Effect of climate change on agricultural output in Ethiopia

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Abstract
Currently change in climate is known as the main environmental difficult that the world face. Its effect is openly reduces agricultural output in particular and economic growth in general. The main objective of the study was to examine the long run and short run effect of climate change on agricultural output in Ethiopia over a period of 1980-2016. The Auto Regresive Distributive Lag approach to co integration was applied to examine the long run and short run effect of climate change on agricultural output. ADF test was used for Unit root test. Result of bound test reveals that there is stable long run relationship between RAGDP, labour force, Mean annual rainfall, Average temperature, agriculture land, and fertilizer input import. The estimated long run model reveals that climate changes have an important effect on agricultural output which is the main contributor of overall GDP of the country. The coefficient of error correction term is -0.738 suggesting about 73.8% annual adjustment towards long run equilibrium. The estimate coefficients of short run show that mean annual rainfall have significant effect whereas average temperature has insignificant effect on output. In the long run both main variable of interest have significant effect on agricultural output with a positive effect from mean annual rainfall and negative effect from average temperature. In order to lessen the effects the study recommends concerned body needs to create a specific policies especially focus on technological adoption that avert effect of increase in temperature and that would result increase on the output by adopting technology at macro and micro level, additionally information regarding climate should be available for producers and consumer.

Keywords*:* *Agricultural output, ARDL, Climate, Ethiopia*

JEL Classification: Q1, Q10, R15

INTRODUCTION

Currently change in climate of the world is widely agreed by the scientific community. The Intergovernmental Panel on Climate Change (IPCC) has reached that activities human are changing the climate system and will remain to do so (IPCC, 2014). In the previous century, surface temperatures, associated impacts on physical and biological systems are progressively being observed. These findings tells us that change in climate will result in environmental changes, such as sea level rise, and alterations of climatic zones due to increased temperatures and altering rainfall patterns.

Globally Changes in the concentrations greenhouse gases (GHGs) and aerosols, land cover and solar radiation in atmospheric would alter the system of climate energy balance. GHGs emissions are increased over time due to human activities. Economic and population growth are most drivers of increase in Carbon dioxide (IPCC, 2014). More than 75% of all Co2 emission comes from developed country. Recently there is accelerating emission GHGs in emerging economies like Brazil, China, and India had a serious concern. More over the effect is not equally shared. Least developing countries and people receive the effect of climate change first and will suffer the most as these nations are more susceptible to the negative effects of change in climate which would affect productivity and human health (Akram & Abdul, 2015).

Ethiopia is the least developing country in the world, but recently Ethiopia had an remarkable track of record growth and reduction in poverty in recent years, with GDP growth averaging 10.1 over two decades, about 8 percent GDP per capital growth. Poverty has dropped prominently and inequality, 30 percent Gini index which is low by international and Sub Saharan Africa (SSA) standards (International Monetary Fund, 2016). However, Ethiopia is heavily dependent on rain fed agriculture. The physical location and landscape coupled with little adaptive capacity necessitate a high vulnerability to adverse impacts of change in climate, due to these the country face drought in different periods due to climate changes that directly affecting agricultural output (International Monetary Fund, 2016). This makes the country to face different drought cause problems in different periods that leads chronic food shortage and food insecurity for long periods (Gebreegziabher et al, 2011). For instance in 2015/16 El Nino driven climate change caused one of the worst drought in many region of Ethiopia. This directly affect agricultural sector's performance which would affect other sector in the economy (World Bank, 2010).

The vulnerability of agriculture production to climate change in Ethiopia have a direct effect on rural population whose activity is producing agricultural products for their livelihoods and to generate income and it has indirect effect on other sector like industry sector those who use raw material from agriculture sector and urban population through increasing price of agricultural product. This would affect the economic growth through food security, water and energy supply, poverty reduction and development (National Meteorology Agency, 2007). Climate changes in Ethiopia are occurring that affect directly agricultural output of the country which depends on climate input.

Change in the pattern of rainfall and temperature would affects the economy. Ethiopia recorded the lowest annual rainfall in 30 years in 2015 due to El Niño this would affect the economy where half of GDP comes from agriculture and 99% of electrical energy in a country on which different sector is dependent is generated by hydroelectric power which in turn depends on rainfall capacity (Ali, 2012). A change in climate in Ethiopia may reduce 10% by 2045 country GDP, mostly through influences on agricultural output, these changes also affect economic activity and intensify the prevailing socio-economic problems (United State Agency International Development, 2013).

Besides the importance of agriculture sector, any shock related to agriculture would has wider economic impact on agriculture and other sectors. Previously research is conducted in this area for instance, Tadele et al (2010), Yalew (2016), Deressa (2007) the first two studies analyzed the impact of climate change on agriculture by using computable general equilibrium analysis, whereas Deressa studies effects by using Ricardian approach, Ali (2012) analyzed impact of climate change on economic growth.

Most of those researches are used computable general equilibrium analysis which face a limitation in that it doesn't consider temporal effect of climate change on agriculture, Ricardaian approach is grounded on survey data on climate change so it may face valuation problem by respondents and require awareness and the other examined impact of climate change on economic growth, but climate change directly affect agriculture sector. The aim of the study is to relate climate change to single aggregate agricultural output that time series analysis, to fill the gap, supplement on the prevailing literature, and researching in this area is useful for national policies. So the study focuses on effect of climate change on agricultural output in Ethiopia by using time series data that span from 1980-2016.

LITERATURE REVIEW

Climate change and agriculture

Agriculture can be affected by Climate in a variety of ways. Temperature, radiation, rainfall, soil moisture changes in average temperatures; rainfall and climate extremes with an important impact on soil erosion, changes in pests and diseases, changes in atmospheric carbon dioxide, changes in the nutritional quality of some foods, changes in growing season, and changes in sea level and carbon dioxide (CO2) concentration are all important variables to determine agricultural productivity, and their relationships are not simply linear (Zhai & Zhuang, 2009). Existing studies shows that there are starting point for these climate variables above which crop doesn't grow. For instance, the modeling studies discoursed in recent IPCC reports indicate that an increase in temperature from moderate to medium by 1–3ºC, along with associated CO2 increases and rainfall changes, are likely to benefit crop yields in temperate regions. Whereas, in low-latitude regions, an increase in temperature in moderate temperature by 1–2ºC are expected to have negative yield impacts for major cereals. Warming of over 3ºC would result reduction in crop in all regions (IPCC, 2007).

Contribution of agriculture to the economy of Ethiopia

Agriculture is known to supply the country with food grains, cash crops, and dairy and meat products among other things. Besides, the sector provides relatively abundant food and raw materials to the increasing industry-based urban population. Productivity in the agricultural improves the level of income received by the rural people. Increased income is believed to generate increased demand for the manufactured goods from the industrial sector, in addition to increase income improve the living standard and to take a part in international market. Outside of gold, Ethiopia's top five exports are all agricultural products: coffee, sesame, fruits and vegetables, and leather. Thus, both domestically and internationally, agriculture remains at the heart of Ethiopia's development (Agricultural Transformation Agency, 2016).

In reaching middle income country by 2025 agriculture sector plays a major contribution to the goal this through Shifting smallholder farmers from survival centered production to market oriented production by adopting modern tools and techniques is main agenda for the sector. For long-term success, this shift must be done while simultaneously bolstering resilience toward climate change and ensuring environmental sustainability (ATA, 2016).There is year to year fluctuation in agricultural GDP this variation is due to climate change. So ignoring this sector would have a huge impact on countries economy.

Empirical literature on impact of climate change

Barrios et al. (2007) studies effect of climatic change on the total agricultural output of Sub- developing countries by dividing into sub Saharan and non-sub Saharan

Africa. The study used cross-country panel dataset within the framework of agricultural production. The findings of the study revealed that change in climate, agricultural production in SSA is affected by climate change whereas, agricultural production in Non-Sub Saharan Africa not affected by climate change.

Ogbuabor & Egwuchukwu (2017) conducted on effect of climate change on the economy of Nigeria, by employing OLS method and error correction model. Time series data variable like annual rainfall, carbon emission and forest depletion are used to capture climate change and government expenditure, domestic private investment, exchange rate was used as control variable. They founds that carbon emission affect growth adversely in long run and short run, forest depletion affects negatively in the short run.

Akram (2016) study investigated effects of climate change on the economic growth of Pakistan.by disaggregating the study result show that temperature has a negative and significant relationship with GDP, in addition there is also negative relationship with productivity in the agricultural sector, manufacturing and services sectors. As of compared to manufacturing and services, negative effects is higher for the Agriculture sector.

Alagided et al (2014) examines the effect of change in climate on economic growth for 27 Sub Saharan Africa countries including Ethiopia. They used panel co integration method. Temperature and precipitation are variables to capture climate change. There result show that a increase in temperature diminishes economic performance in SSA and they concluded that given sub-Saharan Africa relies on agriculture sector for the majority of economic output, a higher temperature could actually reduce agricultural output.

Ali (2012), studies on the impact of climate change on rain fed economy. He used annual rainfall, labor force and land under major crops and co-integration method for analysis. He finds rainfalls variation have a negative effect on growth.

As several empirical and theoretical reviews shows climate variable like temperature, rainfall, soil moisture, deforestation and land degradation affect economic growth through effect on agricultural output as the empirical evidence shows, more over rather than affecting economic growth it directly affect agricultural output which in turn affect livelihoods for the majority of people.

MODEL SPECIFICATION AND METHODOLOGY

Data description and source

The Table 1 shows measurement of variable and source of data that was used in the study. Data included in this study based on availability of data and based its impact on dependent variables.

Table 1. Summary of the data source by variable

Type of variable	Unit of variable	Source
Agriculture output	Real Agricultural Gross Domestic Product	MOFeD
Labor force	Total labor force(15-64)ages	CSA
Agricultural land	Percentage of total land	WDI
Temperature	Degree Celsius	CCKP
Rainfall	Millimeter	CCKP
Fertilizer input import	Metric ton	NBE

*Source: **MOFeD** = Ministry of Finance and Economic Development; **CSA** = Central Statistical Agency; **WDI** = World Development Indicator; **CCKP** = Climate Change Knowledge Portal; **NBE**= National Bank of Ethiopia*

Method of data analysis and estimation techniques

The reason for conducting stationarity test is the use of non-stationary data can lead to spurious regressions. If the variables employed in a regression model are not stationary, then it can be proved that the standard assumptions for asymptotic analysis will not be valid. In other words, the usual t-ratios will not follow a t-distribution, and the F-statistic will not follow an F-distribution, and so on (Brooks, 2008).

To test unit root there are a number of varying approach have been developed. Among the methods of testing the presence of a unit root in a series the common ones include Dickey-Fuller (DF), and Augmented Dickey Fuller (ADF), Based on DF test, the series Y is stationary if the absolute value of 'δ' in the equation is less than unity. However, it is not stationary if the absolute value of 'δ' is greater than or equal to unity.

Yt = δYt-1 + Ut…………………..........…………………………………………… (1)

ΔYt = αY t-1 + Ut ……………………………………………………..…….......... (2)

Where, α = (1-δ)

Hence, the null that δ=1 is equivalent to H0: α=0. However, DF test assumes that the data generating process follows the Auto Regressive of order one which biases the test in the presence of serial correlation. In order to calculate the critical values of the τ (tau) statistic, Dicky-Fuller assumes that the error terms (ut) are not correlated (Enders, 1996). But the error term in the Dickey-Fuller test usually has autocorrelation, which needs to be removed if the result is to be valid. In addition, the critical values of τ (tau) statistics do not follow the normal distribution function and in general, the critical value is considerably larger than its counterpart of t- distribution. Therefore, using such critical values can lead to over-rejection of the null hypotheses when it is true. The ADF unit root test is used to overcome this limitation of DF test. ADF overcome these limitations by adding additional lag of first differenced of dependent variable. Therefore, this study used ADF test for stationary test.
Procedure for ADF test

$\Delta yt = a + \delta t + \gamma yt - 1 + \sum_{t=1}^{p} \mu \Delta yt - i + \ \epsilon t$……………………………..…....... (3)

Where δ is a time series variables under consideration in this model at time t,
t - time trend variable
Δ - denotes the first difference operator
ϵt - the error term; p is the optimal lag length of each variable chosen such that first- differenced terms make a white noise.
Thus, the ADF test is the null hypothesis of no unit root (stationary).

That is: H0: $\gamma = 0$ H1: $\gamma \neq 0$ If the t value or t-statistic is more negative than the critical values, the null hypothesis (I.e. H0) is rejected and the conclusion is that the series is stationary. Conversely, if the t-statistic is less negative than the critical values, the null hypothesis is accepted and the conclusion is that the series is non-stationary.

The term of co integration was first introduced by Engle & Granger (1987) after the work of Granger and New bold (1974) on spurious regression. In other words, there exists one or more linear combination of those I(1) time series (that is stationary (or I(0)). Those stationary combinations are called co integrating equations. There are three major methods of testing co integration: the Engel-Granger two-step procedure (EG), the Johansen Maximum Likelihood procedure and ARDL bound test approach to co integration. Engle granger have its short comings these shortcomings are it is difficult to determine the number of equilibrium relationship if the variable are more than two, since it allows for single co integration and Johansen co integration approach method needs a variable to be integrated order of same whether I(0) or I(1) but not mix of the two. But, ARDL overcome this problem.

A large number of past studies have used the Johansen co integration technique to determine the long-term relationships between variables of interest. In fact, this remains the technique of choice for many researchers who argue that this is the most accurate method to apply for I(1) variables. Recently, however, a series of studies by Pesaran et al (1996) have introduced an alternative co integration technique known as the Autoregressive Distributed Lag (ARDL) bound test. This technique has a number of advantages over Johansen co integration techniques. First, the ARDL model is the more statistically significant approach to determine the co integration relation in small samples. It can also leads us to know error correction model which can be derived from ARDL model through a simple linear transformation, which integrates short run adjustments with long run equilibrium without losing long run information and error correction term shows how much of the disequilibrium is being corrected, that is, the extent to which any disequilibrium in the previous period is being adjusted in year

The purpose of this study is to analyze the effect of climate change on agriculture output in Ethiopia. The study starts with the important work; neo-classical growth model developed by Solow (1956).The neo-classical production function is specified in terms of traditional inputs like labor and capital. The following neoclassical production function was used. The advantage of this approach is that it controls explicitly for other inputs as indicated by (Deschenes and Greenstone 2004), However, its disadvantage lies in the fact that it does not take in to account of the full range of compensatory responses to changes in climate made by farmers(Barrios et al 2007).

$$Yt = f(Lt\ Kt)\ldots\ldots(4)$$

Where Yt is aggregate real output, Lt is labor and kt is capital inputs
The model is specified as the following

$$Y(t) = f(L, AT, MAR, F, AL)\ldots\ldots(5)$$

Where Y(t)(RAGDP) is real agricultural domestic growth product, L labor force, AT Average temperature, MAR mean annual rainfall, F fertilizer input import and AL Agricultural land.
Then converting to natural logarithm the model is

$$\log(RAGDP) = \beta o + \beta 1 \log(LF) + \beta 2 \log(AT) + \beta 3 \log(MAR) + \beta 5 \log(AL) + \beta 6 \log(F) + \varepsilon t\ldots\ldots(6)$$

Where logRAGDP=natural logarithm of Real agricultural growth domestic product
Log LF=natural logarithm of labor force
LogAT= natural logarithm of Mean Annual temperature
LogAR= natural logarithm of Mean Annual rainfall
LogAL=natural logarithm of Agricultural land
Log F=natural logarithm of fertilizer input import
et=error term and $\beta 0$ are constant term while $\beta 1, \beta 2, \beta 3, \beta 4, \beta 5$, and $\beta 6$ are parameter of independent variable to be estimated.

Table 2. Definition of variable and expected sign

Variable	Description	Expected sign
Real Agricultural gross domestic product	total produce of the agricultural sector in the economy in a given year	
Labor force	Labor force (age from 15-64 years) a total number of labor force that are economically active.	positive
Average temperature	is annual temperature is averaged over 12 months of temperature that the country receive	Negative
Mean Annual rainfall	rainfall that the country receives in 12 months taken as an average over those months throughout the years	Positive
Agricultural land	The share of land area that is arable, under permanent crops, and under permanent pastures.	Positive
Fertilizer input import	Fertilizer is the ingredient which increases the productivity of agricultural products	positive

RESULT AND DISCUSSION

Unit root test result

Before measuring a model Time series data ought to be checked. Based on unit root test This study employed ADF unit root test to check stationarity of data. The stationarirty of the data shows that or order of integration is mixed I(0) and I(1) which leads us to use ARDL model.

Table 3. Result of unit root test based on Augmented Dickey Fuller at level and First difference

Variable	With intercept and no trend		With intercept and trend		Order of integration
	At levels	First difference	At levels	First difference	
Log(RAGDP)	0.22919	9.264041**	5.124627***	9.450906***	I(1)
Log(MAR)	4.993207**	7.939576***	5.866566***	7.957953**	I(0)
Log(LF)	0.751465	3.767619**	3.767619 **	7.715934***	I(1)
Log(FI)	0.246291	10.98597***	4.405396**	11.11200***	I(1)
Log(AL)	1.58964	5.488356***	0.952445	5.686601***	I(1)
Log(AT)	2.6790818*	5.953295**	3.32928*	5.877539**	I(0)

*Source: author calculation, 2018 Notes: The rejection of the null hypothesis is based on MacKinnon (1996) critical values Null hypothesis: series has unit root. *Rejection at 1% level. ** Rejection at 10% &5 % and *** Rejection at (1%, 5% & 10%) level.*

Selecting optimal lag length

Most important thing is selecting order of the model that result in a good model that gives a good result and good forecast. Optimum number of lag that would be included in the model is known as order of the VAR model. Different types of lag selection criteria are there for the selection of the lag order. Those are, which includes the sequential modified likelihood ratio (LR), Akaike information criteria (AIC),Final prediction error (FPE), Schwarz information criterion(SC) and Hannan-Quinn information criterion(HQIC). The following table shows the lag length chosen by different information criteria. The study used two lag length based on LR.

Table 4. Results of lag order selection criteria

Lag	logL	LR	FPE	AIC	SC	HQ
0	142.3707	NA	1.32e-11	-8.021806	-7.752445	-7.129947
1	270.639	201.7089	6.02e-14	-13.44893	-11.56343*	-12.80592
2	324.2405	66.2248*	2.64e-14	-14.48474	-10.98309	-13.29057
3	381.7345	50.72994	1.39e-14	15.74956	-10.63129	-14.00377

*Source: author calculation, 2016 *indicates the lag length selected by the criteria*

ARDL bound test to co integration result

Based on likelihood ratio (LR) lag length criteria for the model bound test is applied so as to find the presence of long run relationship among the variables included in the model and test is as displayed here.

Table 5. Bound test result

Variable	F-statistics	Co integration
F(RAGDP, LF, MAR, FI,AL,AT)	9.686542***	Co integration
Critical value	Lower bound	Upper bound
1%	3.41	4.68
5%	2.62	3.79
10%	2.26	3.35

*Source: author calculation, 2016 *** rejection of null hypothesis no co integration at 1%, 5%, and 10% significance level.*

The table reveals that F-statistics 9.686542 which exceed the upper bound at 1%, 5%, and 10% critical value and this implies there is a long run relationship among variables in the model.

Estimation of long run model result

Effect of mean annual rainfall on agricultural output; since the formulated econometric equation is in log-log form, the coefficients is interpreted as elasticity or responsiveness of change. The findings in table 5 Reveal that mean annual rainfall have a positive and significant effect on agricultural output measured by RAGDP. The result indicating that 1 percent increase in mean annual rainfall increases agricultural output by 0.56 percent or 1mm increase or change in rainfall leads to an increase of RAGDP by 0.56% in the long run. This result suggests that rainfall is the most important in determining agricultural output which is the major contributor to economic growth and it is consistent with result by Barrios, et al (2007) in Sub Saharan Africa they found that if rainfall is decline it would reduce agricultural output and if rainfall increase agricultural output would be increase in SSA. This shows rainfall is major factors that determine agricultural output in SSA. Rainfall in Ethiopia is a major input in determining output due to this the country is named as rain fed economy, where rainfall play an important role. In addition this result is go in line with Muraya & Ruigu (2017) where they found that rainfall affect positively and significant relationship with agricultural productivity in the long run.

Table 6. Estimation of long run model ARDL result Dependent variable is log(RAGDP)

Variable	Coefficient	Standard error	t-statistics	p-value
Log(MAR)	0.5675	0.159450	3.559667	0.0014**
Log(AT)	-2.56001	0.663537	-3.858147	0.0006**
Log(LF)	0.959257	0.125867	7.621193	0.0000***
Log(AL)	0.313009	0.091934	3.404700	0.0021***
Log(FI)	0.202502	0.043884	4.614436	0.0001***
Constant	9.215554	2.071634	4.4484470	0.0000***

*Source: Author calculation, 2016 ***, **, *significant at 5%, 10%, and 1%.*

R^2 =0.987 Adj R^2=0.983 DW=2.03609 F statistics=269.1345 Prob (F-statics)=0.0000

Effect of temperature on agricultural output; the results indicate that average temperature have a negative effect on agricultural output and significantly reduce agricultural output. A one percent increase in average temperature would reduce agricultural output by 2.5% in the long run. The long run elasticity of agricultural output with respect to average temperature is -2.5 indicating that agricultural output is most sensitive to an increase in average temperature in the long run, this due to an increase in temperature change will likely result in decreasing agricultural productivity. This may be that high temperature depletes soil nutrient making it hard on livestock and agricultural output generally. In the long run increase in temperature reduces soil moisture that negatively affects crop production which reduces agricultural output. in short term temperature increase may increase crop productivity and others output, but in long term result in heat stress, reduction of water, reduction of feed resources livestock, and agriculture production failure that leads to reduction of agricultural output which directly affect country economy generally and rural and urban population particularly through increasing price of agricultural output for urban population.

Effect of labor force on agricultural output; as agricultural sector absorb major part of labor force contributing around 72.7% of employment in the economy. In the long run the effect labor force on agricultural output is positive and significant at all levels. In the long run there would be change in occupation of labor from traditional to educated labor that produce more output in agriculture sector. This would cause agricultural output to be positively affected by labor force. And it goes the same direction with agricultural output. A 1percent increase in labor force would result in increase of agricultural output by 0.95% percent and its significant at all levels.

Effect of fertilizer input import on agricultural output; Fertilizer is the main input in agriculture sector especially for crop production that would increase agricultural output. As table shows it have positive effect on agricultural output as it increase agricultural output and it have significant effect on it. A 1 percent increase in fertilizer input import would lead to 0.20% increase in agricultural output. An increase in the fertilizer import over a period increases the output. An increase in the fertilizer input import which means an increase of in its consumption in other words increase output of crop production particularly and increase agricultural output generally. An increase in agricultural output leads to an increase of overall GDP and improve the living standard of rural population whose their livelihoods are dependent on agriculture. If there is an increase in agricultural output it increases export of the country which leads to gain of foreign exchange to the country. This result is similar with Tekeste (2012) who used fertilizer input import as control variable and he found positive and significant effect on agricultural export through effect on agricultural output.

Effect of agricultural land on agricultural output; The long run result indicate that indicate that 1% increase in agricultural land leads to 0.31% increase in agricultural output since agricultural land play an important role in determining agricultural output where there is an increase in agricultural land there would be increase in output and it have significant effect on agricultural output that result in increase in gross domestic product in general.

Error correction representation of ARDL result

Error correction model shows by how much yearly adjustment would be made if there is dis- equilibrium in the previous year and shows short run effect of variables on the dependent variables.

Table 6. Error correction result dependent variable is LD (RAGDP)

Variable	Coefficient	Standard error	T statistics	P value
LD(MAR)	0.419322	0.121361	3.455157	0.0018**
LD(LF)	0.708676	0.093313	7.594582	0.0000**
LD(FI)	0.057706	0.027364	2.10889	0.0444
LD(AT)	-0.048664	0.459323	-0.105947	0.9164
LD(AL)	0.231243	0.067514	3.425102	0.0020**
ECT-1	-0.738778	0.070093	-10.539989	0.0000**

*L- is refers to logarithm D- lagged difference. *, ** and *** indicates significance at the 10, 5 and 1 percent levels.*

The short run result shows that last year mean annual rainfall have positive and significant impact on agricultural output while last year temperature have negatively affect agricultural output but it have insignificant effect on agricultural output, Where as other variables have positive impact on agricultural output. The error correction terms represent speed of adjustment towards the long run equilibrium. This coefficient term indicate that 73.8% of the disequilibrium in the previous period is corrected in one year.

Diagnostic test result

In order to know the validity of the short-run and long-run estimation in the ARDL model, the diagnostic tests like Serial correlation test (Brush & Godfray LM test), Heteroscedasticity test (Breusch and Godfray LM test), Normality (Jaque-Bera test), Functional form (Ramseys RESET) and multicollinearity test(VIF) test were performed. The tests and their respective statistics are shortened by Table 7.

Table 7. Diagnostic test result

Test	LM version		F-version	
	Statistic	P-value	Statistic	P-value
Normality: Jarque-Bera test	x^2 (2)0.07865	0.8997	not applicable	
Serial Correlation: Breusch-Godfrey serial correlation LM test	x^2(2)14.8009	0.0006	F(1,26) 0.0122	0.9130
Heteroskedasticity:Breusch-Godfrey test	x^2(2)13.79060	0.0721	F(1,28) 0.0721	2.0957
Ramsey RESET test	x^2(26)0.56478	0.3682	F(1,26) 0.0165	0.8987
Multicollinearity test: Mean VIF (3.27)				

To test for normality of the residual the study used Jarque-Bera normality test. As the result in the table the P-value of the equation is greater than 5%. Therefore, the study failed to reject the null hypothesis and conclude that error terms of the specified model are normally distributed. To check whether model have heteroscedasticity this study used Breusch-pagan-Godfrey test. Accordingly the p-values of the equations is above the critical value (5%), implying that the residuals of the equations have no problem of heteroscedasticity. Under Breusch-Godfrey serial correlation test result shown in the table above, for the model their p-value is greater than 5% in case of LM version which assures that there is no serial correlation problem and the study accepts the null hypothesis, therefore there is no serial correlation between residuals under this study . in addition the study conducted Multicollinearity test by VIF shows mean VIF is less than 10 which shows there is no multicollinearity exist among variables.

Model stability

In addition to the above tests, the stability of long run estimates should be tested by applying the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) test. Since the test statistics of this stability tests can be graphed, we can identify not only their significance but also at what point of time a possible instability (structural break) occurred. If the plot of CUSUM and CUSUMSQ statistic moves between the critical bounds (at 5%significance level), then the estimated coefficients are said to be stable.

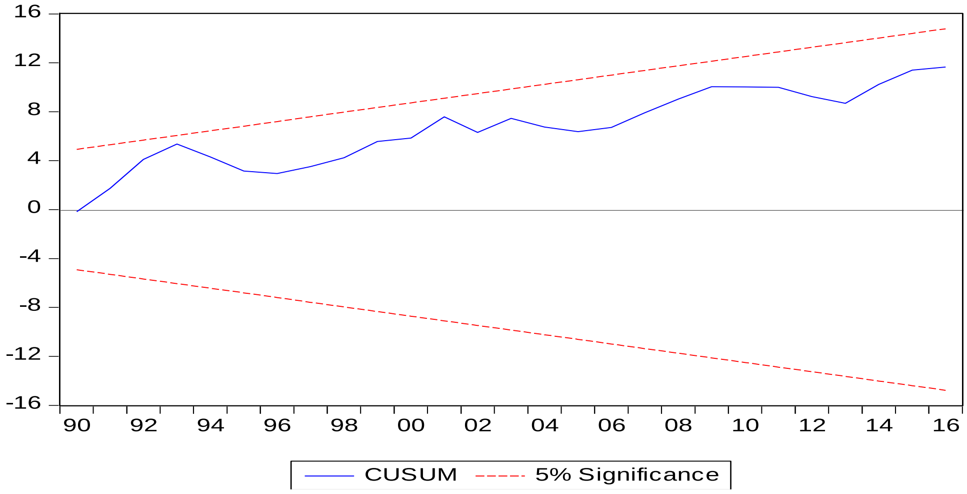

Figure 1. Plot of cumulative sum of recursive residuals

Note: *The straight lines represent critical bounds at 5% significance level*

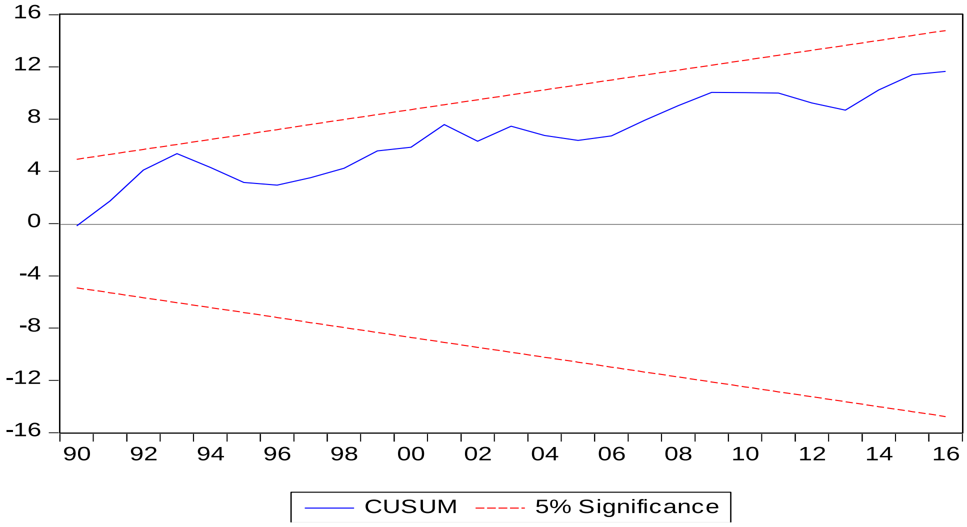

Figure 2. Plot of cumulative sum of squares of recursive residuals

Note: *The straight lines represent critical bounds at 5% significance level. As can be seen from both figure, the plot of CUSUM test did not cross the critical limits and CUSUMSQ test shows that the graphs do not cross the lower and upper critical limits Similarly,. So, we can conclude that long and short runs estimates are stable which shows the results of the estimated model are reliable and efficient.*

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The main objective of the study was to analyze effect of climate change on agricultural output in Ethiopia using real agricultural gross domestic product as proxy for agricultural output. The study used ARDL approach to co integration. The main finding of this study is that in the long run climate change proxied by mean annual rainfall and average temperature has an impact on agricultural output. In the long run mean annual rainfall has a positive and significant effect on agricultural output, whereas average temperatures have a negative and significant effect on agriculture output. In other words, holding other thing remaining constant, one percent increase in mean annual rainfall has resulted in 0.56% RAGDP in the long run, However one percent increase in temperature has resulted 2.56% reduction of RAGDP. In short run coefficient of error correction -0.738 suggesting about 73.8% annual adjustment towards long run equilibrium. This shows there is existence of stable long run relationship among variables. The estimated short run reveals that rainfall has a positive impact on agricultural output, whereas average temperatures have a negative impact on agricultural output but, unlike its long run significant impact temperatures has no significant short run impact on agricultural output.

Recommendations

In order to reduce effect of climate change in the long run and short run mitigation and adaptation strategies should be in place. Adaptation strategies may focus on the option of producing or water harvesting as it rains instead of waiting for the traditional seasons of agricultural activities. Adaptation is important in long run whereas mitigation play an important role in short run. In addition to this government, and other stakeholders should make agricultural sector a climate change resilient by using different technology and providing sufficient and timely information for farmers on climate forecast both at macro and micro level. Diversifying the economy to climate resistant sector to Minimize dependence on rainfall economy.

REFERENCE

Agricultural Transformation Agency (ATA). (2016), *Annual report on agricultural output* Addis Ababa, Ethiopia

Akram, N. & Hamid, A. (2015). *Climate change: A threat to the economic growth of Pakistan. Progress in Development Studies*, 15(1), 73-86

Alagidede, P., Adu, G. & Frimpong, P.Boakye (2014) The Effect of Climate Change on Economic Growth: Evidence from Sub-Saharan Africa. *WIDER Working Paper* 2014/017. Helsinki: UNU-WIDER

Ali S. N. (2012). *Climate Change and Economic Growth in a Rain-Fed Economy: How Much Does Rainfall Variability Cost Ethiopia?* Available at SSRN: https://ssrn.com/abstract=2018233 or http://dx.doi.org/10.2139/ssrn.2018233

Barrios, S. & Ouattara, B. & Strobl, E. (2008). The Impact of Climatic Change on Agricultural Production: Is it different for Africa? *Food Policy*. 33, 287-298.

Brooks, C. (2008). Univariatetime series modeling and forecasting. Introductory Econometrics for Finance. 2nd Ed. *Cambridge University Press. Cambridge, Massachusetts.*

Deressa, T.T. (2007). *Measuring the Economic Impact of Climate Change on Ethiopian Agriculture: Ricardian Approach*. World Bank Policy Research Working Paper No.4342.

Deschenes, O., & Greenstone, M. (2004). *The Economic Impacts of Climate Change: Evidence from Agricultural Profits and Random.* NBER Working Paper Series No. 10663. Cambridge: National Bureau of Economic Research American Economic Review.

Enders, W.(1996). *Applied Econometric Time Series*. Lowa State University: John Wiley & Sons INC

Engle, R. F. & Granger, C.W.J. (1987). Co-integration and Error Corrections: Representation, Estimation and Testing. *Econometrica*, 55(2), 251-276

Ferede T, Ayenew B &. Hanjra A(2010) Agroecology Matters: *Impacts Of Climate Change On Agriculture And Its Implications For Food Security In Ethiopia*. In Hanjra, Munir A. (Ed.). Global food security: emerging issues and economic implications. New York, NY, USA: Nova Science Publishers.

Gebreegziabher, Z., Stage, J., Mekonnen, A. & Alemu, A. (2016). Climate change and the Ethiopian economy: a CGE analysis, *Environment and Development Economics,* 21(2), 205-225.

Granger, C. W. J. & Newbold, P. (1974). Spurious Regressions in Econometrics. *Journal of Econometrics*, 2, 111-120

International Monetary Fund (IMF). (2016) *Country Report of Federal democratic Republic Ethiopia*. Washington D.C: IMF

Intergovernmental Panel on Climate Change (IPCC). (2014). *Climate change report adaption, impact and vulnerability regional aspects synthesis repor*t, in Pachauri R.K, & L.A Meyer(eds), Contribution of working groups I,II and III to fifth Assessment report of intergovernmental panel on climate change' Switzerland: IPCC Geneva

Intergovernmental Panel on Climate Change (IPCC). (2007b, November) *Climate Change 2007: Synthesis Report*, in Pachauri R. K., Reisinger A.(eds), Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Vol. 446. Switzerland: IPCC Geneva.

Jonathan E. O. & , Emmanuel I. E. (2017) The Impact of Climate Change on the Nigerian Economy, *International Journal of Energy Economics and Policy,* 7(2), 217 - 223

Muraya, B.W. & Ruigu, G. (2017). Determinants of agricultural productivity in Kenya. *International Journal of Economics, commerce and management, 5(4), 159 - 179*

National Meteorological Agency (NMA). (2007), *Climate Change National Adaptation Program of Action (NAPA) of Ethiopia*, NMS, Addis Ababa, Ethiopia

Pesaran, M. H. & Smith, R.P (1998). Structural analysis of co integration VARS. *Journal of economic surveys,* 12(5), 471-505

Pesaran M.H, R.J. Smith, & Y. Shin,(1996) Testing for the Existence of a long run Relationship, DAE Working paper No.9622, *Department of Applied Economics, University of Cambridge*

Solow, R. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics,* 70(1), 65-94

Tekeste, S. (2012). *Determinants of agricultural export performance in Ethiopia*, (Master thesis) Addis Ababa University, Ethiopia.

United States Agency for International Development (USAID). (2013). *Ethiopia climate vulnerability profile*. Available: https://www.climatelinks.org/resources/ethiopia-climate-vulnerability-profile

World Bank. (2008). *Ethiopia - A Country Study on the Economic Impacts of Climate Change*. Washington, DC: World Bank.

Yalew, A.W. (2016) *Economy-wide Effects of Climate Change in Ethiopia*. Paper to be presented at International Conference on Economic Modeling, Lisbon Portugal

Zhai, F. & Zhuang, J. (2012). *Agricultural Impact of Climate Change: A General Equilibrium Analysis with Special Reference to Southeast Asia*. ADBI Working Paper Series No. 131. Tokyo: Asian Development Bank Institute. Available: http://www.adbi.org/workingpaper/2009/02/23/2887.agricultural.impact.climate.change