in temperature, rainfall, wind pattern and other climate variables that occur over decades or longer (IPCC, 2015), whereas, climate variability is the way climate fluctuates monthly, seasonally and yearly as above or below a long-term average value (NOAA, 2009). Both change and variability of climate as well as increasing the occurrence and frequency of extreme weather events could reduce water supplies for irrigation and enhancing severity of soil erosion (Bates *et al*., 2008).

The agricultural sector is known to be climate-sensitive in nature, and particularly rainfed crop production system which is dominating in most developing countries is vulnerable to climate change and variability. Consequently, smallholder farmers in developing countries tend to be among the most climate change exposed communities (Pettengell, 2010). Especially communities in countries with limited economic resources, low levels of technology development, poor information and skills, poor infrastructure, unstable or weak institutions, along with inequitable empowerment and access to resources have little capacity to adapt to climate change. However, rainfed agriculture is yet the dominant source of food production and the livelihood foundation of the majority of the rural poor in sub-Saharan Africa (Cooper *et al*., 2009).

Similarly, Ethiopia's agricultural sector, which is dominated by small scale, crop-livestock mixed farming system, is the main source of the economy. It constitutes more than half of the national gross domestic product (GDP) generating more than 85% of the foreign exchange earnings, and employed about 80% of the working population (Yesuf *et al.,* 2008). Its dependence on rainfed agriculture makes the country particularly vulnerable to the adverse impacts of climate variability.

Similarly, the major *Maize* production areas in Sidama region including Hawassa Zuria district have been experiencing crop yield reduction. However, historical impacts of climate change hazards are not systematically well documented as well as quantitative climate change impact assessments are not properly conducted so far in the district of Hawassa Zuria. Therefore, it was found to be vital to provide site specific information, to address the knowledge gap in climate change and variability impacts especially on smallholder farmers' crop production in the district. This study was thus conducted with the aim of investigating the long term trends of climate variables especially temperature and rainfall along with their impacts on rainfed *Maize* production and identify factors that affect climate change adaptation strategies used by the farming community in Sidama Region, Hawassa district.

2. METHEDS AND MATERIALS

Description of the study area:

The study was conducted in Hawassa zuria district, Sidama Regional State of Ethiopia, which is located about 302 km south of Addis Ababa along the way to Moyale and in the out skirts of Hawassa city administration. It is with an altitude ranging from 1600 to 1800 meters above sea level and roughly lies at geographical coordinates between 6°83' to 7°17'N and 38°24' to 38°72'E.

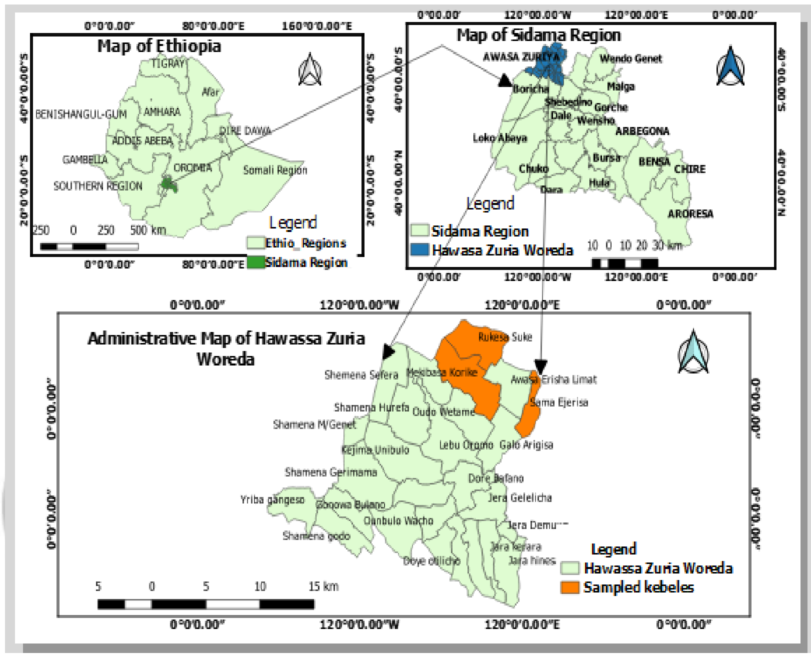

Figure 1.Map of the study area

Hawassa zuria district receives an average annual rainfall of 900 to 1200mm with mean temperature of 20°C (SNNPR-CSA, 2016). The agro ecology is categorized under Sub-humid weather with bimodal rainfall pattern, named as; *belg (*small rainy season that extends from March to May) and *kiremt* (main rainy season, extends from June to September). The land use data of the district shows that, about 8545 hectares is cultivated for both annual and perennials crops, while 21850 hectare is allotted for grazing and 730 hectares covered by shrubs, 107.5 hectares cultivable, 75 hectares un cultivable, 593.2 hectares irrigated, 2374 can be irrigated (DOA, 2015/2016). The main components crops of the farming system in the district include; *Maize, Haricot bean, Chat, Vegetables* and *livestock*.

Research Design and Sampling Techniques

The study used a cross-sectional survey design with both qualitative and quantitative approaches. In this research, mixed methods were used for better understanding of the situation in the villages than what could have been made with the use of only one method. In cross sectional survey, information on all variables was collected at specific point in time, and association between explanatory variables and response variables was done.

Multistage sampling procedure was also used, in which Hawassa zuria district was purposely selected since it is one of the vulnerable areas to climate related changes in Sidama Region. Three mainly maize producing *kebeles* (administrative units) were then selected out of the 23 rural *kebeles*, after which 331 households were identified by using systematic random sampling technique with probability proportional size for the reason that it has advantage in providing information on large group of people, within limited time and a cost-effective manner (Geofrey *et al.,* 2005). Yamane's (1967) simplified formula was then used to determine the required sample size at 95% confidence level and 5% level of precision as shown below.

$$n = \frac{N}{1+N(e)^2}$$

Where,

n is the sample size,

N is the population size (total household heads), and

e is the 5% level of precision.

Then, $n = \frac{1917}{1+1917(0.0025)} = 331$

Table 1: Sample household size used for the study from each kebeles

No	Name of sampled kebeles	Household Size	Sample Size
1	Makibassa Korqe	683	116
2	Rukessa Suke	607	101
3	Sama Ejerssa	627	114
Total		1917	331

Source: Sample survey, 2020

Data Types and Collection Methods

Both primary and secondary data comprising of qualitative and quantitative variables were collected during the study. The primary data focusing on socio- economic & demographic characteristics were collected from sample households. Additional data were also collected using focus group discussions (FGDS) and Key Informant Interviews KII). Whereas, secondary data were collected from; annual reports and documents of Governmental organizations (GO) and Non-Governmental organizations (NGO), from National Meteorology agency (NMA), Hawassa zuria district Agriculture and Natural Resource Office, published and unpublished materials.

Household survey was the major source of data collection for this study which was implemented using structured questions focusing on the major research objectives. Socioeconomic and demographic characteristics of respondent household heads were mainly included in the survey. In order to easily communicate with the respondents and reduce time, the questionnaires were translated into the local language (*Sidaamu Afoo*). The respondent sample farmers were then characterized by socioeconomic and demographic profile for the study such as; sex, age, education level, farm-land size, family size, monthly income, farm experience, livestock ownership.

Focus group discussion: Focus group discussions were organized at community level with a group of small holder farmers between 5-8 with 18 years and above (man and woman) randomly selected to discuss on the existing and persistent impacts of climate change and variability on *Maize* production and actual adaptation measures used as response to the impacts of extreme weather events. With the help of village leaders, a sample of farmers able to answer the questions listed in the FGDs check list were identified. These FGDs included both man and women as well as aged and young farmers. During the field survey 21 FGDs were conducted 7 of each selected 3 *kebeles* for the study.

Key Informant Interview: Includes district Agricultural and Natural Resource Management officer, disaster prevention and preparedness officer, *kebele* administrators and development agents. Total 12 key informant interviews were consulted in order to gain more understanding on the impacts of climate change on agriculture.

Secondary data: 33 years rainfall and temperature data were obtained from National Meteorological Agency (NMA), while 15 years *Maize* production data from District Agricultural and Natural Resource Office (DANRO). The temperature and rainfall trends were, thus, compared with the *Maize* data and the respondents' perception of climate change trends and with its effect.

Data entry and analysis

Table 2 provides a summary of analytical methods (models) used for each objective, types of data required for specific variables employed in the data analysis and suitable analytical software for each model.

Table 2.Analytical framework

Objectives	Type of data and data requirements	Analytical test models	Analytical Software
Assess long-term climatic change and variability trend especially rainfall and temperature in the study area	Time series data of rainfall (annual and seasonal) and temperature (maximum and minimum) Time series:1987-2019	*Regression Trend analysis*	STATA
		Coefficient of variability (CV)	STATA
		Mann-Kendall trend test	Man- Kendall trend test program
Evaluate the impacts of climate change and variability on production of Maize in study area	*Dependent variables: Maize* yield data. *Independent variables:* Rainfall and temperature. Time series:1987-2019	*Correlation analysis*	STATA
Identify the climate change adaptation strategies and mechanisms used by the farming community in study areas.	*Dependent variables:* Adaptation strategies *Independent variables:* Socio-economic and demographic characteristics of household	Adaptation Strategy Index (ASI)	Microsoft Excel
Assess the major factor that influence farmers' adaptation of climate change adaptation strategies.	*Dependent variable:* adaptation strategies. *Independent variables:* Sex, age, household size, education, household land size, farming experience, monthly income, access to credit service, access to extension services and livestock ownership. Type of data: Household survey data	*Multinomial Logit Model*	STATA

Source: Author, 2020

3. RESULTS AND DISCUSSIONS

3.1. Climate Trend Analysis

3.1.1 Rainfall trends

i. Regression Analysis

The same time, the trend equation of the annual rainfall shows an increased trend with 2.22 mm per year over the past 33 years (Figure 2). The statistical analysis also revealed that the increase in annual rainfall was insignificant, since the role of time series expressed by coefficient was only about 2.29% despite inter-annual fluctuations. This result is in line with the findings of (Nicholson *et al.,* 2000) that reported variability in annual rainfall in the semi-arid and sub humid zones of West Africa.

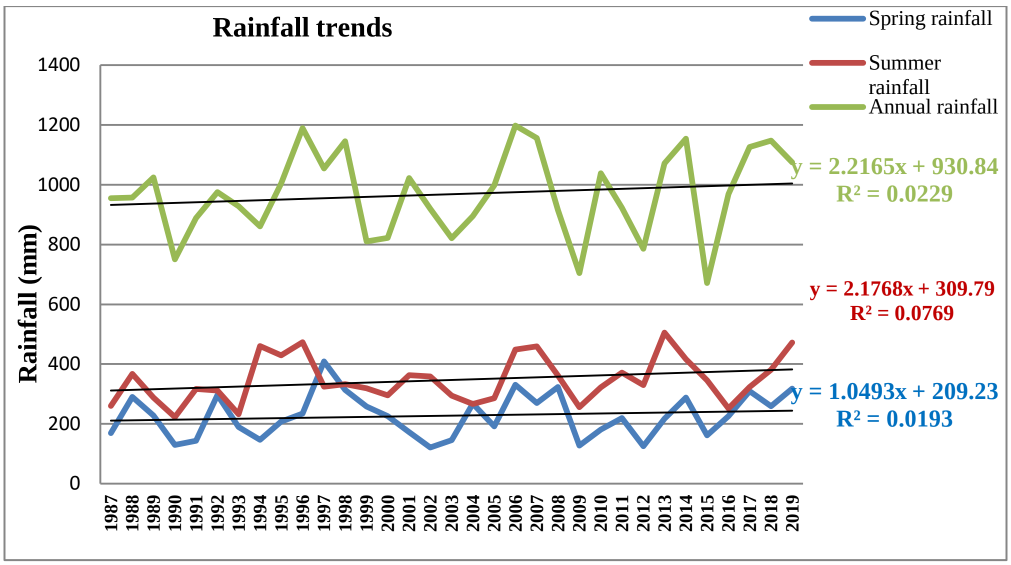

Figure2. Annual and seasonal rainfall trend for past 33 years (1987-2019)

Source: National Meteorological Agency (NMA, 2020)

ii. Coefficient of variability for rainfall

The data obtained from Ethiopia Metrological Agency in study area revealed that the coefficients of variations of study area were; 14.7%, 21.9% and 32.2% for annual, summer (*Kiremt*) and spring (*Belg*) respectively, which indicates that, rainfall variability during the *belg* season was very high, while the *kiremt* rainfall variability was moderate and the annual rainfall was less variable during 1987-2019 (Table 3). Various studies indicated that the trends in inter-annual and inter-seasonal rainfall variability was decline in amount and increase in intensity along with increasing temperature which would aggravate the rate of erosion, and consequently reflecting negative implication on crop productivity.

Table 3. Annual and seasonal rainfall variability results (1987-2019)

Rainfall (mm)	Minimum (mm)	Maximum (mm)	Mean (mm)	Stdv (mm)	CV (%)
Annual	670.9	1197.9	968.5	142	14.7
Summer *(Kiremt)*	223,0	505.9	346.8	76	21.9
Spring *(Belg)*	120.5	408.8	227.0	73	32.2

Source: National Meteorological Agency (NMA, 2020)

According to National Meteorological Agency of Ethiopia (NMA), in the Sidama Region Hawassa zuria district, the seasonal rainfall shows lower inter-annual variability than the summer (main rain season, June-end of September) and belg (small rainy season, March-May) rainfall. The summer (kremit) and spring-(belg) rainfalls have shown an increasing trend per year in the period noted.

The summer rain in this study has shown an increasing trend with 2.17 mm per year in the period noted but not statically significant (Figure 2). Summer is the main rainy season in the study area on which farmers are engaged to produce their crop. However, according to NMA data, the seasonal total amount of rainfall during the summer (June to end of September) showed higher variability especially during the years 1987, 1988, 1990, 1993, 1994, 1995, 1996, 2004, 2006, 2007, 2010, 2013, 2016 and 2019 which were below the average of rainfall in the study area. This has to be shown by SPI values.

The spring/belg season rainfall has shown an increasing trend from1987-2019 by 1.05 mm per year in the study area despite not significant (Figure 2). Generally, seasonal time series rainfall data did not show statically significant trend similar to the annual time series data (Table 4).

iii. Annual standard precipitation index (SPI)

The standardized anomaly of total annual rainfall revealed that, above average rainfall in the area was recorded for 17 years and below average rainfall for 16 years (Figure 3). Based on standard precipitation index procedure, the rainfall period of study area approximately categorized in to three decades. First decade (1987-1996) was relatively drier, while the second (1997-2006) decade and third decades (2007-2019) were relatively wet, confirming the slightly increasing trend already observed in the trend analysis of this study.

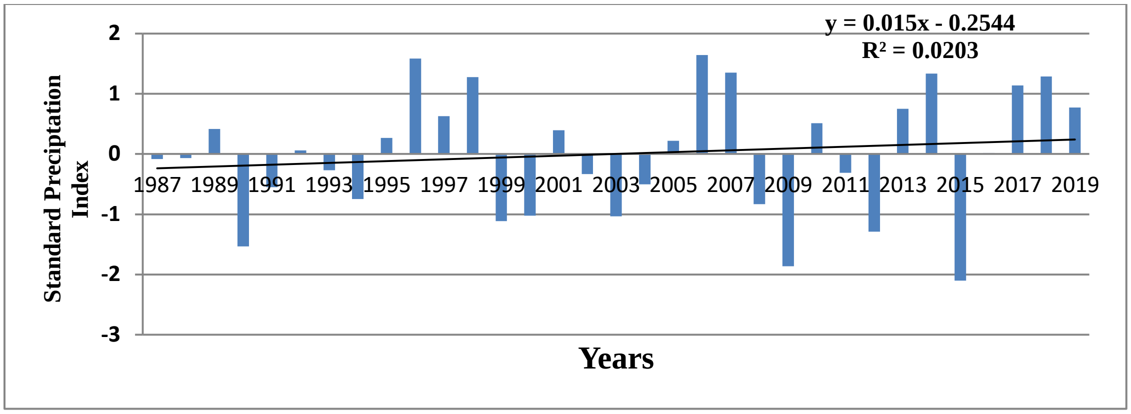

Figure 3 Annual SPI of Hawassa Zuria District

Source: National Meteorological Agency (NMA, 2020)

iv. Mann-Kendall trend analysis

Results *Mann-Kendall's trend test* indicated increasing rainfall trend in Hawassa zuria district (Table 4). Hence, significance test for the trend is of paramount importance in order to predict the occurrence of extreme weather events and their likely impacts. However, the trend test at 0.05 levels was not statistically significant.

Table 4 Rainfall Mann-Kendall's trend test results (1987-2019)

Rainfall (mm)	Mann-Kendall Trend(S)	Significant (α)	Sen's Slope	Trend
Annual	1.01	-	3.539	Not significant trend
Summer (Kiremt)	1.56	-	2.226	Not significant trend
Spring (Belg)	0.9	-	1.471	Not significant trend

Source: National Meteorological Agency (NMA, 2020)

3.1.2. Temperature trends

The trend analysis of annual temperature (minimum and maximum) in the current study shows significant increment in the *District* during the past 33 years (Table 5).

Table 3.Average annual and seasonal temperature trend (1987-2019)

Temperature (^oC)		Mean	Stdv (^oC)	CV (%)	Mann-Kendall Trend	Significant (α)	Sen's Slope
Annual	Minimum	13.15	0.70	5.39	5.53	***	0.061
	Maximum	27.48	0.46	1.69	2.93	**	0.026

Source: National Meteorological Agency (NMA, 2020)

The mean minimum temperature increased by 0.028°C per annum during 1987-2019 (Figure 4). The Mann- Kendall trend test also showed that, the mean maximum temperature significantly increasing per annum (Table 5). (UNDP, 2008) report also revealed an increasing trend of mean annual temperature of Ethiopia by 0.37°Cper decade. Similarly, (NMA, 2007) average annual maximum temperature in the country has increased by 0.1°C per decade.

The present result was in line with that of (Kassie *et al.,* 2013), wherein the climate of Central Rift Valley of Ethiopia will get warmer in the coming decades and the increasing rate in minimum temperature will be higher than the maximum temperature, particularly under the current emission scenarios. If the temperature shows an increasing trend, then it becomes essential to understand how this may also affect the ecosystems and human life if such a trend continues. Accordingly, change in a temperature pattern can lead to shift in species habitat of forests and insects. The rise in temperature can also result in intense heat waves that could be challenging for aging and other vulnerable populations (Evans A., and Perschel R., 2009).

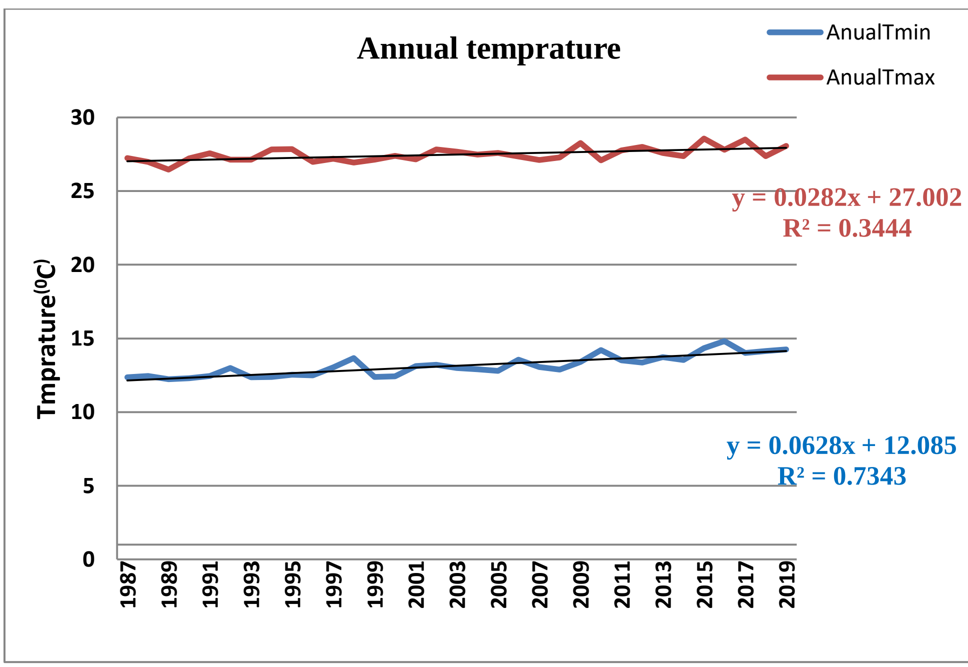

Figure 4 Annual minimum and maximum temperature trend for 33 years (1987-2019)

Source: National Meteorological Agency (NMA, 2020)

3.2. Perception of Farmers on Major Climate Variables

3.2.1 Farmers perception on trends in rainfall

Most of the interviewed farmers perceived the existence of rainfall changes in terms of both the amount and distribution over the years (Figure 5). Of the interviewed respondents, 81% felt a decrease in the amount of rainfall. However, 11%, and 8% respondents felt an increase and no change respectively this result contraire data obtained from NMA. Similar to this finding the study conducted in seven districts of Kenya showed that 88 % of the farm households perceived that, the amount of rainfall decreased over the last 20 years. Similarly, 91% of farmers reported a long-term increase in rainfall variability, across all districts and agro-ecological zones (Bryan *et al.,* 2010).

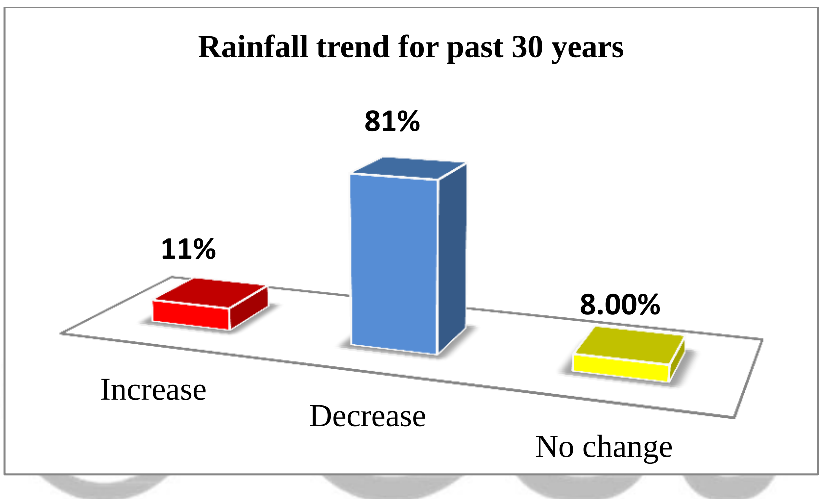

Figure 1.Trend of rainfall in Hawassa Zuria District for past 30 years

Source: household survey result in the study area, 2020

3.2.2 Farmers perception on trends in temperature

The majority of respondents (85.30%) perceived an increase in temperature over the past 33 years (Figure 6). About 11.40% perceived a decreasing in temperature and 3.30% no long-term change in temperature. Similar results were obtained from the NMA and focus group discussion. Generally, farmers believe that the increasing temperature trend was associated with the decreasing changes in rainfall. Similarly, to this finding the research work conducted by (Anbesu, 2013) at Dodota Woreda revealed that 97.5% of respondents feel that temperature of the study area was increasing in the last three decades.

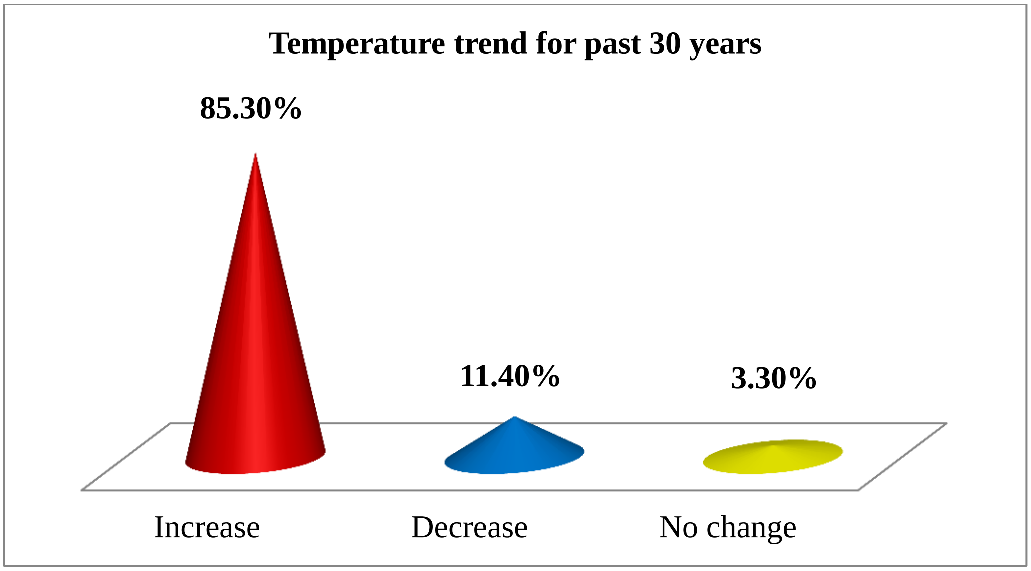

Figure 2.Trends of temperature for the past 30 years

Source: Household survey result in the study area, 2020

3.3. Trend in *Maize* Productivity in the Study Area

Time series yield data of the period from 2004 to 2018 which were obtained from Hawassa Zuria Agriculture and Natural Resource office showed that the trend of *Maize* productivity in the past 14 years decreased by the rate of 0.04qt/ha per annum (Figure 10). Coefficient of determination value also indicated that, about 0.22% of the decline in *Maize* productivity in the study area accounted for the time series of 2004-2018. The declining trend of *Maize* productivity in Hawassa zuria district is mainly due to variability's in the onset of seasonal rainfall and increasing temperature which causes higher potential evapo-transpiration. Generally increased temperature accelerates the loss of water from the soil and the plant thereby affects *Maize* production from vegetative to final grain yield.

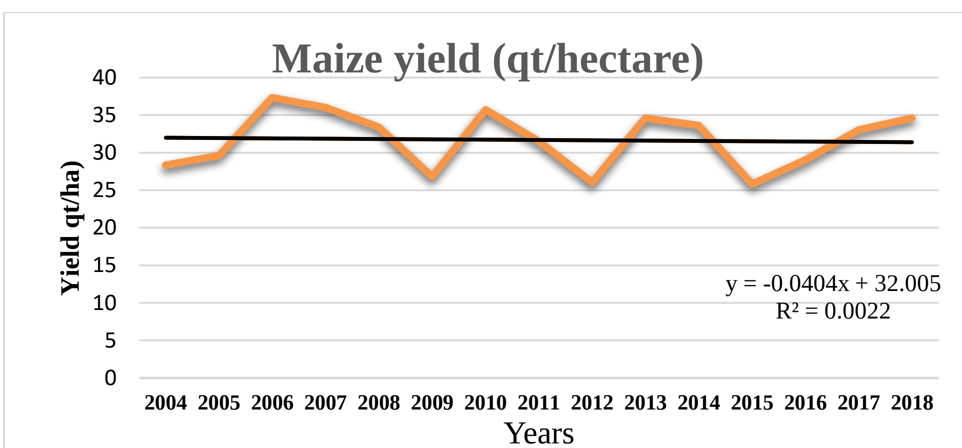

Figure 7 Maize productivity trends for 12 years (2008-2019)

Source: Hawassa Zuria District Agriculture and Natural Resource Office (2020)

Although the impacts of climate variability and change on crop production are more of negative, they substantially vary between crops (IPCC, 2015). According to the experts from the focus group discussion and key informant interviews in the study area, Maize production is the main source of livelihoods, and has been significantly affected by climate variability and change.

3.4. Impacts of Climate Variables on *Maize* Production

The impact of rainfall on crop production can be related to its total seasonal amount or its intra seasonal distribution. In the extreme case of droughts, with very low total seasonal amounts of rainfall, crop production suffers the most. But more subtle intra-seasonal variations in rainfall distribution during crop growing periods, without a change in total seasonal amount, can also cause substantial reductions in yields. This means that the number of rainy days during the growing period is as important, if not more, as that of the seasonal total (Woldemlak, 2006).

The correlation result between *Maize* productivity and annual rainfall is 0.88 which indicates that there is strong positive linear relationship between them, when the other independent variables remain constant (Table 6). Similarly, the correlation results between *Maize* productivity and summer *(keremt)* as well as *Belg* rainfalls are 0.69 and 0.68 showing the existence of strong positive linear relationship between maize productivity and both seasonal rainfalls respectively.

On the other hand, the correlation result between yield of *Maize* productivity and annual maximum temperature is-0.69 which shows the presence of strong negative relationship between *Maize* productivity and annual maximum temperature, as the other independent variables remain constant. The present study implies that an increase in temperature imposes stress on *Maize* crop, which affects its productivity in many ways. For instance, increased temperature leads to intensive evapo-transpiration resulting in drying soil moisture and ultimate crop failure.

Table 4.Correlations of maize yield with annual mean rainfall and temperature in the study area during (2007-2019)

Variable	correlation(r)	Sig (p-value)
Annual RF	0.883***	0.0000
Summer(keremt) RF	0.690***	0.0044
Spring (Belge) RF	0.679***	0.0054
Annual Min T^O	-0.006	0.9825
Annual Max T^O	-0.690***	0.0044

***, **, * Correlation is significant at the1%, 5% and 10% level 2-tailed

Source: National Meteorological Agency (NMA) and Hawassa Zuria Agriculture and Natural Resource Office (2020)

3.5. Farmers' Adaptation Strategies and Mechanisms to Climate Change and Variability

Based on the data from the farm households' survey, the results indicated that 89.1% of farmers are using various adaptation strategies and mechanisms to avert the effects of climate change and variability on their farm, while, 11.9% of the farmers are not using any of the adaptation strategies being adopted by their partners in study area. Moreover, those farmers who are exercising climate change adaptation practice are even using more than one type of strategies. This implies that a single strategy is not adequate in adapting to the impact of climate change thus combination of several strategies is likely to be more effective than a single strategy. The adaptation mechanisms of the studied households who have been using various livelihood strategies in study area are presented below based on rank (Table 6).

Out of six adaptation strategies, being adopted by the farmers, using improved crop varieties was ranked as the first and most important adaptation strategies to climate change. Similar studies were reported by (Bikila, 2013) and (Saguye, 2016), stating that using drought resistant improved short maturing crop varieties was taken as the common climate change adaptation strategy of farmers in Southern Ethiopia.

Mixed crop livestock system was also identified as the second in adaptation strategy in the current study. These results indicated that, farmers use mixed crop livestock farming as adaptation strategy to reduce the associated risks of climate change in the *District*. In line with this, previous studies by (Lemma, 2016) also demonstrated that mixed crop livestock farming adaptation practice was the dominant adaptation strategy to reduce climate change-related problems in the drier areas of Ethiopia.

The third most important adaptation strategy in the study was the "Soil and water conservation (SWC)". Construction of physical soil and water conservation structures is also being practiced by the farmers as one of the most important adaptation strategies in the study area.

The other climate change adaptation strategies include; adjusting planting date (early and late planting), enhancing traditional irrigation schemes (including water harvesting) and income source diversification were practiced among others across the study *Kebeles*.

Table 6 Ranked order of the adaptation strategies to climate change in study area.

Adaptation measures	**Importance on your farm**				**ASI**	**Rank**
	High	**Medium**	**Low**	**No**		
Improved crop varieties	113	76	33	-	524	1
Mixed crop-livestock system	107	36	27	72	420	3
Adjusting planting date	99	84	34	25	499	2
Small-scale irrigation	33	27	24	158	177	6
Soil and conservations practices	62	77	38	65	378	4
Income diversification	46	61	42	93	302	5

Source: Computed based on Survey result (2020)

3.6. Factors influencing farmer's adaptation strategies to climate change and variability

Marginal effects from the MNL, which measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable, are reported and discussed. In all cases, the estimated coefficients should be compared with the base category of using improved *Maize* variety to climate extreme events. The marginal effects, along with the levels of statistical significance are also presented below (Table 7).

The marginal effects of marginal probabilities are a function of probabilities and measures expected to change within the probabilities. In the following section, only the variables that were statistically significant at less than or equal to 1%, 5% and 10% probability levels are interpreted and discussed.

Age: The age of the household head was one of the statistically significant explanatory variables that have negative and positive coefficient (Table 7). The positive sign indicates that it has a positive influence on taking an adaptation strategy to climate change. As the age of the household head increases by one year, the probability of household head using mixed crop livestock system as an adaptation strategy to climate change is increased by 10.4%, at less than (1%) probability significant level, keeping other variables constant. Similarly, as a year increase in the age of the household head, the probability to use adjusting planting date as adaptation strategy increases by 6.3% with the p-value of (<5%), keeping another variables constant.

The result also indicates that, as the age of the household head increases by one year the probability of using irrigation adaptation strategy to climate change decrease by 8.5% with the p-value of (<0.05%). Similarly, as a year increase in the age of the household head, the probability of farmers not use adaptation strategy decrease by 4.2% at less than (1%) significant level, keeping another variables constant.

Family Size: The family size of the household head was a statistically significant explanatory variable in this model, which indicates farmers' adaptation strategy to climate change is also significantly affected by the number of family size. A one-unit increase in the family member resulted in an increase of probability of farmers using soil and water conservation as adaptation strategy increased by 16% at less than (1%) significant, holding another variables constant (Table 7). (Gbetibouo, 2009) also showed that household with larger family size are more willing to choose soil conservation techniques as adaptation measures that are labor-intensive especially in small scale farming. On the other hand, the current result indicated that one unit increases in the member of the family resulted in a 5.3% decrease in the probability of farmers implementing mixed crop livestock system as adaptation strategy with the p-value of (<5%). This agrees with the study reported by (Belay *et al.,* 2017) study.

Education: The results of this study revealed significant and negative effects of education on soil and water conservation, mixed crop livestock system, irrigation and no adaptation (resistance to accept adaptation) strategies to climate change and variability. However, as the education of household head increases by one level, the probability of adopting planting date adjustment as adaptation strategy increases by 2.1% with the p-value of (<10%), keeping another variables constant. While no adaptation (resistance to accept adaptation) strategies decreases by 4.3% with the p-value of (<5%), keeping other variables constant (Table 7). On the other hand, the use of mixed crop livestock system as adaption strategy declines with an increase in education level of the household head. Although, looked this result seems in contrary to the expectation whereby higher level of education to be positively related to adaptation to climate change, it may be associated with the complex nature of the specific strategy to be practiced in modern crop production system.

Farm land size: The farmer's land size had a positive and significant impact on farmers' choice of adaptation methods to climatic change. Accordingly, the results of the current study revealed that, as farm size of household head increases by one hectare, the probability of the farmers to use income diversification by using to non-farm adaptation options significantly increases at (<1%) significant level.

Livestock ownership: is significant explanatory variable in this study. It was positively influencing the farmer's adaptation decision of taking mixed crop livestock system as a climate change adaptation measure. A one unit increase in the number of livestock owned by households, the probability of using mixed crop livestock system as adaptation strategies to climate change and variability also increased by 5.3 % with the p-value of (<5%), keeping another variables constant (Table 7).

Monthly income: monthly income of the household head is also a significant explanatory variable as shown in the Table 7. The result of this analysis reveals that income of household had a negative and positive significant influence on no adaptation (resistance to accept adaptation) and using irrigation adaptation strategies in response to climate change, respectively. A one present (ETB) increases monthly income of household, the probability of farmers to use adaptation strategies of irrigation increased by 7.9%. And also, a one percent (ETB) increases monthly income of household, the probability of farmers no adaptation (resistance to accept adaptation) strategies decreased by 3.6% with p-value of (<5%), keeping other variables constant (Table 7). This result is in line with the outcome of (Tagel, 2013).

Table 7 Marginal effects from the multinomial logit model on the Climate Change and variability adaptation strategies.

Explanatory Variables	**Without any adaptation measures** Coeff. (P-value)	**Mixed crop livestock system** Coeff. (P-value)	**Adjusting planting date** Coeff. (P-value)	**Irrigation use** Coeff. (P-value)	**Soil and water conservation (SWC)** Coeff. (P-value)	**Income source diversification** Coeff. (P-value)
SEX	-.065446 (0.104)	-.0401405 (0.513)	.0961736 (0.157)	-.0015023 (0.966)	.0492153 (0.428)	-.007133 (0.849)
AGE	-.0424385 **(0.006) *****	.1042483 **(0.003) *****	.0634295 **(0.020) ****	-.0854037 **(0.028) ****	-.0564898 **(0.067) ***	.0121602 (0.664)
LEDUC	-.0430618 **(0.026) ****	-.0979342 **(0.000) *****	.0216806 **(0.074) ***	-.0147778 (0.273)	.0040355 (0.798)	.0093568 (0.392)
FAMSIZE	-.0151262 (0.455)	-.0537658 **(0.049) ****	-.0215596 (0.304)	.0197537 (0.286)	.1644352 **(0.000) *****	.0446878 **(0.050) ****
FRMLAND	-.0183899 (0.403)	-.0347493 (0.132)	-.0012752 (0.936)	.019889 (0.238)	-.0191701 (0.377)	.0378734 **(0.000) *****
ACEXTSERV	-.2537563 (0.527)	-.0028807 (1.000)	-.0204231 (0.998)	.0111775 (0.999)	-.1503477 (0.995)	.6196739 (0.995)
ACCRDTSERV	.6232141 (0.991)	-.476017 (0.994)	.8840636 (0.995)	-.103877 (0.968)	-.2957667 (0.985)	-.0014629 (1.000)
FARMEXP	-.0197507 (0.282)	.0265215 (0.509)	-.0279324 (0.284)	.02564 (0.460)	.0246146 (0.500)	-.0207538 (0.516)
LIVOWSHIP	.0149752 (0.437)	.0532063 **(0.031) ****	-.0032614 (0.869)	-.002473 (0.900)	.0067161 (0.793)	-.0237183 (0.265)
MTHLTINC	-.0367241 **(0.024) ****	-.0141428 (0.602)	-.0439451 (0.132)	.0790247 **(0.000) *****	-.0162761 (0.491)	.0150112 (0.320)

Notes: ***, **, * denote significant at 1%, 5% and 10% probability level respectively. The values indicate coefficient (P-value). **Source:** Computed by STATA version 14.1 based on survey result (2020)

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The meteorological data confirmed that, the rainfall in the study area is characterized by insignificant increase and greater inter annual and seasonal variability. The rainfall is described by alteration of wet and dry years in a periodic pattern over the past 33 years (1987-2019). Annual temperature in the study area showed increasing trend for the last three decades. The study has also confirmed that, Hawassa zuria *District* is found to be increasingly vulnerable to the risks of climate change and associated extreme weather events including drought.

Since, *Maize* production in the study area is immensely dependent on rainfall and its variability has affected the production. The results of this study have shown that, the lesser rainfall variability, the lower maize yield anomalies. Consequently, *Maize* production showed considerably positive and strongly significant relation with annual rainfall and positively significant correlation with summer and spring rainfalls. Whereas, *Maize* productivity shown weak and non-significant relation with annual minimum temperature and also weak negative significant relation with annual maximum temperature.

The most common adaptation options of the farmers in response to impacts of climate change and variability on crop *Maize* production in the study area include: using improved crop varieties, mixed crop and livestock system, using irrigation, soil and water conservation, adjusting planting date and income diversification activities.

According to this study, shortage of rainfall and increment of temperature have been found to be the main causes resulting in; crop failure, Poor livestock productivity, decrease income of agriculture, lapse of rainfall time and loss of plant and animal species, as well as severe soil erosion are the most common climate change-related hazards that occurred in the study area.

According to the multinomial logistic regression model (MNL) results age, education, family size, monthly income, livestock ownership and farm size had significant influence on farmers' choice of climate change adaptation strategies.

5.2. Recommendations

To facilitate proper adaptation options to the impacts of climate change and variability in *Maize* production, stake holders should:

1. Ministry of education and different NGOs invest more in education since educated households performed better than non-educated in using yield increasing technology packages which could increase farm income.
2. National meteorology agency installs meteorological station in the *District* to fill the information gap on weather variability and monitoring of crop-climate relationship in the area in order to achieve better *Maize* yield
3. Ministry of Agriculture and Regional Agricultural Bureau have to provide farmers with improved agricultural inputs including improved and drought tolerant crop varieties to reduce climate related risks especially on smallholder farmers.
4. Ministry of water and irrigation integrate efficient agricultural water management practice with productivity enhancing interventions including irrigation to supplement crop water requirement in the *District*.
5. Integrate indigenous knowledge with science-based technologies in order to support adaptation capacity of the farming community.

REFERENCE

Abate Fayesa (2009). Climate change impact on livelihood, vulnerability and coping mechanisms: A Case study of west arsi zone, Ethiopia. Lund University Master's Program in Environmental Studies and Sustainability Scince (LUMES)

Anbesu, B., (2013). Farmers Perception and Adaptation to Climate Change and Variability Doctoral dissertation, Addis Ababa University, Ethiopia.

Bates, B, Kundzewicz ZW, Wu S, Palutikof J (2008). Climate Change and Water: IPCC Technical Paper VI. Geneva, Switzerland: IPCC Secretariat. Accessed July 10, 2016.https://www.ipcc.ch/pdf/ technical-papers/climate-change-water-en.pdf.

Belay, A., Recha, J.W., Woldeamanuel, T., Morton, J.F., (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Central Rift Valley of Ethiopia.Agric.Food Secur.6 (1), 24.

Bikila, A., (2013). Farmers' Perception and Adaptation to Climate Change and Variability: The Case of DodotaWoreda, Arsi zone, Oromia Region, Ethiopia. Addis Ababa University.

Bryan, E., Temesgen Deressa, Gbetibouo, G.A., and Ringler, C., (2010). Adaptation to Climate change in Ethiopia and South Africa: options and constraints. Available from: http//www. Science direct. Publications. Com

Conway D, Schipper ELF (2011). Adaptation to climate change in Africa: challenges and opportunities identified from Ethiopia. Global Environmental Change 21:227-237.

Cooper, P. J. M., Rao, K. P. C., Singh, P., Dimes, J., Traore, P., Dixit, P., Twomlow, S. J.,(2009).Farming with current and future climate risk: Advancing a'Hypothesis of Hope 'for rainfed agriculture in the semi-arid tropics. Jounal of SAT Agricultural Research 7, 1-19.

CSA, (2008). FDRE CSA Agricultural Sample Survey: Report on area and production of Belg Season Crops for Private Peasant holding, Addis Ababa.

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T., Yesuf, M., (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environmental Change 19, 248-255.

Evans, A., Perschel R., (2009). A review of forestry mitigation and adaptation strategies in the Northeast U.S. Climatic Change 96:167–18, DOI 10.1007/s10584-009-9569-3.

Gbetibou, O., (2009). "Understanding Farmers " Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa." Washington, D.C.USA.

Geoffrey, T., Mark, P. and Spencer, J., (2005). Establishing a causal chain: why experiments are often more effective than mediational analyses in examining psychological processes. Journal of personality and social psychology, 89 (6): 845.

IPCC (2015). Expert Meeting on Climate Change, Food, and Agriculture' Meeting Report.Edited by: Michael D. Mastrandrea, Katharine J. Mach, Vicente R. Barros, T. ErenBilir, David J. Dokken, Ottmar Edenhofer, Christopher B. Field, Taka Hiraishi, Susanne Kadner, Thelma Krug, Jan C. Minx, Ramón Pichs-Madruga, Gian-Kasper Plattner, Dahe Qin, Youba Sokona, Thomas F. Stocker, Melinda Tignor. Dublin, Ireland 27-29 May 2015.

Kendall, M.G. (1975). Rank Correlation Measures; Charles Griffin: London, UK.

Legrève, A, Duveiller, E, (2010) Prevailing potential disease and pest epidemics under a changing climate. In climate change and crop production, CABI press, Europe, pp. 263-283.

Lemma, W.A., (2016). Analysis of Smallholder Farmers' Perceptions of Climate Change and Adaptation Strategies to Climate Change: The Case of Western Amhara Region, Ethiopia.

Nicholson SE, Some B, Kone B (2000). An Analysis of Recent Rainfall Conditions in West Africa, Including the Rainy Seasons of the 1997 El Nino and the 1998 La Nina Years. Journal of Climate 13:2628-2640.

NMA (2007) Climate Change National Adaptation program of Action (NAPA) of Ethiopia. Addis Ababa: NMA, Oxfam International.

NOAA (2009). Climate Literacy: The Essential Principles of Climate Sciences. U.S. Global Change Research Program. https://www.climate.noaa.gov/education/

Parry, M.L., Canziani, O.F., Paluticof, J., Vander Linden, P.J., and Honson. C.E.(2007). Climate change: impacts, adaptation and vulnerability. Contribution of working group II to the Thrid assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge. United Kingdom.

Pettengell, C. (2010). Climate change Adaptation, Enabling people living in poverty to adapt. Oxfam research report.

Saguye, T.S., (2016). Determinants of Smallholder Farmers' Adoption of Climate Change and Variability Adaptation Strategies: Evidence from GezeGofa District, GamoGofa Zone, Southern Ethiopia.

Tang, (2013). Effects of high night temperature on yield and agronomic traits of irrigated rice under field chamber system condition. Australian Journal of Crop Science. AJCS 7(1):7-13

UNDP, (2008). "Adaptation to Climate Change: The New Challenge for Development in the Developing World. An Environment & Energy Group Publication. The United Nations Development Program (UNDP)"

Woldemlak, B. and Conway, D. (2009). A note on temporal and spatial variability of rainfall in drought prone Amhara regions of Ethiopia. International Journal of Climatology 27:1467-147

Yamane, Taro. (1967). Statistics, An Introductory Analysis, 2nd Ed., New York: Harper and Row.

Yesuf, M, Di Falco, S, Deressa T, Ringler, C, Kohlin, G (2008). The impact of climate change and adaptation on food production in low-income countries: evidence from the Nile Basin, Ethiopia. International Food Policy Research Institute. Discussion Paper No. 828.