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**THE IMPACT OF CLIMATIC CHANGE ON THE PERFORMANCE AND GROWTH OF THE ETHIOPIAN ECONOMY :TIME SERIES ANALYSIS**

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**THE IMPACT OF CLIMATIC CHANGE ON THE PERFORMANCE AND GROWTH OF THE ETHIOPIAN ECONOMY: TIME SERIES ANALYSIS**

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# CERTIFICATE

CERTIFIED THAT THE PROJECT WORK ENTITLED “THE IMPACT OF CLIMATIC CHANGE ON THE PERFORMANCE AND GROWTH OF THE ETHIOPIAN ECONOMY: TIME SERIES ANALYSIS” SUMITTED BY LOZALEGESSE KEBEDE (MRS.) IS HER OWN WORK AND HAS BEEN DONE IN LIGHT OF MY SUPERVISION.

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## TABLE OF CONTENTS

**ACRONYMS**

| | |
|---|---|
| AEZ | Agro-ecological Zone |
| AOGCM | Atmospheric-Oceanic Global Circulation Model |
| CCC | Canadian Climate Center |
| CES | Constant Elasticity of Substitution |
| CET | Constant Elasticity of Transformation |
| CGCM2 | Coupled Global Climate Model |
| CGE | Computable General Equilibrium |
| CO2 | Carbon Dioxide |
| EDRI | Ethiopian Development Research Institute |
| FAO | Food and Agriculture Organization |
| FCU | Foreign Currency Units |
| GDP | Gross Domestic Product |
| GFDL | Geophysical Fluid Dynamics Laboratory |
| GHG | Greenhouse Gases |
| GTP | Growth Transformation Plan |
| HadCM3 | Hadley Centre Coupled Model |
| HDI | Human Development Index |
| IPCC | Intergovernmental Panel on Climate Change |
| LCU | Local Currency Units |
| MDG | Millennium Development Goals |
| MoARD | Ministry of Agriculture and Rural Development |
| MoFED | Ministry of Finance and Economic Development |

| | |
|---|---|
| NBE | National Bank of Ethiopia |
| NMA | National Meteorological Agency |
| NMSA | National Meteorological Services Agency |
| PANE | Poverty Action Network of civil society organizations in Ethiopia |
| PASDEP | A Plan for Accelerated and Sustained Development to End Poverty |
| PCM | Parallel Climate Model |
| SAM | Social Accounting Matrix |
| SRES | Special Report on Emission Scenarios |
| UNDP | United Nations Development Program |

**Tables and Figures**

**ABSTRACT**

*Climate change has become one of the pressing problems worldwide as it affects socio-economic activities - agriculture being one of the most vulnerable sectors. Specifically, this study has attempted to evaluate the short-run economic impacts of climate change (change in the levels of temperature and precipitation) with a focus on the Ethiopian economy. In so doing, it uses a multiple regression model based on the pertinent factors of climate changes. In this case a long term consequences of climate change have given the impression that the climate impacts on economic growth as a general result. However, the impact of climate change on Ethiopian economy is likely to be quite small and it is highly affected by humidity and* $co_2$ *emissions.*

## CHAPTER ONE

### 1. Introduction

### 1.1 Background of the study

In Ethiopia, the majority of the people lives in rural areas and is largely dependent on traditional and unproductive agriculture. As data shows the share of agriculture to GDP has been declining.  The agriculture sector still accounts for large share and it employs much labour force. It is noted that the performance of the sector is essential to economic growth and its productivity is low. It is understood that the development of agriculture supports other sectors' growth and it role in mitigation of poverty is prominent.

In terms of addressing the sources of disparities among countries in their level of per capital income, Geography has a lot to explain. For example extreme events such as droughts are exceptionally higher for Africa [Bloom and sachs, 1998]. What makes a rainfall variability an issue is the fact that it is periodic and yet the frequency is unpredictable. For instance, in the period between 1983 and 1995, 29 African countries where about 51% of the population of the continent lives experienced drought at least once. In the same period, 24 of them where 28 percent of the African population live experienced drought three times and more (Bloom and Sachs, 1998). Ethiopia has been experiencing frequent drought.

According to Webb, von Braun, and Yohannes (1992) , the country faced 11 major drought episodes that led to severe famine between 1953 and 1992. Since then, the drought has become even more frequent : the 1993-94,2000, 2002-03 droughts that occurred in the years 2007 and 2009, it can be observed that drought is recurring but remain unpredictable The incidence of drought have also resulted in total crop failure A recent study by ( Schlenker and Lobell 2010) shows that aggregate to production of five major crops in sub-Saharan Africa will fall by 8 percent ( for cassava) to 22 percent (for maize) due to climate change in the midcentury .More challenging implication of the study is that the impact of climate change will be more severe for well fertilized crops of modern seed varieties. All of these arguments indicate the impacts of the climate conditions should be principally studied. The centre of attention of the study should resolve the cause for the starvation of millions of people and deaths of thousands of domestic animals and wildlife. It is noticeable that economic performance in agriculture dependent economy is intractably tied to the weather conditions.

Climate change will affect the forest conditions (area, health and vitality and biodiversity), allowing increases in growth rates in some areas while endangering the survival of species and forest communities in others. Temperature, availability of water and changes in seasonality may all become limiting factors, depending on geographic area of original climatic conditions, species diversity and human activities.

Most commonly, these changes affect the frequency and intensity of fires and insect pests and diseases, as well as damage done by extreme weather conditions, such as droughts torrential rains and hurricane winds. In some cases, this may lead to expansion of forest areas, for example, temperate forests are expected to spread pole ward. In other case it may lead to reduction of forest areas. In some areas, responses to climate change will affect the demand for forest products. for example, increased demand for forest –based fuels as a substitute for fossil fuels .

Societies react to their perceptions of the actual and potential impacts of climate change on ecosystem by developing policies and legislation. As a result, this paper is initiated to survey the impact of the climate change on the performance and Growth of the Ethiopian Economic: time series Analysis.

Since a main feature of Ethiopian agriculture is that it remains primarily dependent on rainfall, the study indicated the policy implications and examines its direction. As such, any disruption in the amounts and patterns of rainfall will be studies its impact on agricultural production, overall economic growth and food security. Furthermore, it tried to study weather change that is increasingly threatening the country's agricultural production. Thus, it is believed that the study tried to exert its effort to shift radically from rain-fed agriculture. An attempt will be done to alleviate the exposure of adverse climate.

## 1.2 Objective of the study

### 1.2.1 General objectives

The study is designed to study the impact of climate change on the performance and growth of the Ethiopian Economic: Time series analysis. It assesses the impact on per capital growth via climate conditions.

The major objective of the study is to enhance the agricultural productivity of the country. In terms of development approach, Ethiopia should seek collaboration with countries that have advanced agricultural technologies suitable for harsh climates. In this regard, the study pointed out a good exemplary country which has made major strides in this direction. In addition, there is need to deepen study in areas of research on agricultural technologies and water conservation. It is an opportunity that should be seized to produce tangible commitments for the benefit the most vulnerable to climate change. In general, it is intended to point out policy implication regarding the effect of weather on economic growth.

### 1.2.2 Specific Objectives

The specific objective is to find out the pattern of the climatic condition of the country and to analyze constraints and opportunities of the economic integration. Noticeably, rain-fed agriculture has limits in many cases. It cannot be relied on to feed growing populations or be a source of sustainable economic growth. Additionally, there is increasing competition for water for various uses especially with rapid growth in urban populations. Thus, the study should specify the extent of the investment in irrigation infrastructure and also water-conserving technologies such as drip irrigation, dam construction and rain water harvesting.

## 1.3 Statement of the problem

Ethiopia like other Least Developed Countries is the most vulnerable country find herself in the worst situation. In the country, climate change is already affecting economic growth, health indicators, water availability, food production and the fragile ecosystems. As a result, yields from rain-fed agriculture in Ethiopia had been reduced.

Water shortages and the shrinking of land suitable for agriculture would cause other social and political disruptions, including forced migration and conflict. These are dire marks which demand serious attention as we move closer to the historic summit on climate change and the country’s economic performance. The study contributes to that effort by highlighting the gravity of the situation for Ethiopia as well as highlighting some possible actions to meet the challenge.

## 1.4 Research Questions

This paper tried to answer the following research questions:

What is the impact of climatic change on economic Growth and Development?

What should be done to transform adverse effect of weather into useful purpose?

Are there much higher levels of vulnerability to environmental determinants of health, wealth and other factors, and much lower levels of capacity available for coping with environmental change?

To what extent climatic change affects economic growth? Are there indicators that Ethiopia suffers from the casualties attributable to climate change?

Are the questions of climate justice a fundamental issue in Ethiopia?

### 1.5 Significance of the study

The significance of the study can be considered as a major driver for growth and poverty reduction since the focus is on finding solution for poor economy performance. It is noted that climate change does make the impact of adverse weather even more serious. As such, the study must focus on climate change mitigation strategies for agriculture dependent economy. The policy should provide appropriate response to undertake agriculture improvement policies and projects to enhance the sector. It is apparent that distributing climate data regarding seasonal climate forecasts and early warning systems can help small farmers make informed decisions.

Based on the study, capacity building and public awareness on climate-related issues should be prioritized and appropriately indicated and coordinated. These will be important in reducing Ethiopian exposure to the risks associated with the climatic change. All of these issues point to the significant of the study. It is extremely remarkable.

### 1.6 Scope and Limitation of the study

This study attempted to analyze the effects of the majority adverse effects of climate change that are experienced by poor and low-income communities. In addition, it tried to study how much level of vulnerability to environmental determinants of health, wealth and other factors, and much lower levels of capacity available for coping with environmental change. Its core thought is on economic development, i.e. there is effect of climate on economic growth, so it is intended to test the significant relationship of variables and economic growth. It makes a hypothesis which is a proposed explanation for the above phenomenon. For a hypothesis to be put forward as a scientific hypothesis, the scientific method requires that one can test it.

Climate information has been used in Ethiopia for decades, particularly for drought monitoring and early warning (Hellmut et al., 2007). Yet, the availability, access and use of climate data are far from ideal. The main source of climate data is the network of weather stations managed by Ethiopia's National Meteorology Agency (ENMA). Even though the number of stations is reasonably good, and has been increasing, station distribution is very uneven. There are very few stations over the lowlands. Most of the stations are located in cities and towns along the main roads. This limits the availability of climate information and services for rural communities. Where records do exist, they frequently suffer from data gaps and poor quality and are often not easily accessible. This, in turn, has limited the use of the available climate data.

### 1.7 Organization of the study

This paper contains five chapters. Chapter one is the introduction part of the study. In addition to this the chapter also states the problem statement , the intended objectives of the study , the significance it bears , the limitation of the study , the research design and methodology employed and organization of the paper. The second chapter includes literature review about climate change and its impact on the performance of the economy. The third chapter presents an overview of the Ethiopian economy. The fourth chapter presents the data and its analysis on climate change that has effects on drought and famine, in the production of crops, degradation of forest are discussed .More over the causes of climate change is analyzed . The fifth chapter and fine chapter of the paper include the summary of findings, conclusions and possible recommendation.

# CHAPTER TWO

## Review of Related Literature

Climate change is a change in the statistical distribution of Weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i.e., more or fewer extreme weather events). Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Certain human activities have also been identified as significant causes of recent climate change, often referred to as "warming”. Scientists actively work to understand past and future climate by using observations and theoretical models. A climate record extending deep into the Earth's past has been assembled, and continues to be built up, based on geological evidence from borehole temperature profiles, cores removed from deep accumulations of ice, floral and faunal records, glacial and per glacial processes, stable-isotope and other analyses of sediment layers, and records of past sea levels. (en.Wikipedia.org/Wiki/ climate change)

More recent data are provided by the instrumental record. General circulation models, based on the physical sciences, are often used in theoretical approaches to match past climate data, make future projections, and link causes and effects in climate change. Climate is changing, largely due to the observed increases in human activities such as the burning of fossil fuels (coal, oil, and natural gas), agriculture and land clearing. Changes over the 20th century include increases in global average air and ocean temperature, widespread melting of snow and ice and rising global sea levels. The extra heat in the climate system has other impacts such as affecting atmospheric and ocean circulation, which influences rainfall and wind patterns.(en. Wikipedia.org/wiki/climate_ change)

Another serious impact of the increasing concentration of atmospheric carbon dioxide is ocean acidification. Around a quarter of the carbon dioxide produced by humans is absorbed by the oceans. As the carbon dioxide dissolves in sea water it forms a weak carbonic acid, making the ocean more acidic. There are early indications that some marine organisms are already being affected by ocean acidification.(en. Wikipedia.org/wiki/climate_ change)

The global average air temperature has increased by around 0.85 degrees Celsius since 1880.The observed increase in temperatures has occurred across the globe, with rising temperatures recorded on all continents and in the oceans. World Meteorological Organization records show that the decade of 2001-10 was the world's warmest decade on record, and that the 2000s were warmer than the 1990s which in turn were warmer than the 1980s. In Australia, average air temperatures have increased by around 0.9 degrees Celsius since 1910, and each decade has been warmer than the previous decade since the 1950s. Scientists agree that the worst effects of climate change can largely be avoided if carbon dioxide emissions are reduced to an acceptable level. (www.wmo.int/pages/index_en.html)

In this chapter, a theoretical link between climate change and agricultural production is established first. Second, the different economic models used to assess the likely impact of climate change on agricultural productivity and thereby the economy is presented. Finally, the chapter concludes by providing empirical literature reviews on the potential economic impacts of climate change from different corners of the world, with a special focus on Africa.

## 2.1 Climate Change and Agricultural Production

There is a strong and two way interrelationships between climate change and agriculture. The first line is concerned with the contribution of agriculture to the total GHG emissions and hence climate change. The second line is how climate change explains agricultural outputs (Egnonto and Madou, 2008). This study is devoted to the latter side of explanation. Climate change can affect agricultural production in a variety of ways. Temperature and precipitation patterns, extreme climate conditions, surface ,water runoff, soil moisture and CO2 concentration are some of the variables which can considerably affect agricultural development (IPCC, 2007; Zhai and Zhuang, 2009).

Most studies concluded that the relationship between climate change and agricultural production is not simply linear (such as Mendelsohn *et al*., 1994; Kabubo-Mariara andKaranja, 2006; Kurukulasuriya and Mendelsohn, 2008). There is usually a certain level of threshold beyond which the sector may be adversely affected. For instance, IPCC reports that warming of more than 3ºC would have negative impacts on crop productivity globally. However, there is a marked difference regionally with regard to the threshold level. For instance, the potential for crop productivity is likely to increase slightly at mid to high latitudes for local mean temperature increases of up to 1-3°C. On the contrary, low-latitudes will experience losses in crop productivity for even small local temperature increases of 1-2°C (IPCC, 2007b).The changes in precipitation and temperature can directly influence crop production.

Moreover, they might alter the distribution of agro-ecological zones. Precipitation patterns determine the availability of freshwater and the level of soil moisture, which are critical inputs for crop growth. Moderate precipitation may reduce the yield gap between rain-fed and irrigated agriculture by reducing crop variability (Calzadilla *et al.*, 2009).

However, heavy precipitation is very likely to result in soil erosion and difficulty to cultivate land due to water logging of soils. Taken as a whole, it will adversely affect crop production (IPCC, 2007b).Temperature and soil moisture determine the length of growing period and the crop`s development and water requirements.

Higher temperature will shorten the freeze periods, promoting cultivation in marginal croplands. However, in arid and semi-arid areas higher temperature will short the crop cycle and reduce crop yields (IPCC, 2007b). In addition, the ecological changes brought on by warming such as the pattern of pests and diseases will depress agricultural production (Zhai and Zhuang, 2009). Globally, temperature increases of up $2^0$C may have positive impacts on pasture and livestock productivity in humid temperate regions. However, it will reduce livestock production in arid and semi-arid regions (IPCC, 2007b).Crop production will be depressed by increased climate variability and increased intensity and frequency of extreme weather events such as drought and floods (IPCC,2007b; Zhai and Zhuang, 2009; Calzadilla *et al.,* 2009).

Its negative impact is much higher in areas where rain-fed agriculture dominates. For instance, frequent droughts not only reduce water supplies but also increase the amount of water needed for plant transpiration. These events will also increase diseases and mortality of livestock which results in production losses (IPCC, 2007b; Zhai and Zhuang, 2009). Elevated CO2 concentration alone does have a positive impact on crop (plant) production by stimulating plant photosynthesis and water use efficiency- the amount of water required to produce a unit of biomass or yield.

This carbon fertilization effect may favor plants under C3 pathway, such as wheat, rice, soya bean, fine grains, legumes, and most trees, which have a lower rate of photosynthetic efficiency, over C4 plants, such as maize, millet, sorghum, sugarcane, and many grasses (IPCC, 2007b; Cline, 2007; Matarira, 2008; Zhai and Zhuang, 2009). In this respect IPCC predicts 10- 25% yield increases for C3 crops and 0-10% for C4 crops when atmospheric CO2 concentration levels reach 550 parts per million. However, changes in temperature and precipitation may limit these effects (IPCC, 2007b).

Specifically to Ethiopia, climate change affects agricultural production through shortening of maturity period and then decreasing crop yield, changing livestock feed availability, affecting animal health, growth and reproduction, depressing the quality and quantity of forage crops, changing distribution of diseases, changing decomposition rate, contracting pastoral zones, expansion of tropical dry forests and the disappearance of lower montane wet forests, expansion of desertification, etc (NMA, 2007; PANE, 2009).

In most of African countries, there is a strong association between GDP growth and climate variables like rainfall. This resulted owning to lack of economic diversification and strong dependence on the agricultural sector (Bouzaher et al., 2008). The crux of the matter is that, in Africa, this association is a direct reflection of the very high dependence of agricultural production on climate variables.

In Ethiopia, such a relationship is very striking. Agricultural output is highly pronounced even by changes in a single climate variable, i.e., rainfall (PANE, 2009).The same is true for the country’s GDP as it heavily relies on agriculture (World Bank, 2006; PANE, 2009). Rain failure, floods and drought and other changes in the country`s natural and environmental system due to climate change threaten the performance of the economy as a whole and cause severe malnutrition and loss of livelihoods for households mainly in marginal and less productive lands in the country (PANE, 2009).

This effect is attributed to the fact that those changes can seriously depress agricultural production in the country. This clearly demonstrates that economic growth in general and households` welfare in particular are still significantly influenced by changes in rainfall and other climate variables (World Bank, 2006). In conclusion, the impact of climate change in the country can be felt not only on agricultural output but also on other sectors of the economy, the country’s trade patterns, incomes, consumption and welfare of households etc.

## 2.2 Models to assess the Impact of Climate Change

The efforts to measure the economic impact of climate change is growing. However, little research has focused specifically on the developing nations until 1999 (Mendelsohn and Dinar, 1999). Although more studies dedicated to developing countries have emerged since then, a few national level studies for Ethiopia have been done. Accordingly, little is known about how climate change may affect the country’s agriculture and hence the economy. To assess the likely economic impacts of climate change, researchers have used different models partial equilibrium or general equilibrium approaches (Deressa, 2006; Zhai et al., 2009; Deressa and Hassan, 2009).are the common.

Partial equilibrium models are based on the analysis of part of the overall economy such as a single market or subsets of markets or sectors - assuming no interrelationship among sectors. However, general equilibrium models are analytical models, which look at the economy as a complete, interdependent system, thereby providing an economy wide prospective analysis capturing links between all sectors of the economy (Zhai et al., 2009).

### 2.2.1 Partial Equilibrium Models

Three basic partial equilibrium approaches have been developed to assess the impacts of climate change on agriculture. These are: Crop simulation models, Agro-ecological zone models, and Ricardian models (Mendelsohn and Dinar, 1999; Zhai et al., 2009).

### 2.2.2 Crop Simulation Models

Crop-simulation models also known as agro-economic models draw on controlled experiments where crops are grown in a field or laboratory settings simulating for different possible future climate and CO2 levels in order to estimate crop yield responses (Zhai et al., 2009; Zhai and Zhuang, 2009 ). The changes in outcomes are then assigned to the differences in the variables of interest such as temperature, precipitation, and CO2 levels as other changes in the farming methods are not allowed across experimental conditions. The yields are then entered into economic models that predict aggregate crop outputs, prices, and net revenue (Mendelsohn and Dinar, 1999).

Due to the fact that each crop requires extensive experimentation, almost all of the crop simulation studies so far focused only on the most important crops (mostly grains). Moreover, these models do not include farmers' adaptation to changing climate conditions in the estimates. As a result, they tend to overestimate the damages of climate change to agricultural production (Mendelsohn and Dinar, 1999; Seo and Mendelsohn, 2008). In addition, such experiments are costly and hence a few locations can only be tested. This poses another problem as to the representativeness of experiments to the entire farm sector. Hence in developing nations, where there are only a few experimental sites, the results of these models may not be generalizable (Molla, 2008).

### 2.2.3 Agro-ecological Zone (AEZ) Models

The agro-ecological zone (AEZ) model (also known as crop suitability approach) is used to investigate the suitability of various lands and biophysical attributes for crop production. The initial task in this model is to categorize the existing lands into smaller units, which differ in the length of growing period (defined based on temperature, precipitation, soil characteristics, and topography differences) and climate. This approach analyzes land suitability for crop production by including crop characteristics, existing technology, and soil and climate factors (FAO, 1996).

The inclusion of the above variables made the identification and distribution of potential crop producing lands possible. Since climate is included in this model as one of the determinants of land suitability for crop production, it can be used to predict the impact of changing climatic conditions on potential agricultural output and cropping patterns (Molla, 2008). These models suffer from the same limitation as the crop simulation models in that researchers must explicitly account for farmers' adaptation to changing climate conditions (Mendelsohn and Dinar, 1999). They also make use of a simulation of crop yields (not measured crop yields) in order to assess the potential production capacity of different agro-ecological zones. Moreover, the impossibility to predict final outcomes without explicitly modeling all the relevant components remains to be the model`s additional problem. Hence, overlooking a single major factor would seriously damage the model's predictions (Mendelsohn and Tiwari, 2000).

### 2.2.4 Ricardian Models

The Ricardian model is a cross-sectional approach developed by Mendelsohn et al. (1994) in order to examine the impact of climate change on agriculture in the United States (Mendelsohn et al., 1994; Mendelsohn and Nordhaus, 1996; Deressa et al., 2005). It is named after David Ricardo (1772–1823) because of his original observation that the value of land would reflect its net productivity under perfect competition (Deressa et al., 2005; Mariara and Karanja, 2006; Malua and Lambi, 2007; Kurukulasuriya and Mendelsohn, 2008).

This model has been extensively used to measure the marginal contribution of environmental (and other) factors to farm income (land values) by regressing farm performance (land values or net revenue) on environmental and other socio-economic factors (Mendelsohn et al., 1994; Mendelsohn and Dinar, 1999; Deressa et al., 2005). It is often adopted and used in different countries such as Brazil, India, USA (Mendelsohn and Dinar, 1999; Deressa et al., 2005) and some other African countries like Burkina Faso,Cameroon, Egypt, Ethiopia, Kenya, Senegal, South Africa, Zambia and Zimbabwe(Molla, 2008).

The Ricardian model incorporates farmers' adaptation to changing local climate conditions; an advantage over the above two approaches. Because farmers are risk minimizers, there is every reason to expect that they adapt to climate change by altering the crop mix, planting and harvesting dates, and following a host of agro economic practices, among other things (Mendelsohn and Dinar, 1999; Deressa, 2006; Deressa andHassan, 2009). Moreover, the model makes possible comparative assessment of 'with' and 'without' adaptation scenarios (Mano and Nhemachena, 2006). The other advantage of the model is that it can be used at a lesser cost than the other models as secondary data on cross-sectional sites can be relatively easy to collect on climatic, production and socio-economic factors (Deressa, 2006; Deressa and Hassan, 2009). However, the Ricardian model is criticized on certain grounds.

First, it is not based on a carefully controlled experiment across farms. Farms may differ across space for many reasons in addition to those included in any model. Hence, one cannot guarantee that all of the factors have been taken into account in the analysis; some of them may not even be measured at all (Cline, 1996; Mendelsohn and Dinar, 1999). Second, it also suffers from being a partial equilibrium analysis in the sense that it fails to consider price variations; all farms face the same prices which results in bias in welfare calculations (Mendelsohn and Nordhaus, 1996; Cline, 1996).

Finally, it is also weak since it does not take into account carbon fertilization effects; it only uses precipitation and temperature (Cline, 1996; Mendelsohn and Tiwari, 2000).

### 2.2.5 Multiple Regression Model

Regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. (http://en.wikipedia.org/wiki/regression_analysis). More Specifically ,Multiple regressions Model is important to learn more about the relationship between several independent or predictor variables and a dependent or criterion, it is also used to understand which among the independent variable are related to the dependent variables and to explore the forms of this Relationship(en.Wikipedia.org/Wiki/regression model ) . More precisely, multiple regression analysis helps us to predict the value of Y for given values of $X_1$, $X_2$, …, $X_k$ .For instance in determining the yield of rice per acre depends upon quality of seed , fertility of soil , fertilizer used , temperature, rainfall. If one is interested to study the joint effect of all this variables on the rice yield; multiple regression model is the most convenient method because it enable us to study the individual influence of this variables on yield. From all above listed models multiple regression method is the most suitable model to determine the overall fit (variance explained) of the model and the relative contribution of each of the predictors to the total variance explained.

## 2.3 Empirical Literature on the Impact of Climate Change

Zhai and Zhuang (2009) examined the long-run agricultural impact of climate change in the world with special reference to Southeast Asia (Indonesia, Malaysia, Philippines, Singapore, Thailand, and Viet Nam), while the study by Zhai et al. (2009) focused on the People's Republic of China (PRC). Based on a dynamic CGE model of the global economy and the Cline's business as usual crop productivity estimates, both studies found that global crop, livestock and processed food production would shrink by 7.4%, 5.9% and 4.6% respectively in the year 2080. The strongest negative impact of climate change on crop output would be in Sub Saharan Africa, Latin America and South Asia which is about 30%, 24% and 20%, respectively.

The impact on Southeast Asia would be more moderate, but significant at 17% by 2080. In regions where the impacts on agricultural productivity are small or positive, however, crop production would expand. The highest would be in New Zealand which is by about 141%. This is due to its higher agricultural productivity under climate change and relatively small crop share in its economy. In addition, the study reveals that such cross-region variation also applies for livestock and processed food production.

Zhai and Zhuang (2009) further showed that all of the Southeast Asian countries would see output losses in all crop sectors, except rice output in Malaysia. The highest aggregate crop production loss would be experienced by Singapore and the lowest would be in Viet Nam, by about 48% and 11% respectively. Except for Singapore and Thailand, livestock production would decrease in the other countries.

They said study further showed that the projected slowdown in agricultural productivity further affects the macroeconomic performance of the countries. All the six countries would see contractions in real GDP, ranging from 0.3% in Singapore to 2.4% in Thailand. Moreover, a modest reduction in the levels of investment and consumption would happen. According to both papers, on average, China's crop output is seen to experience a decline of 0.1%. It is merely Wheat production which would expand (by 4.2%) while the output of others would contract. Zhai *et al.* (2009) showed that China would experience higher exports and fewer imports in crop sector mainly due to the relatively less climate change damage on crop agriculture as compared to the world`s average. The rise in exports ranges from 46.8% for paddy rice to 126.7% for wheat, while the decline in imports ranges from 14.9% to 34.1%. Crop productivity losses are expected to result decline in the outputs of non-crop agriculture, mining, manufacturing and services ranging from 1% to 2% mainly because of rising input costs and resource diversion towards crop agriculture.

Using the Ricardian model and cross-sectional data, Mendelsohn *et al.* (1994) and Seo and Mendelsohn (2008) assessed the impact of climate change on the US and South American agriculture, respectively. Mendelsohn *et al.* (1994) concluded that climate has a complicated effect on agriculture which is highly nonlinear and varying by season. Specifically, the estimated marginal impacts revealed that higher temperatures are likely to reduce while higher precipitation would stimulate average farm values (except in autumn which would be the reverse). This result is further confirmed by Mano and Nhemachena (2006) on Zimbabwean agriculture, Kabubo-Mariara and Karanja (2006). on crop agriculture in Kenya and Malua and Lambi (2007) on crop farming in Cameroon. However, Seo and Mendelsohn (2008) indicated that both increasing temperature and precipitation would be harmful on South American agriculture even though climate sensitivity varies across farm types (i.e. Crop only, mixed and livestockonly farms).

Some studies investigated the impact of uniform climate scenarios on agriculture. For instance, Mano and Nhemachena (2006) indicated that the uniform scenarios of increasing temperature by 2.5ºC and 5ºC and decreasing precipitation by 7% and 14% results in contraction in net farm revenues across all farms in Zimbabwe. Similarly, Malua and Lambi (2007) found that the uniform scenarios of increasing temperature by 2.50C and 50C would cause a fall in crop net revenues by $0.65 and $1.82 billion, respectively, in Cameroon. In addition, they indicated that the uniform scenarios of decreasing precipitation by 7% and 14% would result a decline in crop net revenues by $2.95 and $4.96 billion, respectively.

Based on $CO_2$ doubling scenario, which predicts a 5˚F and 8% increase in temperature and precipitation, respectively, Mendelsohn *et al.* (1994) estimated the annual agricultural damage in the US to be in the neighborhood of 4-5% using the crop land model. However, it would be slightly beneficial using crop-revenue approach (by around 1% annually). Similarly, Seo and Mendelsohn (2008) assessed the impact of projected climate from CCC and PCM models on South American agriculture. In so doing, PCM scenarios predicted a loss of 23% and 13% of land value in the crop-only and mixed farms, respectively, by the year 2100. Contrarily, livestock-only farms would experience a boost in their incomes by 38%. However using predicted climate from the CCC model, they estimated a much larger decline in incomes of all the farm types. Mano and Nhemachena (2006) also examined the impact of three SRES climate change scenarios, namely CGM2, HadCM3 and PCM on agriculture in Zimbabwe.

They indicated that farm net revenues would decline, respectively, by US$0.8 billion, US$1.3 billion and US$1.4 billion across all farms as of 2100. The study by Kabubo-Mariara and Karanja (2006) used climate scenarios from CCC and GFDL, which predicts a 3.5°C and 4°C increase in temperature, respectively, while both of them predicts a 20% increase in precipitation by the year 2030 over Kenya. The results predicted a 1% (US$3.54 per hectare) gain in high potential zones but a 21.5% (US$54 per hectare) loss in medium and low potential zones for simulations based on CCC model. Using the GFDL model, the result predicted a loss of US$32 per hectare in the high potential zones while the losses would be US$178 per hectare in medium and low potential zones by the year 2030.

Deressa et al. (2005) using the Ricardian model assessed the impact of climate change on South African sugarcane production under irrigation and dry land conditions. Utilizing time series data for the period 1977 to 1998, they showed that climate change has a significant effect on net revenue per hectare in sugarcane farming with higher sensitivity to future increases in temperature than precipitation. This result is similar with the finding of Kabubo-Mariara and Karanja (2006) on Kenyan crop agriculture. In addition, in line with the result of Mendelsohn et al. (1994), Deressa et al. (2005) revealed that an increase in temperature and precipitation by 20C and 7% (doubling of CO2), respectively, has negative impacts on sugarcane production. This result is further shown to be unevenly distributed across the indicated farming types. However, the difference is negligible as the reduction in net revenue per hectare is about 1% more in dry land farming as compared to irrigated farming. Hence, they concluded as if irrigation is not a very effective adaptation measure to mitigate climate change impacts on sugarcane farming.

The other study by Gbetibouo and Hassan (2004) used the same approach to analyze the economic impact of climate change on major South African field crops. Similar to the finding of Deressa et al. (2005) on sugarcane farming, this study concludes that production of field crops in South Africa will be very sensitive to marginal changes in temperature as compared to changes in precipitation. However, unlike Deressa et al. (2005), they argues that moving from rain-fed to irrigated agriculture could be an effective adaptation option to reduce the damages of climate change for the field crops. This result is further confirmed by Kurukulasuriya and Mendelsohn (2008) on African cropland using Ricardian model, cross-sectional data from 11 countries in the region, and future climate scenarios from three AOGCMs. In addition, the marginal impacts of Kurukulasuriya and Mendelsohn (2008) suggest that higher temperatures would increase net revenues from irrigated farms while it would reduce net revenues from dry land farms. However, higher precipitation would stimulate net revenue in both types of farms. Three different studies in Ethiopia relied on the same approach, i.e., Ricardian model. Deressa (2006) analyzed the impact of climate change on total agricultural production, while Deressa and Hassan (2009) and Molla (2008) assessed the impact on crop agriculture. All of them revealed that climate variables have significant impacts on net revenue per hectare. Deressa (2006) concluded that increasing temperature marginally during the winter and summer seasons reduce net revenue per hectare by US$997.7 and US$177.6, respectively. However, it increases net revenue per hectare by US$337.8 and US$1879.7 in the spring and fall seasons, respectively. Deressa and Hassan (2009), on the other hand, indicated that increasing annual temperature reduces net revenue per hectare by US$ 21.61 (though it is insignificant). However, based on Molla(2008), marginal increase in annual temperature for the model without adaptation will lead to a change in crop net revenue of -3358.41 birr for Nile basin of Ethiopia, 3483.25 birr for irrigated farms (though not significant even at 10% level of significance) and -5904.97 birr for dry land farms. But for the model with adaptation, the change in crop net revenues amount -3127.95 birr, 2275.41 birr (not significant) and -4485.46 birr for Nile basin of Ethiopia, irrigated and dry land farms respectively.

Moreover, Deressa (2006) indicated that increasing precipitation marginally increases net revenue per hectare by US$225.1 in the spring season, while it reduces net revenue per hectare by US$464.7, US$18.9 and US$64.2 in the winter, summer and fall seasons, although the last two are insignificant. According to Deressa and Hassan (2009), however, the marginal impact of increasing annual precipitation reduces net revenue per hectare by US$322.75. Molla (2008), on the other hand, showed that it will increase crop net revenues by 322.89 birr, 309.54 birr and 352.68 birr for the model without adaptation while for the model with adaptation the gain amounts 147.45 birr, 147.46 birr and 267.66 birr for Nile basin of Ethiopia, irrigated and dry land farms, respectively.

Deressa (2006) and Molla (2008) further revealed that the uniform scenarios of increasing temperature by 2.5˚C and 5˚C and decreasing precipitation by 7% and 14% are all damaging to agriculture in the country, except Molla(2008) indicated that increasing temperature by 2.5˚C results in net gain for the irrigated farms.. Moreover, using the forecasted values of temperature and precipitation from three climate change models (i.e. CGM2, HaDCM3 and PCM), Deressa (2006) predicted that net revenue per hectare would increase by 2050, while it would decrease by 2100, while Deressa and Hassan (2009) forecasted reduced crop net revenue per hectares both in the year 2050 and 2100. This study further revealed that the impact of climate change would worsen over time unless it is abated using prudent adaptation actions.

### 2.4 Summary of the Literature

This chapter described the ways through which climate change can affect agricultural production, the class of methodologies used to carry out climate change impact studies and the empirical literature related to the topic. According to the literature, temperature and precipitation patterns, extreme climate conditions like floods and drought, surface water runoff, soil moisture and CO2 concentration are some of the important climate variables which can substantially affect agricultural production.

It has been further assessed that Ethiopia is not an exception to be affected by these variables. The class of approaches used to assess the impact of climate change can be seen under partial equilibrium model. Partial equilibrium models include crop-simulation, AEZ and Ricardian models. The impact of climate change on agriculture is indicated to be highly complicated. Some countries (or regions) might benefit as a result of warming, whereas others may lose in terms of agricultural production. The impact may not even be uniformly distributed within a nation if it has different AEZs or farming methods.

In addition, some of the studies revealed that adaptation (like irrigation) may reduce the harmful effects of climate change. In Ethiopia, most of the studies concluded that increasing temperature and decreasing precipitation are damaging to agriculture. All of the studies, however, focused only on the impact on agriculture and they made use of a partial equilibrium analysis which assumes that there is no interrelationship among sectors. Consequently, there lies a need to investigate the economy- wide impacts of climate change in the country.

# CHAPTER THREE

## Background of the Study

### 3.1 Overview of Ethiopian Economy

Although Ethiopia is among the poorest nations of the world (UNDP, 2009), it has experienced rapid economic growth in recent years (Dorosh and Thurlow, 2009; MoFED, 2010a). On average, the real GDP has been growing by around 11% in the period 2005/06 - 2009/10. This growth is complemented by the average growth rates of 8%, 10% and 14.6% achieved by agriculture, industry and service sectors respectively. The overall real GDP growth in comparison with an average population growth rate of 2.6% therefore implies that the average annual per capita income has been increasing at a rate of 8.4% (MoFED, 2010a).

The other human development measures have also shown improvements over time owning to improved economic performance. However, they still remained very low as compared to other countries in the world. This is due to the fact that the country is characterized by low per capita income of only 170 USD, overall adult literacy rate of only 36% and there still exists a very high infant and maternal mortality rates (MoRAD, 2010). In addition, life expectancy at birth is only 54.7 years and the overall HDI is among the lowest in the world (UNDP, 2009).

The remarkable growth that has been achieved in recent years was not free of challenges. some of these challenges which require special mention include low levels of income and savings, low agricultural productivity, limited implementation capacity, unemployment and a narrow modern industrial sector  base. Besides the aforementioned challenges, the growth efforts have also been threatened by the twin challenges of inflation, which is mainly attributed to food prices, and the pressure on the balance of payments (MoFED, 2010b).

Furthermore, whether induced challenges like climate change has been a major threat to the economy (world bank, 2006; world bank, 2008; MoFED, 2010b). these factors coupled with the global financial and economic crisis are seen as the reasons that had and will continue to have a dampening effect on the country`s economic growth (MoFED, 2010b). In terms of the structure of the economy, the contribution of agriculture to the overall GDP has declined from 47% in the year 2003/04 to 41% in 2009/10 while the contribution of the industry has been stable. However, the service sector, for the first time in history, has overtaken agriculture as the largest segment of Ethiopian economy in 2008/2009. Its share increases from 39.7% in 2003/04 to 46% in 2009/10 (MoFED, 2009; MoFED, 2010a). The slow but consistent growth of the service sector is mainly attributed to the growth in real estate, renting and related business activities. Wholesale and retail trade, hotels and restaurants, and banking have also been the other key growth areas in the sector (access capital, 2010).

The industrial sector in the country is still at its infancy level contributing a very small portion to the national GDP. Not only its share in the country`s GDP but also its contribution to GDP growth has been stagnant centered around 13% and 1.3%, respectively, in the period 2002/03 to 2008/09 (NBE, 2009; MOFED, 2009).Though small, the sector`s growth in recent years is mainly attributed to the expansion in electricity and water, owning to huge investments in the hydro electric power generation and expansion activities, mining and construction sub-sectors, for instance, which rose by 5.7%, 12.8% and 11.7%, respectively, in the year 2008/09 (NBE, 2009).Majority of the population in the country obtain their livelihood directly or indirectly from agricultural production. Growth in the economy has been a direct reflection of the performance and growth paths in the sector (NBE, 2009; PANE, 2009). So far the growth strategies of the country gave due attention to agricultural growth.

A Plan for Accelerated and Sustained Development to End Poverty (PASDEP) which covers2005/06-2009/10 put much thrust, among others, on rural and agricultural growth to achieve its pillar strategies (MoFED, 2007). The new Growth and Transformation Plan (GTP) 2010/11-2014/151 of the country, which is prepared based on PASDEP experiences and achievements, still aims at maintaining agriculture as a major source of growth in order to attain a rapid and broad-based economic growth.

The plan explicitly indicates that it is imperative to achieve accelerated and sustained agricultural growth in the next five-years so that it will be possible to reduce poverty and pave the ground work for the attainment of the Millennium Development Goals (MDGs) by 2015(MoFED, 2010a).The agricultural sector being rain-fed is, however, sensitive to changes in temperature and precipitation patterns (World Bank, 2006; World Bank, 2008; Deressa, 2010). On the other hand, the sector is the government`s top priority which will determine the country`s economic fate (MoFED, 2010a). In addition, there is strong inter-linkage between agriculture and the other sectors (NBE, 2009, PANE, 2009). Taken as a whole, any weather induced change could seriously affect the country`s economy through its effect on agriculture.

## 3.2 Overview of Environmental Condition in Ethiopia

### 3.2.1 Environmental Problems in Ethiopia

Environmental problem/stress is now among the major problems which can have significant ecological, social and economic impacts in Ethiopia. The country's underdevelopment, in one way or another, is linked to the changes in its natural and environmental conditions. As a result, according to MoFED (2010b), it has been widely acknowledged recently that addressing such problems does have several important, poverty reduction, equality and human rights dimensions. Hence, it has become a key issue in the development agenda of the nation (MoFED, 2007; MoFED, 2010).

According to NMA (2007) and MoFED (2007), land degradation, soil erosion, deforestation, loss of biodiversity, water and air pollution, and climate change including desertification, recurrent drought, and floods are the major environmental problems in the country. These problems, among others, have been the major source of risk and vulnerability in most parts of the country (NMA, 2007). Of the total area, 70% of the country is dry sub-humid, semi-arid and arid, which is vulnerable to desertification and drought (MoFED, 2007).

Even the humid part of the country is prone to land degradation due to the country's mountainous topography. Furthermore, the increase in livestock and human population and the associated socio-economic activities are all threatening the country`s biodiversity (World Bank, 2006; NMA, 2007).The history of drought in Ethiopia is as old as the country itself (Molla, 2008; WorldBank, 2006). It has been traced as far back as 250 B.C (World Bank, 2006). Furthermore, the frequency of droughts has been very severe.

For instance, Molla (2008) explained that there were about 177 drought incidences from the first century A.D. up to 1500A.D. and around 69 drought events between 1500 A.D. and 1950 in the country and it has been affecting the population from time to time (Molla, 2008). In addition, famine and, recently, flood are the main problems that affect millions of people in the country almost every year. Even though the deterioration of the natural environment due to unchecked human activities and poverty has further worsened the situation, the causes of most of the disasters in the country are climate related (NMA, 2007)

### 3.2.2 Climate Systems in Ethiopia

Climate in Ethiopia is highly controlled by the seasonal migration of the Inter tropical Convergence Zone (ITCZ), which follows the position of the Sun relative to the earth and the associated atmospheric circulation. Furthermore, it is also highly influenced by the country`s complex topography (NMSA, 2001). According to Yohannes (2003) the traditional, the Köppen’s, the Throthwaite’s, therainfall regimes, and the agro climatic zone classification systems are the different ways of classifying the climatic systems of the country (Yohannes, 2003).

However, the traditional and agro-ecological classifications are the most common ones (Deressa,2010). The traditional classification, based on altitude and temperature, shows the presence of five climatic zones (NMA, 2007). Table 2.1 presents the physical characteristics of agro climatic zones.

**Table 1: Traditional Agro climatic Zones and their Physical Characteristics**

| **Zone** | **Altitude (meters)** | **Rainfall (mm/year)** | **Length of growing period (days)** | **Average annual temperature (oC)** |
|---|---|---|---|---|
| *Wurch (upper highlands)* | 3200 plus | 900 – 2200 | 211 - 365 | < 11.5 |
| *Dega (highlands )* | 2,300 –3,200 | 900 – 1,200 | 121 - 210 | 17.5/16 –11.5 |
| *Weyna Dega (midlands )* | 1,500 -2,300 | 800 -1,200 | 91-120 | 20.0-17.5/16 |
| *Kola (lowlands)* | 500-1500 | 200-800 | 46-90 | 27.5-20 |
| *Berha (desert)* | Under 500 | Under 200 | 0-45 | >27.5 |

**Source: MoA**

Alternatively, the agro-ecological zone (AEZ) classification system combining growing periods with temperature and moisture regimes put 18 major AEZs which are further sub-divided into 49 AEZs. According to MoA (2000), these AEZs can be grouped into 6major categories which include the following:

- Arid zone: This zone is less productive and pastoral and occupies 53.5 million hectares of land (31.5% of the country).
- Semi-arid: This agro-ecology is less harsh and occupies 4 million hectares of land (3.5 % of the country).
- Sub-moist: occupies 22.2 million hectares of land (19.7% of the country), highly threatened by erosion.
- Moist: This zone covers 28 million hectares of land (25% of the country) of the most important agricultural land of the country where cereals are the dominant crops.
- Sub-humid and humid: These zones cover 17.5 million hectares of Land (15.5% of the country) and 4.4 million hectares (4% of the country), respectively. They provide the most stable and ideal conditions for annual and perennial crops and are home to the remaining forest and wildlife, having the most biological diversity.
- Per-humid: This agro-ecology covers about 1 million hectares of land (close to 1%of the country) and is suited for perennial crops and forests.

Besides the aforementioned classification methods, the 2005/06 Ethiopian SAM, which is produced by EDRI, distinguished 5 AEZs which mainly differ depending on their climate, moisture regime and land use. This study mainly relies on this classification since the SAM for the country is constructed using this classification. These AEZs are: Humid Lowlands Moisture Reliable; Moisture Sufficient Highlands – Cereals Based; Moisture Sufficient Highlands – Enset Based; Drought-Prone (Highlands); and Pastoralist (Arid Lowland Plains) (EDRI, 2009a).

Climate conditions differ extensively across these AEZs. Mean annual rainfall ranges from about 2000 millimeters over some pocket areas in the southwest to less than

250millimeters over the Afar lowlands in the northeast and Ogaden in the southeast (Deressa, 2010; NMSA, 2001). While mean annual temperature ranges from 10˚C over Moist: This zone covers 28 million hectares of land (25% of the country) of the most important agricultural land of the country where cereals are the dominant crops.

- Sub-humid and humid: These zones cover 17.5 million hectares of land (15.5% of the country) and 4.4 million hectares (4% of the country), respectively. They provide the most stable and ideal conditions for annual and perennial crops and are home to the remaining forest and wildlife, having the most biological diversity.
- Per-humid: This agro-ecology covers about 1 million hectares of land (close to 1 % of the country) and is suited for perennial crops and forests.

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### 3.2.3 Climate Variability and Observed Trends in Ethiopia

As explained in NMA (2007), baseline climate that was developed using historical data of temperature and precipitation from 1971- 2000 for selected stations in Ethiopia showed a very high year-to-year variation in rainfall for the period 1951 to 2005 over the country expressed in terms of normalized rainfall. Over those periods (1951-2000), some of the years have been dry resulting in droughts and famine while others were characterized by wet conditions (NMA, 2007). During extreme drought conditions, it is common that many farmers in the country either die due to hunger or depend on foreign food aid to sustain their lives (Deressa *et al*., 2010). The observed trend in annual rainfall, however, remained more or less constant when averaged over the whole country (NMA, 2007).

Studies also indicate that there has been a very high temperature variation and change in its trend over time. Annual minimum temperatures for the period 1951 to 2005 expressed in terms of temperature differences from the mean and averaged over 40 stations showed a very high variability (NMA, 2007). The country experienced both warm and cool years over those 55 years even though the recent years are generally warmest compared to the early periods. Moreover, there has been a warming trend in the annual minimum temperature from 1951 to 2005. It has been increasing by about 0.37˚C every 10 years (NMA, 2007).

### 3.2.4 Projected Climate over Ethiopia

All models predicting future climate change scenario in Ethiopia put similar conclusion in the sense that temperature would increase over a period of time. However, they give conflicting results concerning the predicted level of precipitation- constant, decreasing and increasing level of projected precipitation level is generated using different models.

According to NMA (2007) forecast, the country will experience an increasing level of temperature and precipitation in the coming decades. Using the software MAGICC/SCENGEN (Model for the Assessment of Greenhouse-gas Induced Climate Change)/ (Regional and global Climate scenario generator) coupled model (Version 4.1) for three periods centered around the years 2030, 2050 and 2080, NMA (2007) generated 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 for the IPCC mid range emission scenario compared to the 1961-1990 normal. Furthermore, it states that a small increase in precipitation can be expected (NMA, 2007). Strzepek and McCluskey (2007) using five climate prediction models; Coupled Global Climate Model (CGCM2), the Hadley Centre Coupled Model (HadCM3), ECHAM, CSIRO2 and the Parallel Climate Model (PCM); based on two scenarios (i.e., A2 and B23) from the IPCC Special Report on Emission Scenarios (SRES) showed that temperature will increase in the coming decades in all of the models. However, precipitation might increase, decrease or become constant depending on the models used (Strzepek and McCluskey, 2007).

# CHAPTER FOUR

## Methodology and Data

Agriculture is the mainstay of the Ethiopian economy in terms of income, employment and generation of export revenue. Its contribution to GDP, although showing a slight decline over the years, has remained very high, at about 44 percent. From among the sub-sectors of agriculture, crop production is major contributor to GDP accounting for about 28 percent in 2005/06. The most important crops grown and their area are described below.

### 4.1 Descriptive Analysis

In this study, mode is selected as an appropriate statistical tool that is used in the process of examining and describing the impact of GDP and climate variables. The indicators used in this part of the analysis are used to see the questions listed below:

What should be done to transform adverse effect of weather into useful purpose?

Are there much higher levels of vulnerability to environmental determinants of health, wealth and other factors, and much lower levels of capacity available for coping with environmental change?

**Table 2 : GDP and Other Data**

| Year | GNI per capital ppp(current in international $) | GDP | GDP annual growth% | CO2 emission | Agricultural land (% of land area | Forest area (% of land area) |
|---|---|---|---|---|---|---|
| 1994 | 390 | 6,801.00 | 3.20 | 2,977.6 | 30.5 | 14.6 |
| 1995 | 410 | 7,523.70 | 6.10 | 2,152.5 | 30.5 | 14.4 |
| 1996 | 460 | 8,391.40 | 12.40 | 3,729.3 | 30.5 | 14.3 |
| 1997 | 460 | 8432.00 | 3.10 | 4,275.7 | 30.5 | 14.1 |
| 1998 | 440 | 7,675.00 | -3.50 | 5,027.5 | 30.5 | 14.0 |
| 1999 | 460 | 7,559.900 | 5.20 | 5,075.1 | 30.7 | 13.8 |
| 2000 | 480 | 8,091.40 | 6.10 | 5,830.5 | 30.7 | 13.7 |
| 2001 | 520 | 8,080.50 | 8.30 | 4,308.7 | 30.6 | 13.6 |
| 2002 | 520 | 7,707.00 | 1.50 | 4,481.1 | 30.3 | 13.4 |
| 2003 | 500 | 8,465.70 | -2.20 | 4,946.8 | 31.6 | 13.3 |
| 2004 | 570 | 9,945.60 | 13.60 | 5,243.8 | 31.6 | 13.1 |
| 2005 | 640 | 12,173.90 | 11.80 | 5,053.1 | 33.1 | 13.0 |
| 2006 | 720 | 15,000.80 | 10.80 | 5,419.8 | 33.7 | 12.9 |
| 2007 | 800 | 19,346.60 | 11.50 | 5,914.9 | 34.2 | 12.7 |
| 2008 | 880 | 26,571.30 | 10.80 | 6,369.6 | 35.1 | 12.6 |
| 2009 | 940 | 31,843.4 | 8.80 | 6,659.3 | 34.5 | 12.4 |
| 2010 | 1,040 | 29,385.6 | 12.60 | 6,494.3 | 35.0 | 12.3 |
| 2011 | 1,150 | 31,367.6 | 11.20 | - | 35.7 | 12.2 |
| 2012 | 1,240 | 42,805.2 | 8.70 | - | 36.5 | 12.0 |
| 2013 | 1,350 | 46,869.3 | 10.40 | - | 37.4 | 12.9 |

**Source: world bank**

**Figure 1 : GNI per capital ppp (current in international $) verses Year**

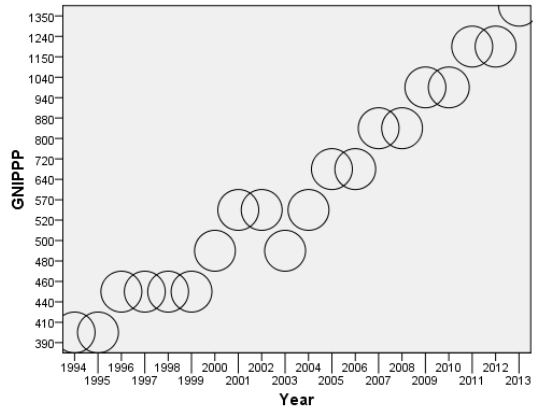



**Figure 2 : GDP verses Year**

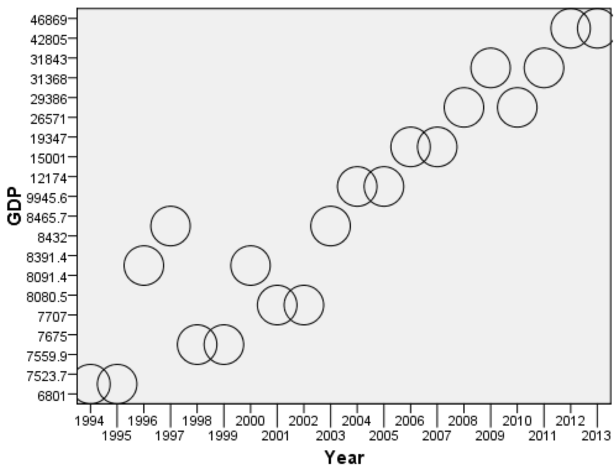
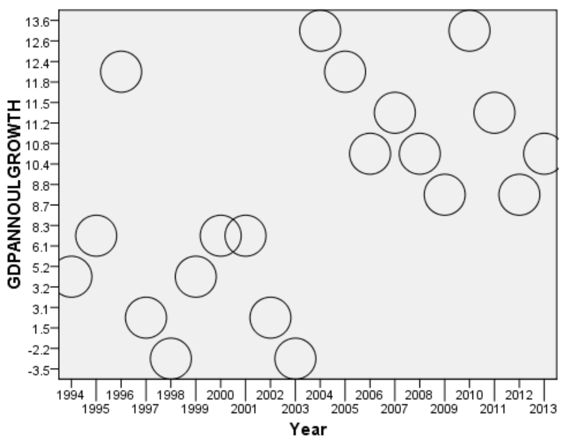
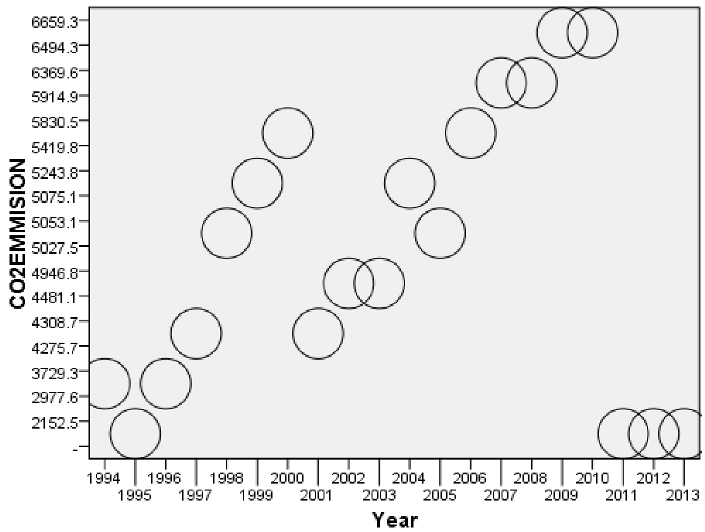



**Figure 3 : GDP Annual Growth verses Year**



As per the above three figures (Figure 1, 2 and 3), even if Ethiopia is among the poorest nations of the world, it has practiced speedy economic growth in recent years. Figure 1 indicated that GNI per capital ppp (current in international $) increases as the years increases. It is said that in many popular news and international organizations the real GDP has been growing by around 11% in the period 2005 - 2010.

Figure 4 : **CO2 Emission verses Year**

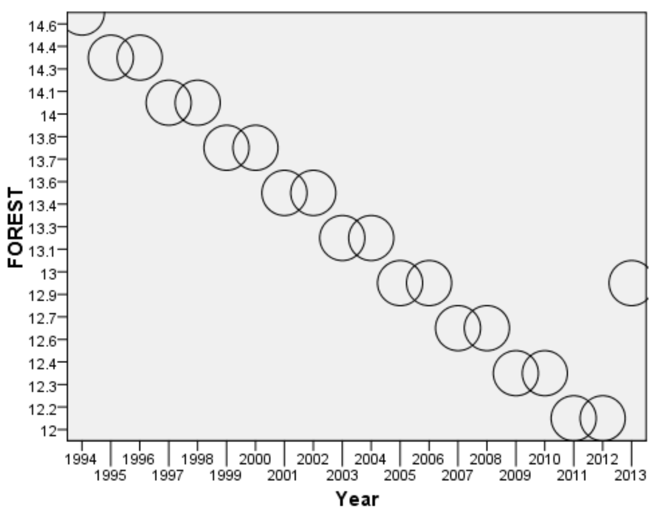



For the literature review, it is found that temperature and precipitation patterns, extreme climate conditions, surface, water runoff, soil moisture and CO2 concentration are some of the variables which can considerably affect agricultural development. Elevated CO2 concentration alone does have a positive impact on crop (plant) production by stimulating plant photosynthesis and water use efficiency- the amount of water required to produce a unit of biomass or yield. CO2 Emission increased in the period 2000 – 2010 in Ethiopia.

**Figure 5: Agricultural Land verses Year**


Agricultural land refers to the share of land area that is arable, under permanent crops, and under permanent pastures. (data.worldbank.org.).The agricultural land usage shows almost a constant trend until 1998's after that an increasing pattern perceived with consecutive three or four years having the same trend it implies that the agricultural sector shows an increasing land usage for the production of output in the economy.

**Figure 6: Forest Land verses Year**

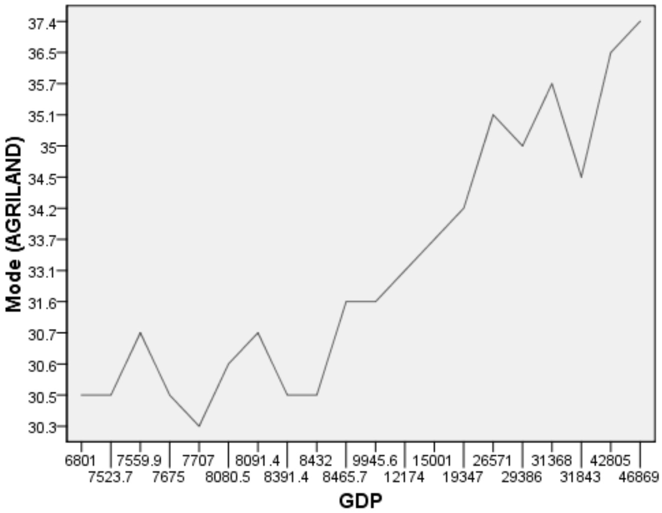


Forest area is a land under natural or planted stands of trees of at least 5 meters in situ, whether productive or not, and excludes tree stands in agricultural production systems (for example, in fruit plantations and agro forestry systems) and trees in urban parks and gardens. (www.trading econmicis.com/ Ethiopia/). The land for forest shows a continuous decline throughout the year Until 2012 and it increase for the year 2013.

**Figure 7: CO2 Emission verses GDP**

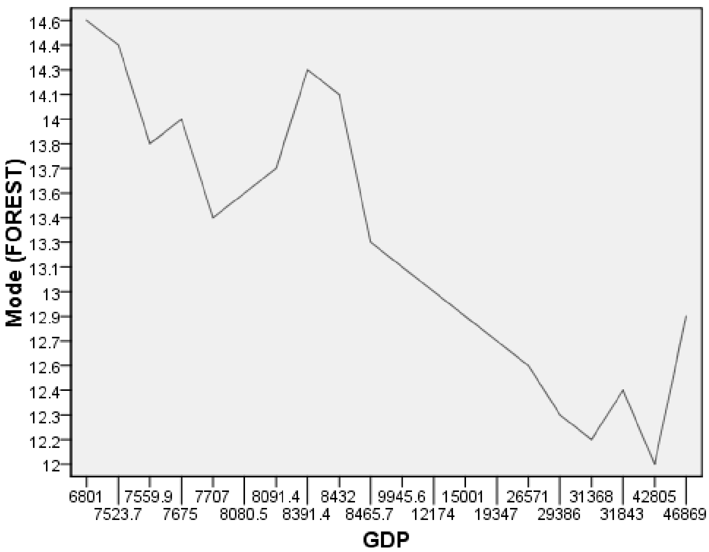

According to the World Bank CO2 emissions are those stemming from the burning of fossils fuels and the manufacture of cement. They include CO2 products during consumption of solid , liquid and gas flaring. Carbon dioxide also enters the Atmosphere from burning wood and waste materials and from some industrial processes such as cement production.(en.wikipedia.org/wiki/CO2 Emission).On the other hand GDP is the value of a country's overall output of goods and services (typically during one fiscal year) at market prices, excluding net income from abroad. As the GDP of the country goes up the CO2 emission shows a similar trend but with some fluctuation , this shows that GDP growth of the country result in rising the emission of CO2 as a result of as the number of manufacturing industry increases which have a positive result in the contribution of GDP of a country but result in too much emission of CO2.

Figure 8: Agricultural Land verses GDP




The contribution of agricultural production shows almost the same for the growth of GDP for the first nine years relative to the period after that, and it increase with fast rate for the next eleven years result in high GDP growth. This indicate that contribution of crop production, pastures to the GDP of a country is significantly high.

Figure 9: Forest Land verses GDP



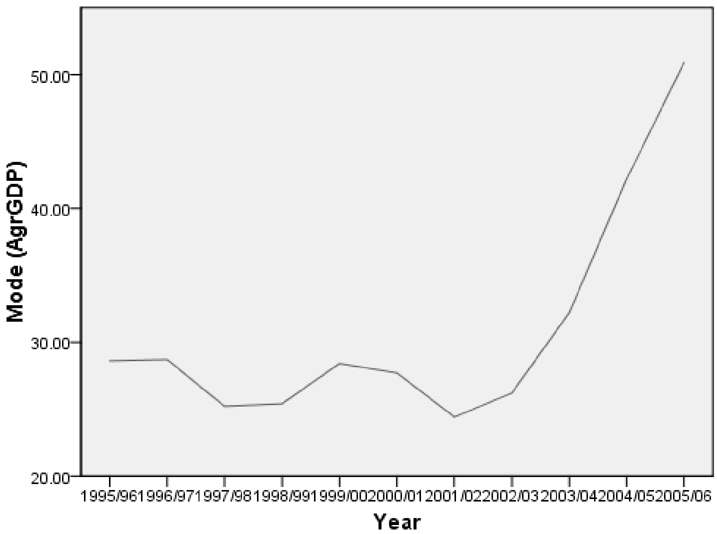

In an agrarian society like Ethiopia, forestry can play significant role in economic development. The forestry GDP as a proportion of the whole economy and in relation to agriculture has been very low. The contribution of forestry to GDP shows a decreasing trend for almost the whole period.

Table 3 : Contribution of Agriculture to GDP (1995/96- 2005/06) (in 000 ETB)

| Year | GDP at Current Market Prices (in Million ETB) | Agricultural GDP (in Million ETB) | Crop GDP (in Million ETB) | Agriculture contribution to GDP | Crop contribution GDP |
|---|---|---|---|---|---|
| 1995/96 | 53.6 | 28.6 | 17.3 | 0.53 | 0.32 |
| 1996/97 | 55.5 | 28.7 | 16.7 | 0.52 | 0.30 |
| 1997/98 | 53.4 | 25.2 | 14.5 | 0.47 | 0.27 |
| 1998/99 | 57.4 | 25.4 | 15.5 | 0.44 | 0.27 |
| 1999/00 | 64.4 | 28.4 | 17.7 | 0.44 | 0.28 |
| 2000/01 | 65.7 | 27.7 | 16.3 | 0.42 | 0.25 |
| 2001/02 | 63.5 | 24.4 | 13.1 | 0.39 | 0.21 |
| 2002/03 | 68.9 | 26.2 | 14.9 | 0.38 | 0.22 |
| 2003/04 | 81.7 | 32.2 | 19.9 | 0.39 | 0.24 |
| 2004/05 | 98.4 | 42.2 | 27.3 | 0.43 | 0.28 |
| 2005/06 | 115.6 | 50.9 | 32.2 | 0.44 | 0.28 |
| | **GDPCMP** | **AgrGDP** | **CropGDP** | **AgrCGDP** | **CropCGDP** |

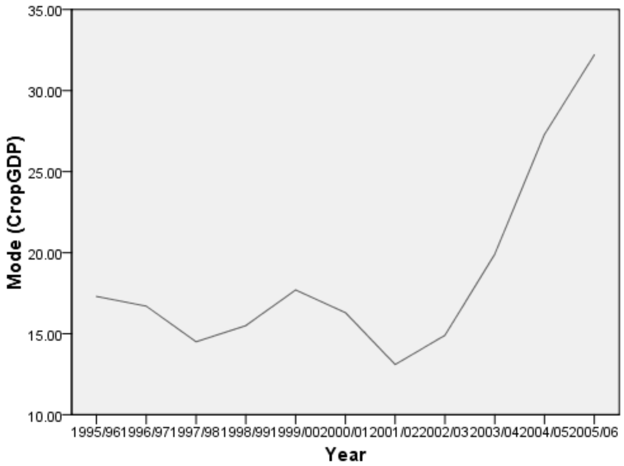
***Source: FDRE***

**Figure 10: Agricultural GDP (in Million ETB) verses Year**




The contribution of Agriculture to GDP has shown a small change until 2002/ 2003 and increase for the next four years with fast rate.

**Figure 11: Crop GDP (in Million ETB) verses Year**




The contribution of crop production to GDP of a country considerably grown fast in the year after 2003/2004 relative to the period before ,that indicate crop production in the country.

**Figure 12: Agriculture contribution to GDP verses Year**

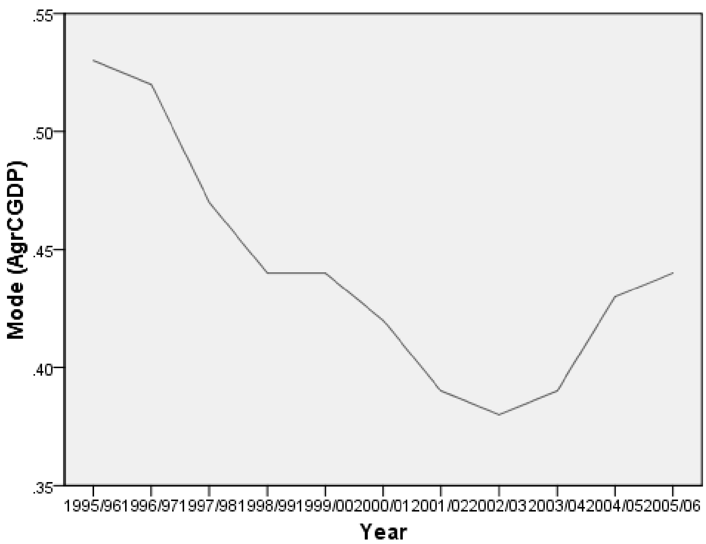
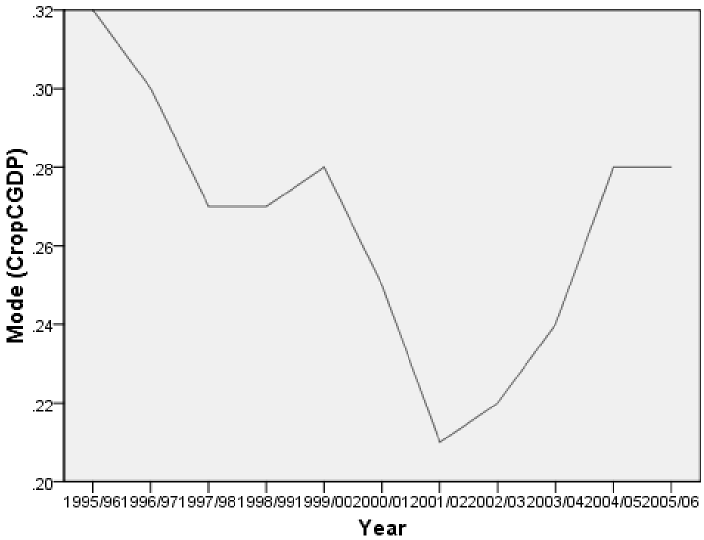


Figure 13: Crop contribution GDP verses Year




### 4.2 Econometric Analysis

It is specified that increasing temperatures and changes in rainfall pattern are also impacting the agricultural sector. Although there are ongoing studies to understand the impacts, some studies have shown certain trends. Researchers use several methods to assess the impact of climatic variability ranging from the traditional approach of historical data analyses by various statistical tools to controlled environment studies and Crop Growth Simulation models in order to understand the impact of temperature, rainfall and CO2 on crop growth and yield (Aggarwal, 2008).

It is intended to collect and use secondary data regarding weather data and GDP per capital from various international and loc al institutes and ministries: World Bank data hub, Ministry of Finance and Economic Development, Ministry of Agriculture as well as Central Stastics Authority. GDP per capita in constant prices or economic growth data spans over a 30 year period will be composed. Additionally, it is proposed to collect data on rain fall, temperature, crop growth and other information and data.

**Data Analysis Method**

- In the study, the set of necessary data will be analysed with statistical tools and the data will be presented in appropriate research format. In the part of descriptive analysis of this is study, ratios, percentages, means, variances and standard deviations will be used in the process of examining and describing growth, impacts of weather, their relationships and effects in agriculture productivity as well as economic performance.

- During this economical analysis, the researcher intended to lower the adverse impact of weather on growth by administering its effects. After the analysis is over the return to normal economic growth depends on the dose pertinent and appropriate weather conditions. The concepts and principles developed in dealing with simple linear regression (i.e. one explanatory variable) may be extended to deal with several explanatory variables. In this case, the idea is to find out the impact, strength and responsiveness and relationship among the variables. The general purpose of selecting this model is to learn more about the relationship between several independent or predictor variables and a dependent variable. The dependent variable (growth) as GDP per capita (constant prices) will be tested in relationship to the factors (explanatory variables). A multiple regression equation for predicting Y can be expressed a follows:

$$\mathbf{E(Y_1/X_{2i}, X_{3i}) = Y' + \alpha_1 + \alpha_2 X_{2i} + \alpha_3 X_{3i}}$$

The explanation of the equation:

Each $X_j$ score for an individual case is multiplied by the corresponding $\alpha_j$ value, the products are added together, and the constant $\alpha_1$ is added to the sum. The result is Y′, the predicted Y value for the case. For a given set of data, the values for $\alpha_1$ and the $\alpha_j$s are determined scientifically to minimize the sum of squared deviations between predicted Y′ and the actual Y scores. (Gujarati, 2007).

The following is a detailed summary of the definition of the various variables used in the paper.

- **GDP per capita (constant 1995 in Birr):** GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources.
- **Climate change:** is a change in the statistical distribution of Weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i.e., more or fewer extreme weather events).

  Climate change is caused by factors such as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Certain human activities have also been identified as significant causes of recent climate change, often referred to as "warming”. Scientists actively work to understand past and future climate by using observations and theoretical models. A climate record extending deep into the Earth's past has been assembled, and continues to be built up, based on geological evidence from borehole temperature profiles, cores removed from deep accumulations of ice, floral and faunal records, glacial and per glacial processes, stable-isotope and other analyses of sediment layers, and records of past sea levels.
- **Carbon Dioxide Emission:** emissions of CO2 from burning oil, coal and gas for energy use. Carbon dioxide also enters the Atmosphere from burning wood and waste materials and from some industrial processes such as cement production. carbon dioxide (CO2) makes up the largest share of "greenhouse gases". The addition of man-made greenhouse gases to the Atmosphere disturbs the earth's radiative balance. This is leading to an increase in the earth's surface temperature and to related effects on climate, sea level rise and world agriculture.

- Rainfall: The quantity of water, usually expressed in millimeters or inches, that is precipitated in liquid form in a specified area and time interval. Rainfall is often considered to include solid precipitation such as snow, hail, and sleet as well. Changes in rainfall and other forms of precipitation will be one of the most critical factors determining the overall impact of climate change. Rainfall is much more difficult to predict than temperature but there are some statements that scientists can make with confidence about the future. (Source : WWW.theguardian.com)

Table 4: Study data for multiple regression analysis – source world bank and Ethiopian Metrological Agency

| Time | GDP (current US$) | GDP per capita (current US$) | GNI per capita, Atlas method (current US$) | CO2 emissions (metric tons per capita) | Agricultural land (% of land area) | Agriculture , value added (annual % growth) | Arable land (% of land area) | CO2 emissions (kg per 2005 US$ of GDP) | CO2 emissions (kg per 2011 PPP $ of GDP) | CO2 emissions (kg per PPP $ of GDP) | rainfall | tem perat ure | Humid ity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 11952306257 | 248.7847805 | 250 | 0.062817817 | 51.14623 | 5.425244 | 9.763851 | 0.444352 | 0.098061 | 0.15139 | 21.7 | 25.4 | 44 |
| 1991 | 13217387675 | 265.7088043 | 240 | 0.060006132 | 51.00636 | 2.472221 | 9.673025 | 0.473271 | 0.104443 | 0.156052 | 48.3 | 8.9 | 54 |
| 1992 | 10300890065 | 199.9176811 | 220 | 0.057575257 | 50.95822 | -1.56645 | 9.673025 | 0.515031 | 0.113659 | 0.166036 | 53.4 | 26.4 | 41 |
| 1993 | 8669071081 | 162.4703454 | 210 | 0.05676655 | 30.54 | 6.586934 | 10 | 0.46477 | 0.102567 | 0.14635 | 115.4 | 8.6 | 48 |
| 1994 | 6801044147 | 123.2074264 | 160 | 0.053942147 | 30.472 | -2.57982 | 9.932 | 0.442768 | 0.097712 | 0.136515 | 30.8 | 25.2 | 49 |
| 1995 | 7523672045 | 131.9398062 | 140 | 0.037748091 | 30.5 | 3.766697 | 9.94 | 0.301599 | 0.066558 | 0.09109 | 21.9 | 8 | 44 |
| 1996 | 8391423399 | 142.6746043 | 150 | 0.063407832 | 30.5 | 16.96199 | 9.927 | 0.464779 | 0.102569 | 0.137856 | 53.6 | 25.1 | 50 |
| 1997 | 8431951046 | 139.1772258 | 140 | 0.070574784 | 30.492 | 2.002147 | 9.9 | 0.51668 | 0.114023 | 0.150672 | 119 | 8.4 | 74 |
| 1998 | 7675000360 | 123.0876527 | 130 | 0.080627733 | 30.508 | -9.64033 | 9.95 | 0.629282 | 0.138872 | 0.181539 | 96.4 | 24.4 | 40 |
| 1999 | 7559865039 | 117.8303645 | 120 | 0.079102494 | 30.676 | 3.397766 | 10 | 0.604065 | 0.133307 | 0.171811 | 32.2 | 10.7 | 59 |
| 2000 | 8091384891 | 122.551807 | 120 | 0.088308985 | 30.662 | 3.053163 | 10 | 0.654245 | 0.144381 | 0.181949 | 34.5 | 25.5 | 82 |
| 2001 | 8080496318 | 118.9062532 | 120 | 0.063403821 | 30.6054 | 9.624307 | 9.9084 | 0.446423 | 0.098518 | 0.121372 | 6.3 | 10.4 | 68 |
| 2002 | 7707034813 | 110.1818052 | 120 | 0.064062617 | 30.268 | -1.87555 | 9.6 | 0.457352 | 0.10093 | 0.122462 | 57.4 | 24.4 | 32 |
| 2003 | 8465744001 | 117.5966562 | 110 | 0.068715182 | 31.607 | -10.4849 | 10.928 | 0.516036 | 0.113881 | 0.135468 | 171.2 | 4.4 | 57 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2004 | 9945571030 | 134.2795789 | 130 | 0.070799012 | 31.607 | 16.94482 | 10.928 | 0.48165 | 0.106292 | 0.123067 | 95.5 | 26.2 | 57 |
| 2005 | 12173919387 | 159.8314365 | 160 | 0.066342512 | 33.101 | 13.54294 | 12.364 | 0.415078 | 0.091601 | 0.102761 | 37.8 | 9.8 | 69 |
| 2006 | 15000803171 | 191.6040212 | 180 | 0.06922699 | 33.691 | 10.90878 | 12.923 | 0.401679 | 0.088644 | 0.096478 | 18.1 | 26.2 | 36 |
| 2007 | 19346646117 | 240.5081531 | 220 | 0.073530817 | 34.219 | 9.448317 | 13.396 | 0.393311 | 0.086797 | 0.092026 | 146.4 | 9.8 | 56 |
| 2008 | 26571320718 | 321.604188 | 270 | 0.07709377 | 35.077 | 7.501473 | 14.038 | 0.382302 | 0.084368 | 0.087736 | 38.3 | 24.3 | 68 |
| 2009 | 31843357840 | 375.3429575 | 330 | 0.078493947 | 34.513 | 6.36096 | 13.606 | 0.367353 | 0.081069 | 0.083662 | 54 | 8.5 | 75 |
| 2010 | 29385611867 | 337.3961428 | 370 | 0.07456497 | 34.985 | 5.130303 | 13.948 | 0.318302 | 0.070244 | 0.071624 | 70.9 | 23.2 | 41 |
| 2011 | 31367606700 | 350.8953116 | 390 | 0.07456497 | 35.683 | 9.014985 | 14.565 | 0.318302 | 0.070244 | 0.071624 | 55 | 11.3 | 57 |
| 2012 | 42805215879 | 466.6494385 | 410 | 0.07456497 | 36.488 | 4.922097 | 15.346 | 0.318302 | 0.070244 | 0.071624 | 87 | 27.3 | 67 |
| 2013 | 46869297571 | 498.0756751 | 470 | 0.07456497 | 36.488 | 4.922097 | 15.346 | 0.318302 | 0.070244 | 0.071624 | 78 | 8.9 | 58 |

### Regression Analysis

Table 5: Study data for multiple Variables Entered/Removed a

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | humudity, rainfall, co2emissionsperkg, tempreture [b] | . | Enter |

a. Dependent Variable: GDPCURRENT

b. All requested variables entered.

Table 6: Study data Model Summary

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | .790[a] | .624 | .544 | 8068105313.684 |

a. Predictors: (Constant), humudity, rainfall, co2emissionsperkg, tempreture

Table 7: Study data ANOVAa

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 2048838704364048600000.000 | 4 | 512209676091012150000.000 | 7.869 | .001[b] |
| | Residual | 1236792143701175400000.000 | 19 | 65094323352693440000.000 | | |
| | Total | 3285630848065224000000.000 | 23 | | | |

a. Dependent Variable: GDPCURRENT

b. Predictors: (Constant), humudity, rainfall, co2emissionsperkg, tempreture

Table 8: Study data coefficientsa

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 28782256492.362 | 11593408245.618 | | 2.483 | **.023** |
| | co2emissionsperkg | -94620772094.142 | 17775705188.291 | -.777 | -5.323 | **.000** |
| | rainfall | 63827603.677 | 42541294.216 | .225 | 1.500 | .150 |
| | tempreture | 376214271.110 | 226480735.657 | .266 | 1.661 | .113 |
| | humudity | 340447331.095 | 135797069.043 | .379 | 2.507 | **.021** |

a. Dependent Variable: GDPCURRENT

The above data showed that the ways through which climate change can affect economic growth on humidity and co2 patterns as their significant value is less than 0.05%. According to the literature, temperature and precipitation patterns, extreme climate conditions like floods and drought, surface water runoff, soil moisture and $CO_2$ concentration are some of the important climate variables which can substantially affect agricultural production. But as the above data showed humidity and $CO_2$ are the basic factors. This can be taken as evidence of irrigation is very important as rainfall cannot be the ultimate choice.

As indicated above, it has been further assessed that Ethiopia is not an exception to be affected by these variables. The class of approaches used to assess the impact of climate change can be seen under partial equilibrium model. Partial equilibrium models include crop-simulation, AEZ and Ricardian models. The impact of climate change on agriculture is indicated to be highly complicated. Some countries (or regions) might benefit as a result of warming, whereas others may lose in terms of agricultural production. The impact may not even be uniformly distributed within a nation if it has different AEZs or farming methods.

As well, some of the studies revealed that adaptation (like irrigation) may reduce the harmful effects of climate change. In Ethiopia, most of the studies concluded that increasing temperature and decreasing precipitation are damaging to agriculture. All of the studies, however, focused only on the impact on agriculture and they made use of a partial equilibrium analysis which assumes that there is no interrelationship among sectors.

**Investigation**

It is a known fact that multicollinearity is a matter of degree. There is no certain test that it is or is not a problem. But, there are several warning signals:

- None of the t-ratios for the individual coefficients is statistically significant, yet the overall F statistic is. But in this case the t-ratio for each coefficient is statistically significant.

- It has been tried a slightly different specification of a model using the same data. It has been observed using seemingly harmless changes (dropping a variable) produce no big shifts.

It has also tried to look at the correlations of the estimated coefficients; but not the variables. High correlations between pairs of coefficients indicate possible collinearity problems. Using spss, it has got the following by running the vce, corr command after a regression.

Table 9: Study data Correlations matrix

| | | | GDPCURRENT | co2emission | rainfall | tempreture | humudity |
|---|---|---|---|---|---|---|---|
| Kendall's tau_b | GDPCURRENT | Correlation Coefficient | 1.000 | .293* | .174 | .015 | .139 |
| | | Sig. (2-tailed) | . | .047 | .234 | .921 | .345 |
| | | N | 24 | 24 | 24 | 24 | 24 |
| | co2emission | Correlation Coefficient | .293* | 1.000 | .132 | .089 | .341* |
| | | Sig. (2-tailed) | .047 | . | .371 | .550 | .022 |
| | | N | 24 | 24 | 24 | 24 | 24 |
| | rainfall | Correlation Coefficient | .174 | .132 | 1.000 | -.204 | .022 |
| | | Sig. (2-tailed) | .234 | .371 | . | .164 | .881 |
| | | N | 24 | 24 | 24 | 24 | 24 |
| | tempreture | Correlation Coefficient | .015 | .089 | -.204 | 1.000 | -.192 |
| | | Sig. (2-tailed) | .921 | .550 | .164 | . | .196 |
| | | N | 24 | 24 | 24 | 24 | 24 |
| | humudity | Correlation Coefficient | .139 | .341* | .022 | -.192 | 1.000 |
| | | Sig. (2-tailed) | .345 | .022 | .881 | .196 | . |
| | | N | 24 | 24 | 24 | 24 | 24 |

*. Correlation is significant at the 0.05 level (2-tailed).

Table 10: Study data Collinearity Diagnostics a

| Model | Dimension | Eigenvalue | Condition Index | Variance Proportions | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | (Constant) | co2emissionsperkg | rainfall | tempreture | humudity |
| 1 | 1 | 4.502 | 1.000 | .00 | .00 | .01 | .01 | .00 |
| | 2 | .319 | 3.756 | .00 | .00 | .50 | .17 | .00 |
| | 3 | .128 | 5.928 | .01 | .01 | .38 | .44 | .12 |
| | 4 | .036 | 11.225 | .00 | .79 | .05 | .18 | .35 |
| | 5 | .015 | 17.375 | .99 | .20 | .06 | .21 | .53 |

a. Dependent Variable: GDPCURRENT

Table 11: Study data basic definitions extracted from World Bank data

| Indicator Name | Long definition |
|---|---|
| GDP (current US$) | GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used. |
| GDP per capita (current US$) | GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. |
| GNI per capita, Atlas method (current US$) | GNI per capita (formerly GNP per capita) is the gross national income, converted to U.S. dollars using the World Bank Atlas method, divided by the midyear population. GNI is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. GNI, calculated in national currency, is usually converted to U.S. dollars at official exchange rates for comparisons across economies, although an alternative rate is used when the official exchange rate is judged to diverge by an exceptionally large margin from the rate actually applied in international transactions. To smooth fluctuations in prices and exchange rates, a special Atlas method of conversion is used by the World Bank. This applies a conversion factor that averages the exchange rate for a given year and the two preceding years, adjusted for differences in rates of inflation between the country, and through 2000, the G-5 countries (France, Germany, Japan, the |

| | |
|---|---|
| | United Kingdom, and the United States). From 2001, these countries include the Euro area, Japan, the United Kingdom, and the United States. |
| GNI per capita, PPP (current international $) | GNI per capita based on purchasing power parity (PPP). PPP GNI is gross national income (GNI) converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GNI as a U.S. dollar has in the United States. GNI is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. Data are in current international dollars based on the 2011 ICP round. |
| CO2 emissions (metric tons per capita) | Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. |
| CO2 emissions (metric tons per capita) | Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. |
| Agricultural land (% of land area) | Agricultural land refers to the share of land area that is arable, under permanent crops, and under permanent pastures. Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded. Land under permanent crops is land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee, and rubber. This category includes land under flowering shrubs, fruit trees, nut trees, and vines, but excludes land under trees grown for wood or timber. Permanent pasture is land used for five or more years for forage, including natural and cultivated crops. |
| Agricultural methane emissions (% of total) | Agricultural methane emissions are emissions from animals, animal waste, rice production, agricultural waste burning (nonenergy, on-site), and savannah burning. |
| Agricultural methane emissions (thousand metric tons of CO2 equivalent) | Agricultural methane emissions are emissions from animals, animal waste, rice production, agricultural waste burning (nonenergy, on-site), and savannah burning. |
| Agricultural nitrous oxide emissions (% of total) | Agricultural nitrous oxide emissions are emissions produced through fertilizer use (synthetic and animal manure), animal waste management, agricultural waste burning (nonenergy, on-site), and savannah burning. |
| Agriculture, value added (annual % growth) | Annual growth rate for agricultural value added based on constant local currency. Aggregates are based on constant 2005 U.S. dollars. Agriculture corresponds to ISIC divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock |

| | |
|---|---|
| | production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. |
| Arable land (% of land area) | Arable land includes land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for mowing or for pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded. |
| CO2 emissions (kg per 2005 US$ of GDP) | Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. |
| CO2 emissions (kg per 2011 PPP $ of GDP) | Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. |
| CO2 emissions (kg per PPP $ of GDP) | Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. |

Economic research on climate impacts discovered that only a partial portion of the market economy is exposed to climate change: agriculture, coastal resources, energy, forestry, tourism, and water. These sectors make up about 5 percent of the global economy and their share is expected to shrink over time. As a result, even if climate change turns out to be large, there is a limit to how much damage climate can do to the economy. Most sectors of the global economy are not climate sensitive.

Certainly, the studies indicated that economies of some countries are more vulnerable to climate change than the global average. In this case, Ethiopia as a developing country in general has a larger share of their economies in agriculture and forestry. It also tend to be in the low latitudes where the impacts to these sectors will be the most severe. The low latitudes tend to be too hot for the most profitable agricultural activities and any further warming will further reduce productivity. Up to 80 percent of the damages from climate change may be concentrated in low latitude countries.

In relation to ecosystem change it will result in massive shifts around the planet. Some of these shifts are already reflected in agriculture and timber but they go beyond the impacts to these market sectors. Parks and other conservation areas will change. Animals will change their range.

This study indicated that the need of the quantity of water, usually expressed in millimeters or inches, which is precipitated in liquid form in a specified area and time interval. We know that rainfall is often considered to include solid precipitation such as snow, hail, and sleet as well. Changes in rainfall and other forms of precipitation will be one of the most critical factors determining the overall impact of climate change. It is known that rainfall is much more difficult to predict than temperature but there are some statements that scientists can make with confidence about the future. However, in this case the rainfall is not the major effect rather humidity is the essential. So the use of irrigation and other means are necessary in this country.

# CHAPTER FIVE

## Summary, Conclusion and Recommendation

Basically, this study was designed to study the impact of climate change on the performance and growth of the Ethiopian Economic: Time series analysis. It assessed the impact on per capital growth via climate conditions. As indicated on chapter one the major objective of the study is to enhance the agricultural productivity of the country. In terms of development advancement, the country is supposed to seek collaboration with countries that have advanced agricultural technologies suitable for harsh climates. In this regard, the study found that there is need to deepen study in areas of research on agricultural technologies and water conservation.

In addition, the specific objective was to find out the pattern of the climatic condition of the country and to analyze constraints and opportunities of the economic integration. Noticeably, rain-fed agriculture has limits in many cases. It cannot be relied on to feed growing populations or be a source of sustainable economic growth. Furthermore, there is increasing competition for water for various uses especially with rapid growth in urban populations. In this highlight, therefore, the study specified the extent of the investment in irrigation infrastructure and also water-conserving technologies such as drip irrigation, dam construction and rain water harvesting.

It was explained that Ethiopia like other Least Developed Countries is the most vulnerable country find herself in the worst situation. In the study, it showed climate change is already affecting economic growth, health indicators, water availability, food production and the fragile ecosystems. As a result, yields from rain-fed agriculture in Ethiopia had been reduced. Water shortages and the shrinking of land suitable for agriculture would cause other social and political disruptions, including forced migration and conflict. These are dire marks which demand serious attention as we move closer to the historic summit on climate change and the country’s economic performance. The study contributes to that effort by highlighting the gravity of the situation for Ethiopia as well as highlighting some possible actions to meet the challenge.

This study explained that the ways through which climate change can affect economic growth on humidity and $CO_2$ patterns as their significant value is less than 0.05%. According to the literature, temperature and precipitation patterns, extreme climate conditions like floods and drought, surface water runoff, soil moisture and $CO_2$ concentration are some of the important climate variables which can substantially affect agricultural production. But as the above data showed humidity and $CO_2$ are the basic factors. This can be taken as evidence of irrigation is very important as rainfall cannot be the ultimate choice.

As recommendation, it is wise to know the biggest threat climate change poses to economic growth. It is important to understand that it is not from climate damages or efficient mitigation policies, but rather from immediate, aggressive, and inefficient mitigation policies. Immediate aggressive mitigation policies should be implemented in this country and it should lead to mitigation costs equal to some specific amount that ought to be done thought pertinent study. In this case the lesson from Indian I necessary and should be communicated with researchers and well known scholars.

In this case, a pertinent adaptation strategies such as a change in the planting date and variety further reduced the extent of loss caused by high temperature should be necessary. Adaptation strategies can assist in providing some relief in future provided these strategies could be operational in field. Possible recommendations include:

- Enlarging production by enhanced crop management, improved/adverse climate tolerant diversities, superior seed sector, technology distribution mechanisms, capital and information should get attention
- In this case it is important to handle the importance of the watershed management projects and their arrangements and it should be implemented effectively and professionally with efficient coordination
- Superior variety and better nitrogen and water management with additional nitrogen fertiliser
- Conservation agriculture is one of the most important strategies for combating climate change adverse impacts.

- Increasing the income from agricultural enterprises by suitable actions such as accelerated development of location-specific fertiliser practices, improved fertiliser supply and distribution system, improved water and fertiliser use.
- Improved risk management through an early warning system and policies that encourage crop insurance can provide protection to the farmers if their farm production is reduced due to natural calamities.
- Employ of information technology that greatly facilitate an early warning system for pest and disease incidence
- Recycling waste water and solid wastes in agriculture since fresh water supplies are limited and has competing uses, and would become even more constrained in changed global climate.
- Harvest and post-harvest management for minimising the losses due to extreme climatic events or mean climate change conditions. Providing community-based post harvest storage spaces at village level can help the farmer to save the produce from exposure to any climate related extreme event. Research efforts are required to design the storage structures and efficient processes for changed climate.

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