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Climate Variability and Its implication on Wheat Productivity; Farmers' Adaptation strategies: in Robe Town and Surrounding Area, Oromia Regional State, Ethiopia

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***Abstract*— *Climate variability has a drastic impact on wheat output and production. Robe town and its surrounding area, south eastern Ethiopia, is among the highly vulnerable areas. The aim of the study was to analyze climate variability and its implications on wheat productivity in Robe town and the surrounding area. The descriptive experimental and survey research strategy was conducted for this study. ARIMA model was used to forecast medium time scale for mean annual temperature and rainfall. To strengthen the finding of the study primary data on the implication of climate variability on Wheat yields and coping strategies used by the farmers in response to climate variability risk were collected by selecting the sample Households. To select sample Households, first three kebeles were purposively selected based on the numbers of farmers exist in those kebeles. Then probabilistic proportionate to size technique was applied to determine the total sample household size from each kebele. Ultimately, a total of 160 sample household heads were selected by using simple random sampling technique. The results of the study shows that the temperature of the town has increased by 0.04^{0}c and the total annual rainfall shows 0.28mm decrement per year over the years considered. 1mm decrement of spring rainfall would result to 0.014 quintal decrement of wheat yields per hectare per year whereas 1^{0}c increment of annual temperature would result to 1.41quintal decrement of yield. The current study also found significant variation in the amount of rainfall and temperature. Majority of the coping mechanisms used by the farmers are traditional and destructive. For the future there will be appreciable increase in temperature (0.71 to 1.27^{0}c) and increasing wheat yield fluctuation due to temperature and rainfall instability.*

Keywords*— *Climate variability, Coping strategies, Robe, wheat productivity.

I. INTRODUCTION

Developing countries in general and least developed countries like Ethiopia in particular are more vulnerable to the adverse impacts of climate variability and change. This is due to their low adaptive capacity and high sensitivity of their socio-economic systems to climate variability and change. Climate related hazards in Ethiopia include drought, floods, heavy rains, strong winds, frost, heat waves [NAPA, 2007]. Climate changes over the late part of the 20th century are well documented. Since 1960s, mean temperatures have increased and precipitation has become frequently variable, with extreme drought and flood events occurring with increased frequency. Global models predict future temperatures and precipitation and generally they concluded that many region of the world will become warmer with great precipitation variation and more frequent climatic extremes [UNFCCC, 2006]. For instance, the global average temperature showed a warming of 0.78 (0.72 to 0.85)^{0}c over the period of 1850 to 2012, and current predictions for the end of the 21st century are that global average temperature increase will be between 1.5°c, and 2°c [IPCC, 2013]. Climate changes and variability will directly and significantly affect the current and the future agriculture [Greg et al., 2010]. The changes and variability of fundamental variables; temperature and rainfall, have been profound effects on agriculture in Robe town and its surrounding area [Mekuria, 2015]. Since, wheat production has been significantly affected by climate change and variation in the study area majority of the people in Robe town and surrounding area which in turn depends mainly on the functioning of wheat system as their source of

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livelihood and income are highly affected. Therefore, such system may be regarded as more important than a similar system in an isolated area. Moreover, even though climate variability accounts the greatest proportion of agricultural loss in the country as a whole and in Robe in particular, the coping mechanisms are still traditional. Hence, the main objective of the study is to assess major climatic variability and its implications on Wheat production and productivity in Robe town and surrounding area, Oromia Regional State.

II. METHODOLOGY

The proposed study was carried out in Robe town and its' surrounding Sinana district.Robe city is the capital city of Bale administrative zone of Oromia regional state, capital city for Sinana district and Robe city administration. The city is found to the South-eastern part of Addis Ababa at 430kms along the highway through Shashemene or 460kms through Asella. In absolute terms the city is found between the latitude of $7^0$3’30’’N to $7^0$10’45’’N and longitude 39^0 57’38’’E to 40^0 2’38’’E. The total proposed area of the city is 8024 hectares according to area measured from the base map of the city surveyed by surveyors of Oromia urban planning institute (Robe Municipality, 2015).

Table.1.1: Description of study sites

District	Latitude & longitude	Elevation (meters above sea level) (m)	Average temperature (^{0}C)	Average rainfall (mm)	Years of observation	No. of years with no data
Robe	7°7’N 40°0’E	2,492	15	1100	1986-2016	-

Source: Robe Municipality, (2015)

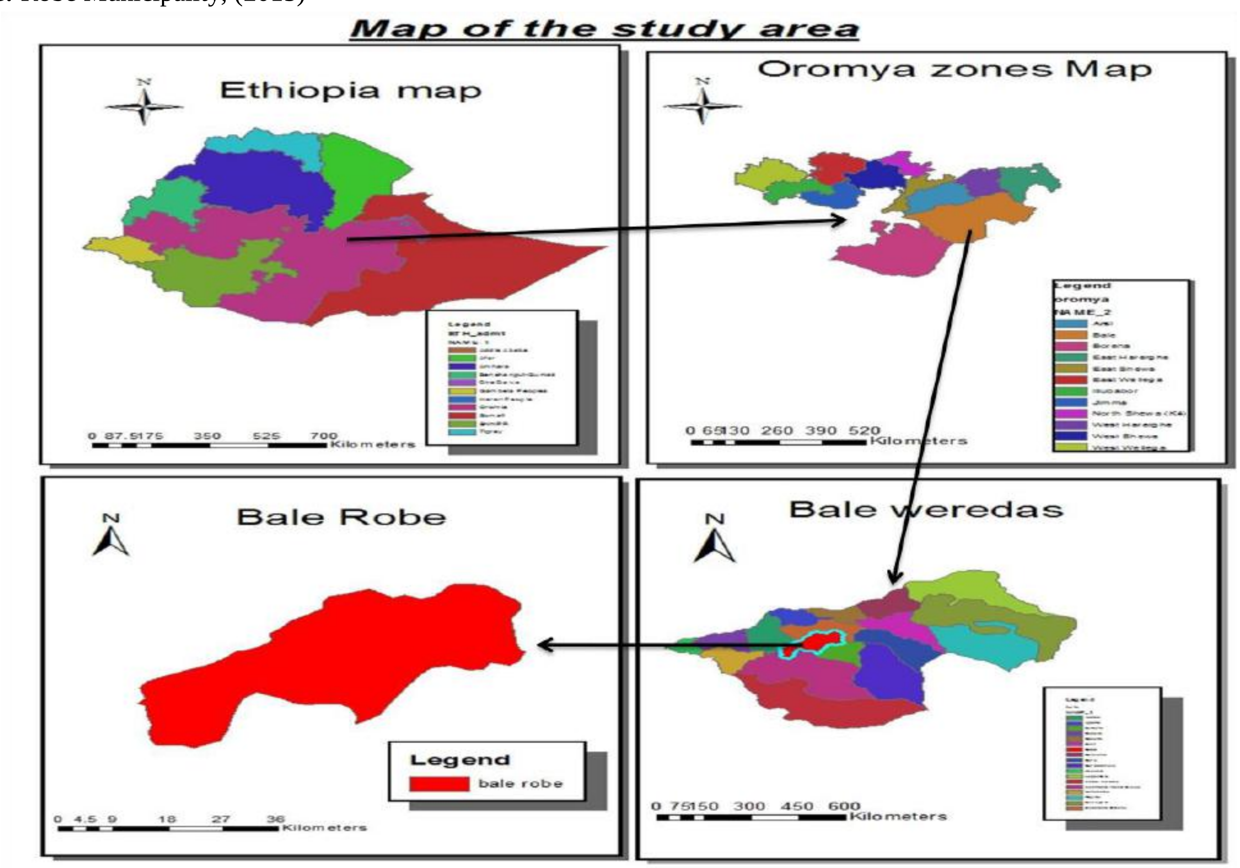

Fig.1.1: Indicator Map of the Study Area

Source: GIS, 2016

2.2. Research Design

A longitudinal research design was used in this study due to its advantage of allowing data to be collected showed long time trends. The design is suitable for descriptive experimental and survey research strategy. The rationale behind employing descriptive type was that it is concerned with describing the characteristics of an event and specific predictions with narration of facts and characteristics about a situation; in this case, the study was analyzed climate variability and its impact on the wheat production and productivity. Moreover, the current study has employed quantitative research approach more dominantly to analyze climate variability and its implications on wheat production and qualitative approach was also employed only to analyze impacts of climate variability on wheat production and farmers' coping measures in the study area using tools like structured questionnaire and key informant Interviews.

To collect secondary data thirty years of climatic data were collected based on IPCC scenario which recommends the thirty years of data for time series analysis of climatic variability and change. Coming to primary data, the two stage sampling design was used to select the sample households. In the first stage, three kebeles(namely Hora Boka, Nano Robe and Kabira Shaya Temo), which were recently expected to be mixed with Robe town and where the large number of farm households are prevalent were purposively selected by the help of land use and administration office workers. In the second stage, according to the number of total Households in each kebele, probabilistic proportionate to size technique was applied to determine the total sample household size from each kebele. Ultimately, a total of 160 sample household heads were selected by using simple random sampling technique.

To analyze the data, both descriptive and inferential statistics were used. The data was edited, coded, and tabulated based on the nature and type of the obtained data on the assessment of climate variability trends, its implications on wheat production and productivity and its coping mechanisms.Hence, descriptive and inferential data analyses were conducted using excel, Origin software-and Statistical Package for Social Sciences (SPSS) version 20.

One of the objectives of this research was to determine the medium range forecast of rainfall and temperature from the past observation in the study area. Modern time series forecasting methods was essentially rooted in the idea that the past tells us something about the future. For this purpose, linear time series ARIMA model was used to forecast from 10 to 20 years of time series. ARIMA model and its variations were based on famous Box-Jenkins principles. The ARIMA (p, d, q) forecasting equation was used where: p, d and q are integers greater than or equal to zero & refers to the order of the autoregressive integrated and moving average (ARIMA) parts of the model respectively.

2.3. Model selection and Approach

The current research was employed quantitative research techniques to analyze the data. Quantitative data analysis was carried out using both ARIMA and inferential statistical tools such as multiple regressions and time series trend analysis as necessary. In the multiple regression dependent variable (wheat yield) and independent variables (annual mean temperature, mean spring temperature, total annual rainfall and total spring rainfall) were calculated and entered in the software. Hence, the functional relationship between wheat productions and some climatic variables namely annual rainfall and number of rain days in a given years were analyzed by using Auto Regressive Integrated Moving Average (ARIMA) approach which is commonly used in time series data for prediction and determining the relationship between variables [Bosello, F. and Zhang, J. 2005]. The ARIMA models work under the basic assumption that some aspects of the past pattern will continue to remain in the future; that is current data have some effect from the previous data which leads to autocorrelation. Main advantages of ARIMA model is its ability to account for autocorrelation problem which OLS linear regression model does not, ARIMA models discover the patterns in the variation not explained by a regression model and incorporate those patterns into its model, according to, Hanke and Wichern [2009]. ARIMA model is suitable for both short term and long term forecast, besides the said advantages the ARIMA model has some weaknesses; ARIMA model needs large amount of historical data and it is not easy to update the parameters of ARIMA model as new data becomes available. In addition to these model summary was considered to check what percent the predictors explain the dependent variable. Moreover, first moments of variation (minimum, maximum, mean, and standard deviation) was obtained using descriptive analysis. Besides, inter annual fluctuation of rainfall, standardized rainfall anomalies, was also calculated. Thus, R square and adjusted R square was interpreted.

The information gathered through interviews was reported through narrative descriptions to complement those that were generalized through software. Finally, conclusions and recommendations were based on research findings and

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preceding facts. The regression equations that were used for trend analysis is:

$Y = \beta o + \beta_1 Xi_1 + \beta_2 Xi_2 + \varepsilon$ ………..............Equation-1

Where Y=Wheat yields in Quintals' per hectare of i[th] year

Xi_1 = Average annual millimeters of rainfall of the i[th] year

Xi_2=*Average* annual degree Celsius of temperature of the i[th] year

βo=Regression constant.

$\beta 1$ = Regression slope

ε = random disturbance term/error term in the observed value for the i[th] year

The magnitudes of the trend was calculated and estimated by global model ordinary least squares (OLS) linear regression method. That is;

$$\hat{Y} = a + bX \text{ ……………………………………………Equation-2}$$

Where a is a constant which gives the value of Y when X=0. It is called the Y-intercept. b is a constant indicating the slope of the regression line, and it gives a measure of the change in Y for a unit change in X. It is also regression coefficient of Y on X.

$\boldsymbol{a}$ and $\boldsymbol{b}$ are found by minimizing

$$SSE = \sum \varepsilon^2 = \sum\left(Y_i - \hat{Y}_i\right)^2 \text{ ……..Equation-3}$$

Where: $Y_i = observed\ value$, $\boldsymbol{SSE}$- Sum Square of Error

$$\hat{Y}_i = estimated\ value = a + bX_i \text{ ……………………………………...….Equation-4}$$

Minimizing $SSE = \sum \varepsilon^2$ gives

$$b = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sum(X_i - \bar{X})^2} = \frac{\sum XY - n\bar{X}\bar{Y}}{\sum X^2 - n\bar{X}^2} \text{ ……...Equation-5}$$

$$a = \bar{Y} - b\bar{X} \text{ ………………………….....................Equation-6}$$

In this case $\beta_o = a$ and $\beta_1 = b$

It was hypothesized that there is no trend in the amount of rainfall or temperature over time. Thus the null hypothesis was stated as; $H0: \beta 1 = 0$. Variability of annual and seasonal rainfall was assessed using Coefficient of Variation (CV), techniques. It was calculated as the ratio of standard deviation to the mean. In addition, first moments of variation (minimum, maximum, mean, and standard deviation) were obtained using descriptive analysis. Besides, the Inter annual fluctuation of rainfall, standardized rainfall anomalies, was calculated as follows:

SRA = (P t - Pm)/σ

where:……………………………….….Equation-7

SRA: is standardized rainfall anomaly,

P t: is annual rainfall in year t,

Pm: is long-term mean annual rainfall over a period of observation and σ: is standard deviation of annual rainfall over the period of observation. Standard rainfall anomalies and mean annual temperature were plotted against time (in years) to visualize the time series variation of annual and seasonal rainfall as well as temperature about the mean. The t-test was used to evaluate statistical significance of the trend at 95% confidence level [Time Series Research Staff, 2016].

2.4. Calibration of prediction model

Real-time seasonal forecasts need to be complemented by an extensive set of retrospective forecasts. Calibration depends on the comparison of past observations against the corresponding retrospective forecasts, so that, long-year data can be arranged accordingly in the format of seasonal climate prediction model. Half of the total year, available rainfall data was used for model construction and the rest data have been used for verification.

Therefore, more years were available for producing retroactive forecasts. Model calibration perform as follows; first, check seasonal forecasts required an estimate of skill and reliability of the forecast system or model is necessary to provide such skill assessments. Secondly, values generated from the model were then calibrated against the observations and remove biases that are often part of the dynamical prediction systems. Hence, the observed data in the past years was taken by assuming that it is going to be predicted then after interring the data in to the model some of the techniques were used in order to compare pairs of predicted and the observed data to which they pertain to proportional correction was also checked. when the difference between the actual and the predicted one is -0.5 to 0.5 then it is the most direct measure of the accuracy of categorical forecasts but when it is beyond this value it was rejected [David, 2002].

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III. RESULTS AND DISCUSSION

3.1. Trends of Climate

3.1.1. Total annual rainfall Trend of the Robe town from 1986-2016

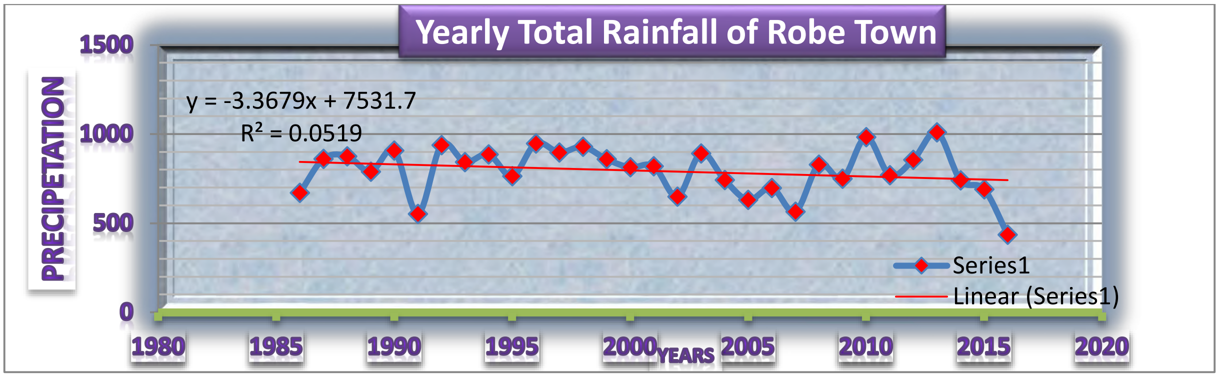

Fig.3.1: Total Annual rainfalls of Robe Town from 1986 to 2016

Source: computed from NMA, 1986-2016

As clearly drawn in Figure 3.1, the total annual rainfall pattern over 30 years for Robe station has been decreased by 3.37mm per year. The average annual rainfall for 30 years (1986 to 2016) was 792.65 mm. The variability is very high that the annual rainfall for these years ranged from 434.7mm (2016) to 1009.5mm (2013), with high variation over the year 1986 to 2016. In general, the total annual rainfall of Robe station has decreasing by 3.37mm per year.

Table.3.1: Total mean, maximum and minimum rainfalls of Robe Town from 1986 to 2016.

District	Variable	Minimum	Max	Mean	CV%	Std. Deviation
Robe	Precipitation	434.70 in 2016	1009.50 in 2013	792.65	20.7	134.43743

Source: Computed from NMA, 1986-2016

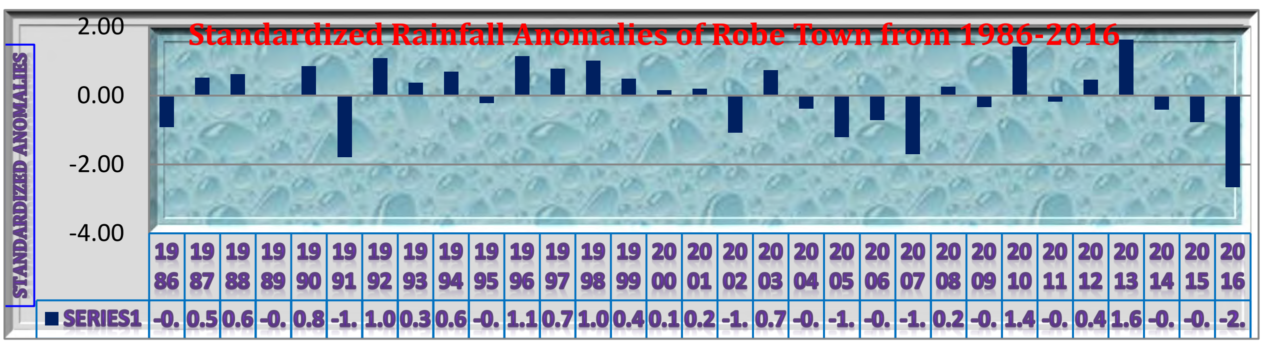

Fig.3.2: Standardized anomalies of annual rainfall in Robe town from 1986-2016.

Source: Computed from NMA, 1986-2016

As clearly evident from Figure 3.2, the standardized anomalies of annual rainfall was calculated for the station, during the periods between 1986 and 2016 noticed the proportion of negative anomalies ranged from 41.9% to 61.3% in Robe from the total observation. In all the years annual rainfall has shown negative anomalies for much of the years.

Based on the result of Coefficient of Variation in Robe over the last three decades it is considered as drought area and that is why currently it is affected by climate variability impact. Because, area with Coefficient of Variation >30, are classified as drought [Australian, 2010]. The year 2016 was come up with the lowest rainfall record from all the years and showed the worst drought year (SRA <-2.66). The other drought year include 1991, 2002, 2005 and 2007. According to the research reported by Dereje et al, [2004], the drought severity classes are extreme drought (SRA < -1.65), severe drought (-1.28 > SRA > -1.65), moderate drought (-0.84 > SRA > -1.28), and no drought (SRA > -0.84). The best cause of variability of rain fall is the El Ni˜no–southern Oscillation (ENSO). The warm phases of ENSO (El Ni˜no) have been associated to reduced rainfall in the main rainy season in north, central, and southern Ethiopia causing severe drought and famine [Woldeamlak et al, 2007;

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Australian, 2010]. Besides, the result of the current study stated that some of the period mentioned was concide with previous research in Ethiopia. According to different literatures 1994, 1995 and 2002 years were drought years in many part of Ethiopia [Woldeamlak et al., 2007; Getenet, 2013].

This means that the decline in precipitation in this period indicates the finding of the study support previously investigated research reports. Therefore from the result, the distribution of the current research rainfall is not the same in Robe town from time to time. Hence, even though positive anomalies were observed in some of the years under the study period, Robe station noted proportion of negative anomalies ranged from 41.9% to 61.3% from the total observation (Table 3.1). All in all Rainfall is the major climate parameter with the highest degree of temporal variability in the station shows year to year variability or fluctuation within the year. Such variation of rainfall between the years is due to changes in space-time patterns of one or more of the climate-controlling systems movement of the ITCZ.

3.1.2. Seasonal precipitation Trend of Robe Town from 1986 to 2016

Periodic linear trend models were fitted on mean precipitation of seasons of different months to determine if there is significant trend in mean precipitation of the past consecutive 30 years of winter, spring, summer and autumn.

Table.3.3: Seasonal mean rainfall and coefficient of variation over 30 years in Robe town.

Stations	Winter		Spring		Summer		Autumn	
	mean (mm)	CV%	mean (mm)	CV%	mean (mm)	CV%	mean (mm)	CV%
Robe	56.1	69	244.8	36	277.7	35	220.8	26

Source: Computed from NMA, 1986-2016

Hence, the seasonal precipitation in Robe in the study period maches with the previous finding which means rainfall is the major climate parameter with the highest degree of temporal variability in all the time scale in months, years, and in seasonal scales shows variations in Robe town in general.

3.1.3. Mean Annual Temperature trends of Robe town from 1986-2016.

The results in Figure (3.3) show that there is statistical significant change (0.04^0c) per year. The yearly maximum temperature of the past 30 years of Robe town was 22.22^0c with the average minimum value of 8.5^0c.

According to Getenet [2013] the coldest temperatures generally occur in December or January and the hottest in February, March, April, or May. However, in many localities July has the coldest temperatures because of the moderating influence of rainfall. May is a hot and dry month, preceding the long rainy season in June, July, and August [NMA, 2007]. Hence, over the past three decades in Robe town the result of temperature indicates that its pattern of is not uniform from month to month. Such temperature variation is due to the climate-controlling systems, movement of the ITCZ. The minimum temperature is more variable since its moving average is (0.0430c) than the maximum temperature (0.0380c). The trend shows that both the maximum and minimum temperature of the Robe town will continue to raise in the future. Trends in mean annual temperature variations in the Robe town, from 1986-2016, shows an appreciably rising trend of 0.40c per decades. This result is greater as other scientific literature conducted at national and international on assessing temperature variability indicated.

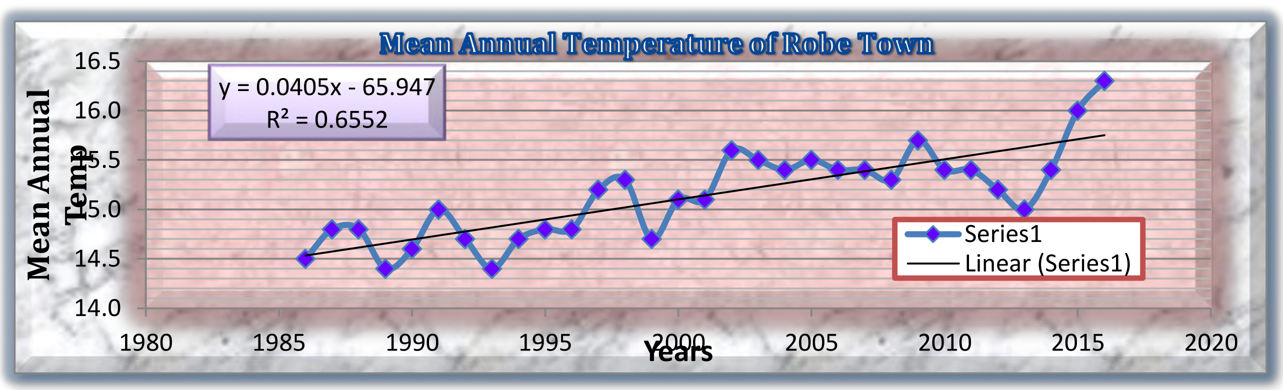

Fig.4.5: Trends in mean annual temperature variations in Robe town from 1986-2016.

Source: Computed from NMA, 1986-2016

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3.1.4. Analysis of seasonal mean temperature from 1986-2016

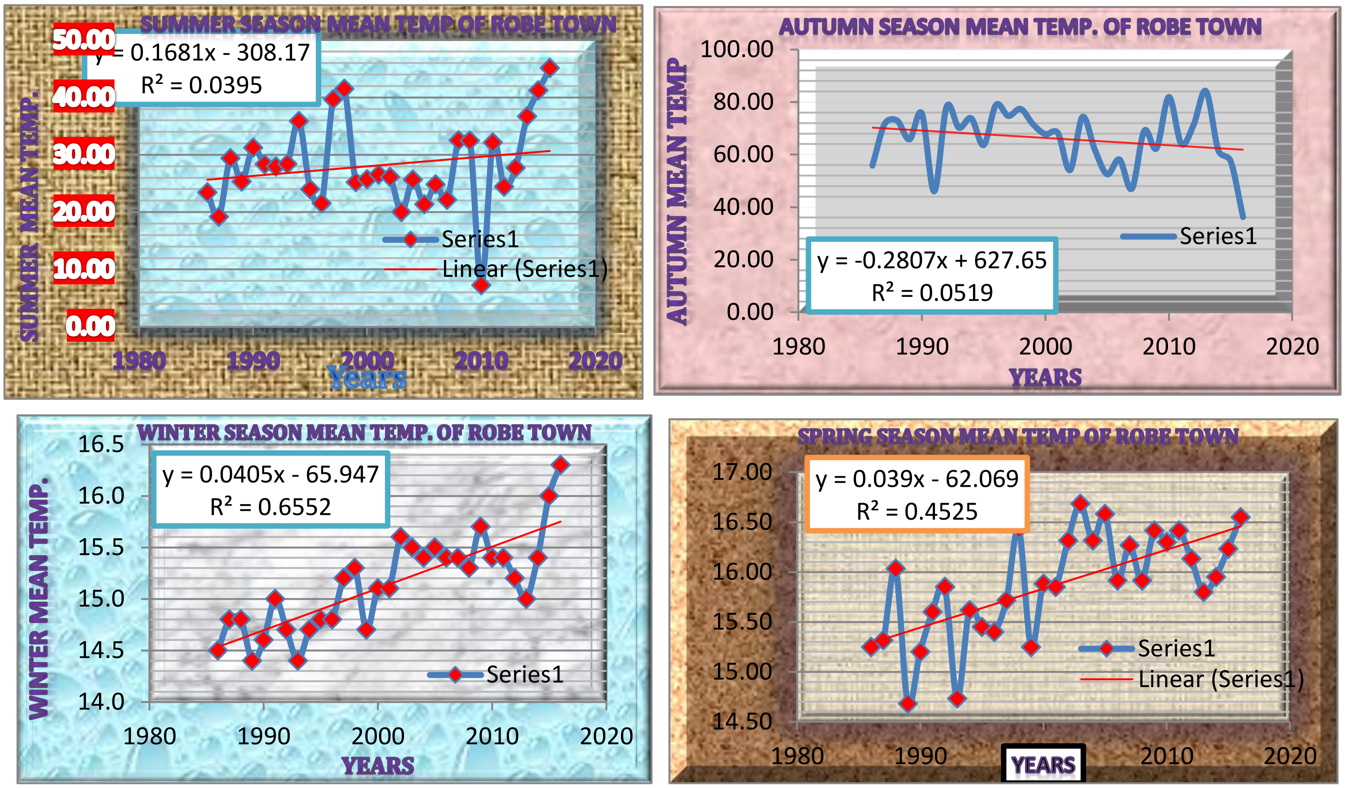

Fig.3.4: Analysis of seasonal mean temperature from 1986-2016

Source: Computed from NMA, 1986-2016

As presented in Figure (3.4), seasonal average temperature was increased over all seasons but the magnitude of the trend varies from season to season. The mean temperature of spring and summer had increased by 0.04ºc/year or 0.4ºc per decade in Robe. In the autumn season the maximum increase was (0.05ºc/year or 0.5ºc per decade) and that of the winter season had increased by 0.03ºc/year or 0.3ºc per decade in Robe.

3.2. Forecasting mean annual temperature and precipitation with the ARIMA Model

For climate variability trends and wheat production prediction purpose ARIMA modelis developed using Equation Y (t) =0.0372 + 0.9749ε(t-1) and $Y = \beta o + \beta_1 Xi_1 + \beta_2 Xi_2 + \varepsilon$. In Equation, Y (t) is the forecasted temperature or rainfall at time t. In the AR part, p is the order of the AR process (lingering effects of previous observations) and I is the AR coefficient (trends). In the MA part, q is the order of the MA or error term of the MA coefficient and ε (t) is the white noise that produces random uncorrelated variables with zero mean and constant variance. The second Equation is for wheat production prediction.

Hence, as the temperature predicted in the study area showed the town will see further warming in the next twenty years at different rates. Which means as the number of years increases the change in degree Celsius increases to the observed time (mean temperature of 1986-2016). For example the temperature will increase by 0.730c, 0.910c, 1.10c and 1.270c by 2020, 2025, 2030 and 2036 respectively in Robe which is consistent with the result of Getenet, [2013] who implied that the mean annual temperature will increase in the range of 0.9 -1.1 °c by 2030; in the range of 1.7 - 2.1 °c by 2050 and in the range of 2.7-3.4 °c by 2080 over Ethiopia compared to the 1961-1990 normal. In addition to this a small increase in annual precipitation is also expected over the study area. Unlike temperature in case of rainfall, Robe station shows different result. As observed from the (Table 3.4) the precipitations will decrease at different millimeter from the observed amount of rainfall (mean of 1986-2016). However, the output of the model also shows neither increasing nor decreasing for in the next few years in Robe town. This shows variations of rain fall will also continue not only in the past but also in the future between years. Regarding wheat yield per hector per year of the study period in Robe town and surrounding area it is forecasted that as it will be sharply decreased per hector per year from 2025 onward

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even though for the next 10 years there will be an increment. This is due to the fact that currently existing temperature in Robe town is at the lowest boundary of temperature requirement for wheat production which in turn gives some guarantee for wheat production.

Table.3.4: Data summary for mean temperature, precipitation & Wheat yield forecast for 20 years computed by ARIMA model and data for hypothesis tested. Source: Computed from NMA, 1986-2016.

Station	Mean annual temperature (℃) From 1986-2016	projected change by 2020 (change in℃)	projected change by 2025 (change in℃)	projected change by 2030 (change in ℃)	projected change by 2036 (change in℃)
Robe	15.09	+0.71	+0.9	+1.1	+1.27
	Mean annual precipitation (mm) From 1986-2016	projected change by 2020 (change in mm)	projected change by 2025 (change in mm)	projected change by 2030 (change in mm)	projected change by 2036 (change in mm)
	865	0	-32	-15	-12.1
	Annual Wheat yield in quintals per hector From 1995-2016	projected change by 2020 (change in mm)	projected change by 2025 (change in mm)	projected change by 2030 (change in mm)	projected change by 203 6 (change in mm)
	26	+4.43	+13.34	+8.6	+7.8

Hypothesis Tested

	t	df	Mean	Std.	Sig. (2 tailed)	Std. Error Mean	95% Confidence Interval	
							Lower	Upper
Mean monthly rainfall	.000	30	68.36	38.79	1.00	11.19890	-24.6503	24.6470
Mean seasonal rainfall	-.020	30	199.9	37.35	1.00	6.70741	-13.8306	13.5661
Mean Annual Rainfall	-47.84	30	233.5	65.074	0.986	11.688	-583.04	-535.30
Medium term future pattern of rainfall	-.003	20	826.7	44.6	.998	9.97	-20.90	20.84
Mean Annual Temperature	.036	30	15.36	.74078	.971	.13305	-.2669	.2766
Medium term future pattern of temperature	12.999	20	16.45	.377	1.00	.08422	.9185	1.2711

3.3. Impacts of climate variability on wheat productivity

There have been changes due to climate variability over the last three decades. Hence, the impacts of this climate variability on wheat productivity in the study area are presented in detail as follows:

3.3.1 Impacts of climate variability on wheat productivity by multiple regressions

Under this subsection the actual impacts of climate parameters (mean annual temperature, mean spring temperature, total annual rainfall and total spring rainfall) on wheat were analyzed by using multiple regression models. The model also revealed to what extent the independent variables explains productivity. So the following table indicates the impacts of climate variability on wheat productivity in the study area.

Table.3.5: Regression analysis

Model Summary								
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Mean Square	F	Sig.	df
1	.537[a]	.288	.169	4.40056	46.962	2.425	.099[b]	3
Dependent Variable: Yearly Wheat product per Hector								
Predictors: (Constant), Total spring season rainfall, Total Annual Rainfall, Average Temperature								

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Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	36.998	32.945		1.123	.276
	Mean Annual Temperature	-1.409	1.770	-.205	-.796	.437
	Total Annual Rainfall	.010	.009	.281	1.124	.004
	Total spring season rainfall	.014	.015	.201	.949	.355
a. Dependent Variable: Yearly Wheat product per Hector						

Source: Computed from SARD and NMA

As presented in Table 3.5, wheat productivity is significantly associated with spring rainfall and mean annual temperature. This means an increment of 1 mm of spring rainfall is likely to result in an increment of 0.014 quintal of wheat yields per hectare per year and 1^0c increment of temperature is likely to result in a decrease of 1.41 quintal of wheat yields per hectare per year (see Table 3.5).

As indicated by Walther, et.al, [2000] indicated, the effects of rainfall and temperature on wheat yield depend on certain threshold. If a variability beyond or below the threshold happened, wheat yields will be negatively affected. On the other hand, as FAO, (2015), indicated wheat yield shows some correlation (R= 0.47) with El Niño sea surface temperature anomalies which is highly predictable factors of cereal and crop production and productivity. In agreement to this but far from it, the problems in Robe town for 2015 and 2016 might agreed with this conclusion for wheat production and productivity. In fact, 2015 and 2016 was characterized by rather unfavorable weather over the whole of the country except for some parts, which experienced an exceptional drought (lasting until the winter 2016). As a matter of fact, the impact is delicated due to the complex Ethiopian topography and climate patterns are contrasted between the influence of the Alps in the north and the hot and dry Indian Ocean in the south. Hence, the outcome of this study states that through regression analysis of climatic parameters in Robe town; 1mm decrement of spring rainfall would result to 0.014 quintal decrement of wheat yields per hectare per year whereas 1mm increment of annual temperature would result to 1.41 quintal decrement of productivity in the study period in Robe town.

So the researcher observed that temperature and spring rainfall are responsible for the decline and fluctuation of wheat over the years because one can see two things in wheat productivity trends. That means there is decreasing trends and within decreasing again there is fluctuation. On the other hand the impacts of total annual rainfall and spring temperature are also observed in the regression result. Even though, no significant impact of total annual rainfall are observed in Table 3.4, both spring rainfall and mean annual temperature are the most key factors for the fluctuation and decline of wheat productivity in the study area. Because both spring rainfall and mean annual temperatures are significantly influence the yields of wheat per year since p value is <0.05 at 5 % level of confidence. Furthermore, the independent variables (predictors) can explained about only 28.8 % by R square or 16.9 % by adjusted R of the dependent variable (productivity). Hence for total annual rainfall, the p value is <0.05 that indicates as there is significant impact for the fluctuation or wheat productivity decline over the years considered. However, the p value of mean spring temperature and Mean annual temperature is > 0.05 which indicates that there is no significant impact for the fluctuation or wheat productivity decline over the years considered. Therefore, the finding of this research agreed with Curtis, [2009] that strengthen the climate variability can affect wheat production through the direct effects on yield via physiological processes, through changes in sowing dates or increased rainfall, and through changes in the areas under production and as regions become more or less unsuitable for wheat due to climate variability.

3.4. Farmers’ coping strategies

3.4.1 Farmers’ response on the methods to cope with the basic commodities and services in Robe town

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Table.3.6: Farmers' response on the Methods to cope with the Basic commodities and Services in Robe town

Variable	Frequency	Percent
eat less	6	3.8
selling/rent the wheat farming itself and others asset	5	3.1
Asking credit from relatives or rural financial institutions	13	8.1
Depend on relatives and NGOs Support	11	6.9
Exposed to Hunger, illness in home, withdrawal of children from school	2	1.3
Engaged in off farm activity	123	76.9

Source: field survey, 2016

Based on the sample survey results in (Table 3.6) 76.9 % of Farmers who were asked to mention how they are surviving since income did not enough all-round the year; reported that they engaged in off farm activity and 8.1% of them said that they request credit from relatives or rural financial institutions. Meanwhile the others 6.9%, 3.8%, 3.1 and 1.3% elaborated as they depend on relatives, NGOs support;eat less; selling/rent the farm itself and others asset and exposed to hunger, illness in home, withdrawal their children from school and etc.

3.4.1.1 Alternative options to reduce the problem used by local farmers

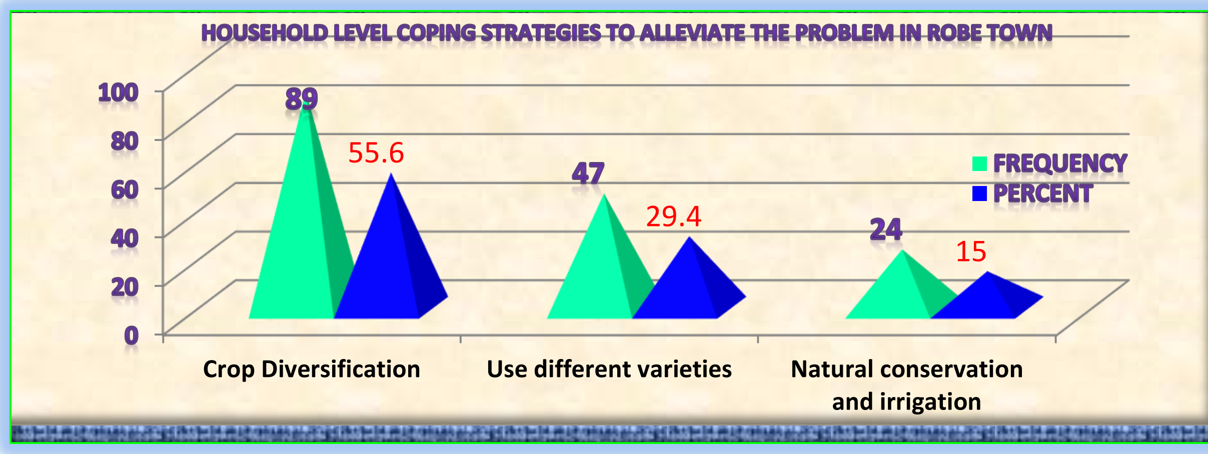

Fig.3.5: Farmers' response on what they do at the household level to alleviate the problem in Robe town

Source: field survey, 2016

As presented in the (Figure 3.5), 55.6 % of the respondents' do crop diversification at the household level to alleviate the problem in the area, 29.4% of them use different varieties and 15% are said they conserve nature, use irrigation at household level to alleviate the problem.

The result of this study revealed that, Effective coping initiative is a multistage process and a careful understanding on traditional and institutional coping strategies. Hence, regarding possible coping strategies to combat climatic variability in the study area, respondents suggest that coping mechanism to climate change are by crop diversification, use different varieties and natural conservation and irrigation, Households in these Kebeles tend to allocate their fixed land (by village and Households) from their customarily farming practice to new [Figure,3.5]. For instance, the midland wheat based area is shifting their land from growing maize and wheat to teff and barley. Similarly, some of the Households shift their time, labor and land resource from crop plantation to livestock production etc. Moreover, some of the respondents sustain all year round by using the previous saving in various forms. On the other hand, about quarter of them used diversification of their income and small scale irrigation systems like horticulture and near river banks during dry seasons [3.6]. Majority of them reported as they engaged in off farm activity and others suggest that "selling their Wheat farm and other assets, renting their land and selling labor. On the other hand, some of them used credit from rural financial institutions and private money lenders. However, the private rural money lenders system exacerbates their problem since rating system is illegal (locally areta system). Because "we pay at the rate of 50 % at the end of Wheat harvesting

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season" they said. So in the subsequent year "we also remain suffering due to the expense of previous year" they said. About few of them are coping by minimizing their daily consumption [Table 3.6].

IV. CONCLUSIONS

Contrary to the expected direction of trends and variability, this study found significant variation in the amount and distribution of monthly, annual and seasonal rainfall as well as temperature. The calculated standardized rainfall anomalies and coefficient of variation showed good agreement indicating there was high variation of rainfall in the area. As a result of rainfall variations the districts become vulnerable to recurrent drought. El-nino and topographical setting may be the main factor for its variation. Concurrently, at 5% level of significance, by the coefficient of regression line the mean monthly temperature, annual mean temperature and seasonal average temperature has increased for Robe town from time to time.

Statistical models, based on indicators of climate have been developed to anticipate shifts in Rainfall, temperature and crop yield in Robe town. Thus, a medium term future pattern of mean annual temperature isfound significantly greater in the amount for future than the previous monthly, annual and seasonal temperature. Hence, prediction by ARIMA model showed in the next twenty years; Robe station will see more warming at different rates as the time increases (0.71 to 1.270c). But, from other years 2036 will see more warming. On the Other side, rainfall and wheat yield showed mixed result in the next 20 years for the district. For instance, 2025 will see more decline of rainfall than any other years.

Regarding the implications of climate variability on wheat yields in the study area there is significant linear relationship between Wheat yields and climate variability. Hence, Wheat yields are significantly declined and fluctuation of productivity is associated with mean annual temperature, spring rainfall and mean annual temperature. Therefore, increasing climatic trends and seasonal variations led to a conclusion that the productivity of Wheat in the study area has been negatively affected by rising mean temperatures and seasonal precipitation variation rather than annual rainfall. The observed climate change patterns and impacts which were diverse temporally and impose their impacts on crop development and production have become significant in Robe town. The most important conclusions to be drawn from the study are that most of the farmers have been using traditional coping strategies such as selling their Wheat farms and other assets, credit from rural money lenders; even though some of them suggested that crop diversification, use different varieties and natural conservation and irrigation are some of their coping strategies. In addition to this, they have been coping by, engaging in off-farm activities such as charcoal selling and temporal and permanent migration and minimizing of their daily consumptions. Thus, most of the coping strategies farmers have been using are destructive rather than constructive and depletive ones.

Therefore, it is recommended that,The office of agriculture in collaboration with Oromia agricultural enterprise Robe branch should encourage farmers to better adapt to future climate condition, by providing new breeds that can stand with climatic change, genetic improvements to identify more drought resistant wheat varieties in addition to link farmers to relevant research institutions to promote access to certified seeds of these varieties. Again government institutional coping strategies should be incorporated for the sustainability of farmers coping strategies; in addition to integration and effective collaboration of all sectors of stakeholders for conservation of water and natural resources. Last but not list, for more confidence further studies by including additional climate models, farmers" perception and additional stations is recommended.

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