ENERGY CONSUMPTION, CARBON DIOXIDE EMISSIONS AND ECONOMIC GROWTH IN ETHIOPIA: A VAR ANALYSIS APPROACH.

BY: ENDEG TEKALIGN

JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

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Acronym

CRGE	Clean Renewable Green Energy
CO_2	Carbon Dioxide Emissions
VAR	Vector Autoregressive
ECM	Error Correction Model
VECM	Vector Error Correction Model
OECD	Organization for Economic Cooperation and Development
IEA	International Energy Agency
GTP	Growth and Transformation Plan
GDP	Gross Domestic Product
MoWE	Ministry of Water and Energy
MME	Ministry of Mines and Energy

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Abstract

This study has attempted to investigate the relationship between energy consumption, CO_2 emissions, and economic growth in Ethiopia in A VAR analysis approach. It uses time series data from 1970/71 to 2010/11. The finding indicates variables of interests are integrated of the same order I(1). Co-integration test approves existence of one co-integrating equation. The Validity of the model was approved by diagnostic tests. The long run relationship and causality result shows energy consumption causes Economic Growth in Ethiopia. The functional relationship supports growth hypothesis. In the long run model there is no significant relation between Co_2 emissions and economic growth as well as in causality result. The result shows Economic Growth in Ethiopia can be achieved without degrading the quality of the environment coming from co_2 emissions. Based on the outcome shocks to energy consumption have a negative impact on economic growth. To secure the sustenance of Co_2 emissions free economic growth in Ethiopia, cost effective, carbon free, and efficient utilization of renewable energy consumption based on the country comparative advantage that consider alternative use of resources are advisable like Hydro and Geothermal.

Key words: Energy consumption, CO_2 Emission, Economic Growth, VAR.

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

The long term trend of economic growth over the last 200 years shows continuous increment over time. To produce such output combinations of physical, natural, social and human capital were used as input. In the some way, energy consumption and carbon dioxide emission were increased in the world so rapidly for the last 200 years. If we compare the growth of CO_2 emissions and the growth of energy use, both on per capita basis CO_2 emission grew more slowly than energy consumption from 1970 to 1990. Since 2000, the variables are going parallel, indicating no further CO_2 savings given the greater use of coal again. Wind and solar contributions are not large enough to make an appreciable difference in CO_2 levels (Alex *et al.*, 2010).

Thus, the African continent while sheltering 15% of the world population, accounts for only 3% of world energy consumption, and the average energy consumption of an African is six times less than that recorded in the world. Contrary to this, USA constitutes 5 percent of the world's population but consume 24 percent of the world's energy. On average, one American consumes as much energy as 2 Japanese, 6 Mexicans, 13 Chinese, 31 Indians, 128 Bangladeshis, 307 Tanzanians and 370 Ethiopians. Sub Saharan Africa account for 9 percent of world population generate 2.5 percent of world economic activity. The region consumes 2.7% of world commercial primary energy. It has 2% of world proven oil reserves, 3% of world proven gas reserves and 6% of world proven coal reserves. There is a large hydropower potential, even able to export for other region in excess of local need (UNEP, 2006).

As compared to other African country Ethiopia share 2.4 percent of total gross domestic product, and, 6.9 percent of total agricultural gross domestic product on average over 2003 to 2011. Over the same period within Eastern Africa the country shares 18.8 percent of total gross domestic product and 29.2 percent of agricultural gross domestic product. In Ethiopia, the agricultural sector absorbs 85 percent of the total employment and contributes 46.3 percent of gross domestic product. It is followed by the service sector which account for 10 percent of total employment and contributes 43 percent of gross domestic product, and the industry account 5 percent of employment and 10.7 of gross domestic product and in terms of population the country was the second populous country in Africa (World Bank, 2013).

According to Ministry of Mines and Energy of Ethiopia (May, 2010) the composition of energy consumption in the country traditional energy sources accounts 94 percent and modern energy sources 6 percent. On average per capita electricity consumption is 28KWH. Beside this, it show the existence of great exploitable potential in natural Gas, coal, wind, solar, geothermal (MW) 5000-7000, hydro (MW) 45000. The CRGE strategy projects that the contribution of agriculture will diminish from 42% to 29%, indicating migration of jobs from the agriculture sector to industry and services. The GTP explicitly recognizes that environment is a vital and important pillar of sustainable development, and implementation of environmental laws is part of building the green economy (MoFED. 2010).

The question of sustaining the economic growth without despoiling environment, resource constraint, steady state of income and environmental quality was an issue for both social and natural science scholars. The growth in economy requires more energy and other resources this in return generates larger quantity of emission to the environment. The accumulation of pollutant and the extraction of resources will lead degradation of environment, loss of human welfare, with rising in income. When the process can run beyond the carrying capacity the whole activity will fall at risk. The other argues the relationship is not fixed along the countries path of development. The environmental Kuznets Curve (EKC) has argued that there is an inverted U-shaped relationship between economic activity and environmental pollution. It explains that environmental degradation initially increases with the increase of income, reaches a threshold point and then it declines with increases income (Panayotou, 2003).

So, the current study designed to Understanding the interaction between energy consumption, CO_2 emissions which is the main cause of global warming, and economic growth in Ethiopia. Its finding has great policy implication for the environment, energy consumption and economic growth of the country.

1.2. Statement of the problem

The relationship between economic growth, energy consumption and the environment is complex. Because different drivers come into play including the scale and composition of the economy, changes in technology that have the potential to reduce the environmental impacts of production and consumption decisions in the economic growth. As policy options industrialists typically argue that environmental policies harm growth by raising production costs. Environmentalists, on the other hand, believe that environmental policies are required to reduce the usage of energy for sustainable growth (Jos *et al.*, 2012).

The empirical findings on the variables relationship also show mixed result: In support of ECK hypothesis, conservations hypothesis, growth hypothesis and neutrality. The study by Harry B., (2011) in China, Tiwar (2011) in India, and Nicholas (2011) in South Africa show that there is a unidirectional causality running from energy consumption to output and bi-directional causality between energy consumption and pollutant emission both in the short and long run indicates that the level of economic activity and energy consumption mutually influence each other and implies that emission reduction policies will hurt economic growth in those country.

Contrary to this, study conducted by Mohammed (2013) and by Sakib*et al.*, (2012) shows that there is no co integrating relationship among the economic growth, energy consumption and CO_2 emission in Australia and Bangladesh respectively. The studies show existence of bi-directional causal link between energy consumption and economic growth. However, there is no causal link between CO_2 emission and economic growth. Their finding indicates that these countries are still in a comfortable position to pursue pro-growth policies without being over-concerned about CO_2 emission.

On the some issue, the study by Mohammed (2012) for 12 Middle East and North African Countries over the period 1981–2005 show that in the long-run energy consumption has a positive significant impact on CO_2 emissions and shows that real GDP exhibits a quadratic relationship with CO_2 emissions for the region as a whole in support of the EKC hypothesis in most studied countries, the turning points are very low in some cases and very high in other cases.

On the other extreme, in supports of the neutrality hypothesis, Viktoras (2013) for Denmark using annual data from 1972-2012 by employing Granger causality test in VAR framework its Result strongly support a unidirectional causality coming from renewable energy consumption to CO_2emissions. But, there is no statistically significant causality between the economic growth and renewable energy consumption, and also between economic growth and CO_2 emissions, this implies that energy conservation policies should not have a significant impact on economic growth in such country.

Abesha (2009) studied Domestic Energy Consumption and Deforestation in Hareri region Assessment of Students' Awareness and Views in Ethiopia. And finds the views about environmental problems resulted from unsustainable dependence of biomass energy and Air pollution, is a serious environmental problem in developed nation, was considered by more than half of students. Finally he recommends the need of awareness creation in the subject area.

Mehari (2011) assessed based on Granger causality relationship using annual data from1981 to 2006 between economic growth and energy consumption in Ethiopia finds unidirectional causality from economic growth to energy consumption. In its definition of variable he Uses Energy use kilo tone of oil equivalent, GDP, Gross fixed capital formation, Labor force 15+ year's total. Finally, in its variance decomposition analysis comparisons of labor and capital with energy indicates that energy was no more than a minor contributing factor to output growth.

This study extend the previous research to investigate not only whether energy consumption and economic growth have a significant impact but also its implication on the environment. According to The Intergovernmental Panel on Climate Change (2001) Ethiopia is one of the countries most likely to suffer extremely from the adverse effect of climate change. Due to environmental degradation caused by global warming problem it predicts a high frequency of extreme climate events, like sea level rise, droughts, and floods for Ethiopia. Necessity of understanding the relationship and reacting accordingly to overcome such types of warning, Existence of controversy among variables relationship both in theory and empirical finding and its importance for policy implication, and different studies conducted in other part of the world is the main rationale motivated this study.

1.3 Objective of the study

The general objective is to examine the relationships between energy consumption, carbon dioxide emission and economic growth in Ethiopia. Under this, the specific objectives' are:-

-To examine the relation between energy consumption and economic growth

-To examine the relation between economic growth and carbon dioxide emission

-To identify existence of co-movement among energy consumption, carbon dioxide emission and economic growth.

1.4 Significance of the study

Identifying the link between energy consumption, carbon dioxide emission and economic growth will provide information to the policy makers to enable them to come up with the appropriate policies regarding the subject area. In line with this, the findings of this study have significant policy implications for energy sector, environmental protection and for any one further concern on economic growth in Ethiopia. Identifying direction of causality and the variables relation pattern will provide information for further study and policy actions of the country.

1.5 Scope of the study

The study uses annual data measured in aggregate term from 1970/71-2010/11 for variables included in the model to study the Linkage of energy consumption, carbon dioxide emission and economic growth in Ethiopia. Energy consumption sub divided in to renewable and non renewable sources but this study considers the aggregate cases in terms of energy use kg of oil equivalent per capita. Carbon dioxide emissions include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. So, this study measures emissions in terms of metric tons per capita. Economic growth can be measured in different ways and considers many components, for simplicity purpose it represent in GDP per capita of Ethiopian Birr.

1.6. Organization of the study

The whole paper organized in to five chapters. The first chapter contains: introduction of the study, statement of the problem, research hypothesis, and significance of the study, scope of the study, and the organization of the paper itself. In chapter two, theoretical, and empirical findings literature in the study areas generally and over view of energy consumption, carbon dioxide emission and economic growth in Ethiopia particularly will be discussed. In Research methodology part of chapter three, model specification, data issues and estimation procedures will be discussed in detail. In Chapter four empirical results of data analysis will be evaluated. In the last chapter Discussion and Implications with possible policy proposition will be forwarded based on empirical findings of the study.

1.7. Limitations of the study and the directions for further study

The study has been carefully prepared and totally reached its objectives. However, there are a number of shortcoming to be mentioned and will be considered in further study. Number of observation due to availability of data, use of different proxy variables, So, the study will be further advanced by including additional variables for omitted variable bias, considering aggregate vise disaggregate data and specification of energy both in term of demand and supply equations may result in detail analysis in this area of study.

Chapter Two

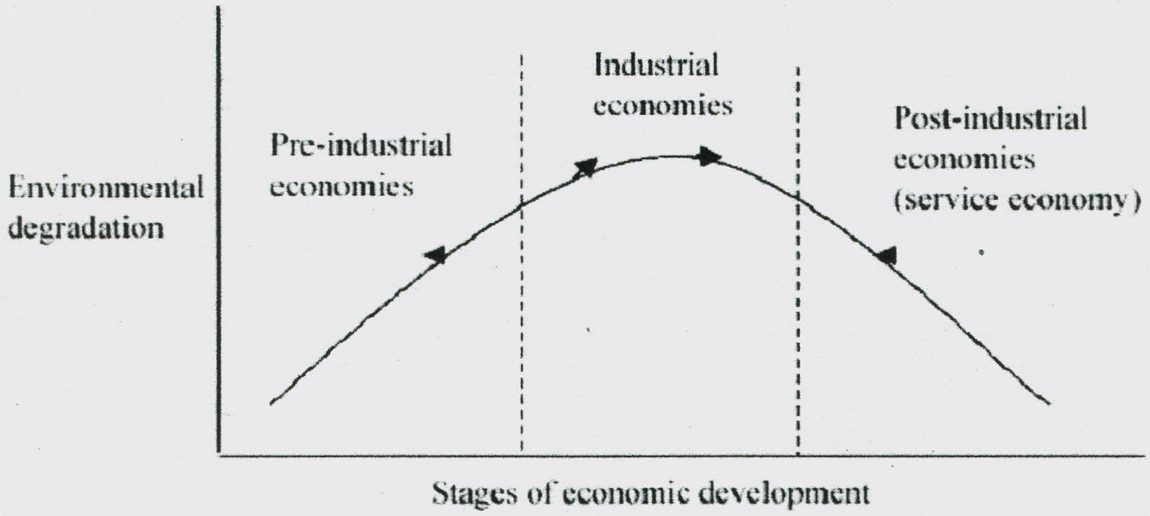
Literature Review

2.1 Theoretical Literature

2.1.1 Economic Growth and the Environment

For growing economic activity production and consumption requires larger inputs of energy and material, and generates larger quantities of waste by-products. Increased extraction of natural resources, accumulation of waste and concentration of pollutants will therefore overwhelm the carrying capacity of the biosphere and result in the degradation of environmental quality and a decline in human welfare, despite rising incomes. At the other extreme, are those who argue that the fastest road to environmental improvement is along the path of economic growth justify the case when higher incomes increased demand for goods and services that are less material intensive, as well as demand for improved environmental quality that leads to the adoption of environmental protection measures. Some went as far as claiming that environmental regulation, by reducing economic growth, may actually reduce environmental quality (Panayotou, 2003)

Yet, others have hypothesized that the relationship between economic growth and environmental quality, whether positive or negative, is not fixed along a country's development path; indeed it may change sign from positive to negative as a country reaches a level of income at which people demand and afford more efficient infrastructure and a cleaner environment. At low levels of development, both the quantity and the intensity of environmental degradation are limited to the impacts of subsistence economic activity on the resource base and to limited quantities of biodegradable wastes. As agriculture and resource extraction intensifies and industrialization takes off, both resource depletion and waste generation accelerate. At higher levels of development, structural change towards information-based industries and services, more efficient technologies, and increased demand for environmental quality result in leveling-off and a steady decline of environmental degradation (Ibid).



Source: economic growth and the environment (Ibid, p. 46)

According to Alex *et al.,* (2010) the limits theory defines the economy-environment relationship in terms of environmental damage hitting a threshold beyond which production is so badly affected that the economy shrinks. It considers the possibility of breaching environmental thresholds before the economy reaches the EKC turning point. It suggest that the risk of small changes causing catastrophic damage means that solely focusing on economic growth to deliver environmental outcomes could be counter-productive.

According to David (2004) there may be no conclusive evidence on the relationship due to some reasons. First, the scale effect: state's economic growth has a negative effect on the environment, where increased production and consumption causes increased environmental damage. Second, The composition effect: the composition of production changes along the growth path initially economic growth leads to industrialization and as the goods balance shifts from agriculture to manufactured products, environmental damage increases but the balance then shifts from producing manufactured goods to producing services, due to both demand- and supply-side changes, reducing the level of domestic environmental damage. Finally, technical effect: technological developments lead to a change in the environmental impacts of production.

2.1.2 Economic Growth and Energy consumption

Mainstream economists usually think of capital, labor, and land as the primary factors of production, and goods such fuels and materials as the intermediate inputs. The concept of the production function is next used to examine the key factors that could reduce or strengthen the linkage between energy use and economic activity over time. This production theory is very general and is less subject to criticism than are the specific models of economic growth. These key factors are (1) substitution between energy and other inputs within an existing technology, (2) technological change, (3) shifts in the composition of the energy input, and (4) shifts in the composition of economic output to be useful, such studies must not be grounded in a single theory, potential mechanism, or school of thought. The first law of thermodynamics implies the mass-balance principle: In order to obtain a given material output, greater or equal quantities of matter must enter the production process as inputs, with the residual as a pollutant. The second law of thermodynamics the efficiency law implies that a minimum quantity of energy is required to carry out the transformation of matter (David, 2004).

2.2. Global Economic Growth, Energy Consumption and Green Gas Emissions

The long term trend of economic output shows continuous increment over time. This leads rising level of employment, income, and promote both private and public investment in vast sectors. To produce such output combination of physical, natural, social and human capital where used. Natural capital includes raw materials extract from the earth, carbon sequestration services provided by soil and forest. Its unique elements are some have finite limits, irreversible change, its impact extends across many generations, due to critical threshold sudden and dramatic change may occurs. So, it needs to be used sustainably and efficiently in order to secure growth in the long run. In the some way energy consumption and carbon dioxide emission were increased in the world so roughly the last 200 years. This rise in energy consumption is primarily from increased fossil fuel consumption demand (Green Energy act, 2009).

If we compare the growth of CO_2 emissions and the growth of energy use, both on per capita basis CO_2 emission grew more slowly than energy consumption in the 1970 to 1990 period, due to the changing fuel mix more nuclear and more natural gas, relative to coal during the period. Since 2000, the variables are going parallel, indicating no further CO_2 savings given the greater use of coal again. Wind and solar contributions are not large enough to make an appreciable difference in CO_2 levels. While, in Africa including Ethiopia the economy still dominated by agriculture and energy consumption pattern dominated by primary energy source (EIA, 2012).

According to Netherlands environmental assessment agency: - since, 2000, an estimated total of 420 billion tonnes CO_2 was cumulatively emitted due to human activities including deforestation. Scientific literature suggests that limiting average global temperature rise to 2 °C above pre-industrial levels – the target internationally adopted in UN climate negotiations – is possible if cumulative emissions in the 2000–2050 period do not exceed 1,000 to 1,500 billion tonnes CO_2. If the current global increase in CO2 emissions continues, cumulative emissions will surpass this total within the next two decades (Jos *et al.*, 2012)

The European Union saw a 10% decrease in natural gas consumption. This is remarkable, because one third of the European gas consumption is normally used for space heating. In addition, the companies covered by the EU Emissions Trading System reported 2.0% less CO_2 emissions in 2011 than in 2010, for more than 11,000 installations that cover more than 40% of the EU's CO_2 emissions. High oil prices affected fuel consumption, particularly in the United States, where average petrol prices jumped 28% in 2011 even more than in 2008 when oil prices soared. However, even more important is the fact that CO_2 emissions from OECD countries currently account for only one third of global emissions. China and India account for the same share and their emissions increased by 9% and 6%, respectively, in 2011. Although all developing countries together increased their emissions on average by 6%, the increases in China and India caused by far the largest increase in global emissions of 1.0 billion tons in 2011(Ibid).

2.3. Overview of Ethiopian economic growth, energy consumption and Greenhouse Gas Emissions:

2.3.1. Economic growth trend in Ethiopian 1930–2012

According to Alemayehu (2005), to accomplish transition from a subsistence economy to an agro-industrial economy during 1930–1974 Ethiopia needed an infrastructure to exploit resources, a material base to improve living conditions, and better health, education, communications, and other services. The First Five-Year Plan (1957-61), Second Five-Year Plan (1962-67), and the Third Five-Year Plan (1968-73) were set to attain these broad objectives. Though, fail to achieve as planed target due to the administrative and technical capabilities to implement a national development plan, staffing problems because they neglected to identify the resources and to establish the organizational structures necessary to facilitate large scale economic development.

In the 1974-78 period of the revolution GDP increased at an average annual rate of only 0.4 percent; instead, the military budget consumed a substantial portion of the nation's resources, the government's nationalization measures and the highly unstable political climate caused economic dislocation in sectors such as agriculture and manufacturing. Finally, internal political upheaval, armed conflict, and radical institutional reform marked the economy. In the second phase (1978-80), the economy began to recover as the government consolidated power and implemented institutional reforms grew at an average annual rate of 5.7 percent. In the third phase (1980-85), the economy experienced a setback except, for Ethiopian fiscal year (EFY) 1982/83, the growth of GDP declined. The 1984-85 drought affected almost all regions of the country, the manufacturing sector stagnated as agricultural inputs declined, the lack of foreign exchange and declining investment reversed the relatively high manufacturing growth rates of 1978-90 Finally, Ethiopia's large military establishment of 40 to 50 percent of the government's current expenditure created a major burden on the economy continued to stagnate (Alemayehu, 2005).

Since 1992 Ethiopia has instituted a series of medium to long term plans and focused policies such as the Agriculture Development Led Industrialization (ADLI), Poverty Reduction Strategy Paper (PRSP), a Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) 2005/6 - 2009/10/. As a result the 1990s and early 2000s have registered positive growth, with an average real total and per capita GDP of 3.7% and 0.7% per annum, respectively. During SDPRP, 2002/03-2004/05 the country began to register better economic performance, with averages GDP growth of 6.7% per year and an average annual per capita income growth rate of 3.65%. The 2nd and 3rd years of SDPRP period actually registered double digit economic growth, with annual rates of 11.9% and 10.6%, respectively. Since then, the country has maintained high growth rates (MoFED, 2012).

According to Ethiopian economic update II Over the past decade, Ethiopia has achieved high economic growth, averaging 10.7 percent per year. The economy continued to expand at a rapid pace of 8.5 percent in 2011/12 and rank the country 12th fastest growing economy in the World. Agriculture, industry, and services grew by 4.9 percent, 13.6 percent, and 11.1 percent, respectively. The expansion of the services and agricultural sectors explain most of this growth 57 and 26 percent, respectively, while the contribution of industry was relatively modest 16.7 percent (WB, 2013).

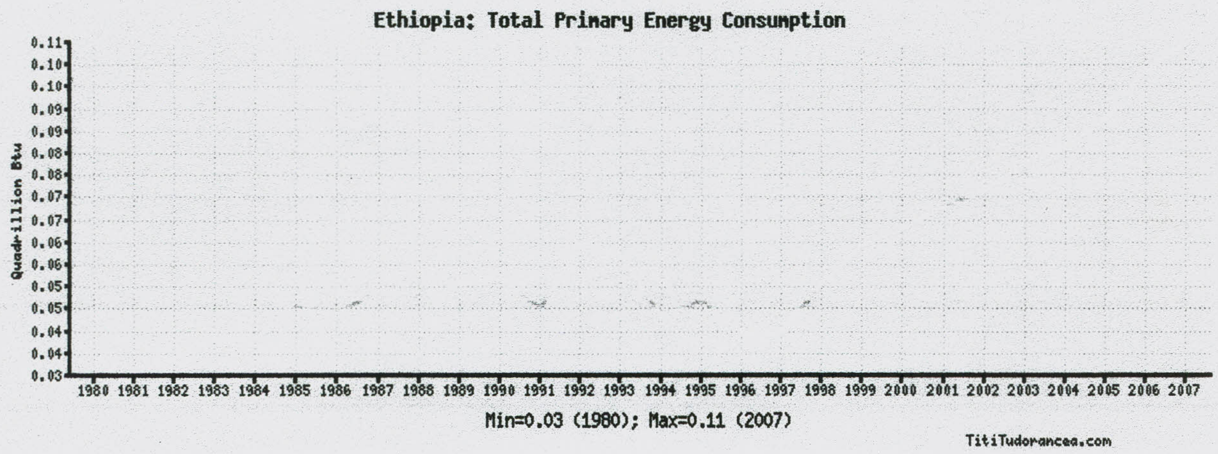
2.3.2. Energy consumption in Ethiopia

Source of energy can be categorized as renewable and non- renewable. Sources of energy that are mostly biomass based and are available in unlimited amount in nature. Under this category come such energy sources as fuel wood, petro-plants, agricultural waste like bio-gas, animal dung, wind energy, water energy, tidal energy, geothermal energy, solar energy, etc. Energy sources such as petroleum, coal, natural gas, nuclear power and the like are categorized as non–renewable. The non-renewable or exhaustible energy sources are available in limited amount and develop over a longer paired of time and as a result of unlimited use; such resources are likely to be exhausted any day (Aklilu, 2005).

The provision of energy service has a central role in economic development. Economic development of both rural and urban societies could be accelerated and achieved if energy is available. Both small and medium scale industries can be grown and provide potential for employment along farming if modern energy supply and improved technology is used. Hence, renewable energy such as hydro, including small scale geothermal, wind, solar and biomass energy in liquid and gaseous form which are suitable for clean and sustainable development should be developed, exploited and promoted so as to bring fundamental and desired change on the living standard of the Ethiopian population, who the majority of them are subsistence farmers and live below poverty level (Asress, 2002).

In the energy consumption pattern, the main characteristics of developing countries are their dependence on biomass fuel and very little use of commercial energy source. This kind of feature is strongly seen in this country too. The overall energy profile of Ethiopia is characterized by heavy dependency on biomass with a limited use of "modern" form of energy and a generally low level of per capita energy consumption. From sustainable development perspective, the key challenge of the energy sector in Ethiopia is to provide power to the majority of the community at an affordable price. Access to energy play a critical role in alleviating poverty through rural job creation, education, improved health and living conditions. It also plays a major role in natural resource conservation and environmental protection. Thus, the development of energy sector on a sustainable basis constitutes the principal challenge of promoting a sustainable development in Ethiopia (Desta and Mulugeta, 2002).

The energy balance of the country as of 1995/96 reveals that total energy consumption in Ethiopia was estimated at 723 peta joules or about 50 million tons of wood equivalent and is characterized by high dependence on biomass fuels. The contribution of wood fuel alone was about 77 percent of the final consumption and agricultural residue and dung accounted for about 16 percent which means that the share of traditional fuels in the national energy consumption was above 90 percent. Modern energy petroleum fuel and electricity accounted only for about 5.5% of total energy consumption, the share of petroleum being about 4.8% and that of Electricity being 0.7%. The Sector breakdown reveals that about 90 percent of the overall energy consumption of the country is that of households out of which the share of urban households is only 6 %. Rural households almost entirely rely on the traditional fuels where as the share of modern fuels in urban households' consumption was about 20 percent. Thus, the extent of dependence on traditional fuels is very high (Mekonnen, 2000).



Source; (MME. 2009).

As we see from the above graph total primary energy consumption of the country start to increase continuously from 1997 onward. The overall change is from its minimum 0.03 in 1980 quadrillion BTU to the maximum of 0.77 in 2007. In the same way the overall energy consumption of the country from both traditional and modern sources over the 2003/4 to 2007/8 is shown under table 2.3 below. The major source of the electricity supplied in the country is from hydropower, which contributes about 84% (668 MW) of the total supply. This amount is, however, less than 2% of the economically affordable power capacity of the total potential of water resource. On the contrary, most towns, villages and rural areas generally lack any access to electricity. Presently only 33% of population is said to have access to electricity. In 2009 the electric energy consumption per capita is estimated to be 44 kWh, which is one of the lowest consumption among the least developing countries (Ministry of Mines and Energy, 2009).

Table: 2.3 Traditional and commercial energy consumption of Ethiopia /2003/4 to 2007/8

Description	Year			
	2004/05	2005/06	2006/07	2007/08
Thermal and Hydropower production (GWH)	2,578.7	2,896.6	3,301.9	3,547.0
Thermal and Hydropower Sales(GWH)	2,069.2	2,361.4	2,636.9	3,217.8
Petroleum product import (000 metric tons)	1,322.43	1,475.12	1,646.51	1,881.27
Petroleum product consumption(000 metric tons)	1,366.28	1,536.51	1,655.82	1,880.66
Biomass energy production(Tera Joules)	1,067,679	76,070	78,234	1,192,186
Per capita commercial energy consumption(toe)	0.0185	0.0205	0.0216	0.0259
Per capital electric consumption (KWh)	29.6	32.94	35.87	43.53

Source: (MME.2009).

On the other hand Fossil fuel energy consumption which comprises coal, oil, petroleum, and natural gas products measured at 5.72 % of total energy consumption in Ethiopia for 2011. The latest value for Energy use (kg of oil equivalent) per $1,000 GDP (constant 2005 PPP) in Ethiopia was 429.36 as of 2010 and over the past 29 years, the value for this indicator has fluctuated between 697.30 in 1992 and 418.79 in 2006.The value for Energy use (kt of oil equivalent) in Ethiopia was 33,202 as of 2010 over the past 39 years this indicator reached a maximum value of 33,202 in 2010 and a minimum value of 8,607 in 1971 (IEA, 2012).

2.3.3 Greenhouse Gas Emissions of Ethiopia

Evidences that could be associated with climate change have already started appearing in Ethiopia. It is reported that in the last 50 years only, the annual average minimum temperature over the country has been increasing by 0.2 °c every decade. Climate change related events like the occurrences of frequent and extensive droughts in recent decades, spreading of malaria in high land areas which have never experienced before, loss of biodiversity and decline in wildlife number have been observed. Even the country has recently experienced flood hazard which has killed more than 500 people in 2006. This was associated with extreme weather event related to climate changes according to some sources (UNEP, 2006).

In addition to various climate change study projects, the initial national communication of the country was prepared. The climate change study was done by the support from the US and focused on inventory of GHGs emissions. This report described inventories of greenhouse gas emissions and efforts to reduce emissions as well as adaptations to climate change. The contribution of Ethiopia to the global GHGs emission is negligible. Using the 1995 Global Warming Potential (GWP) values of the Intergovernmental Panel on Climate Change (IPCC) over 100 years' time horizons it is reported to be about 48,003 Gg CO_2-equivalent in1994. The per capita emission would be about 0.8976 tons of CO_2 –equivalent (MME, 1994).

The greenhouse gas emission from energy sector is also important contributor to the total national emission. According to the 2004 inventory, it was accounted for more than 50% of the total GHGs emission and was twice of the 1994 values. Among these sub sectors, the transport and the domestic take the largest contribution which accounts about 68% and 16.1% respectively in 2004. The combustion of fossil fuels mainly in the transportation sector was responsible for 88 % of the total CO_2 in 1994 (B & M Development Consultant PLC, 2006).

According to International Energy Statistics, 2012 The value for CO_2 emissions (kt) in Ethiopia was 7,887.72 as of 2009 and over the past 49 years this indicator reached a maximum value of 7,887.72 in 2009 and a minimum value of 341.03 in 1961. The latest value for CO_2 emissions (kg per 2000 US$ of GDP) in Ethiopia was 0.48 as of 2009. Over the past 28 years, the value for this indicator has fluctuated between 0.72 in 2000 and 0.29 in 1982. In term of CO_2 metric tons per capita it fluctuates from .01589222 in 1960 to .07456479 in 2010 (IEA, 2012).

2.4. Empirical findings on: energy consumption, carbon dioxide emission and economic growth relationship

The empirical findings results on the variables are vary from country to country: even though scholars way of analysis techniques, data issues and model of their estimations are different. The studies by Mohammed *et al.,*(2012) for 12 Middle East and North African Countries over the period 1981–2005 using co integration techniques show that in the long-run energy consumption has a positive significant impact on CO2 emissions. And real GDP exhibits a quadratic relationship with CO2 emissions for the region as a whole. However, although the estimated long-run coefficients of income and its square satisfy the EKC hypothesis in most studied countries, the turning points are very low in some cases and very high in other cases, hence providing poor evidence in support of the EKC hypothesis.

Nicholas M. (2011) in south Africa using ARDL finds distinct unidirectional causal flow from economic growth to carbon emissions and energy consumption Granger-causes both carbon emissions and economic growth. More importantly the finding indicates carbon emission constitutes an impediment to sustainable economic growth in the country. In India by Tiwari (2011) and Harry B., (2012) in china using Co integration and vector error correction results indicates the variables are related in the long run and shows inefficient use of energy leads environmental pressure tend to rise faster than economic growth. In Chine the results also reveal bi-directional causality between coal consumption and pollutant emission both in the short and long run it indicates the difficulty to pursue a greenhouse gas abatement policy through reducing coal consumption in the country.

Sakib*et* (2012) for Bangladesh and, Mahammed. S., and Shahjahan K., (2013) in Australia employed Johansen co integration using a multivariate framework their empirical findings indicate bi-directional causal link between energy consumption and economic growth for Australia and the energy use can lead to CO_2 for Bangladesh. The study points out that there is no causal relationship between Economic Growth and CO_2, for the two countries.

In supports of the neutrality hypothesis, for Denmark using annual data from 1972-2012 by Viktoras (2013) to examine causal relationship between variables employing Granger causality test in VAR framework Results strongly support a unidirectional causality coming from renewable energy consumption to CO_2 emissions. Its result also indicates that there is no statistically significant causality between the economic growth and renewable energy consumption, between economic growth and CO_2 emissions, and implies that energy conservation policies should not have a significant impact on economic growth.

Abesha (2009) studied Domestic Energy Consumption and Deforestation in Hareri region Assessment of Students' Awareness and Views in Ethiopia. And finds the views about environmental problems resulted from unsustainable dependence of biomass energy and Air pollution, is a serious environmental problem in developed nation, was considered by more than half of students. Finally he recommends the need of awareness creation in the subject area. Similarly Mehari (2011) examined energy and economic growth in Ethiopia in Granger causality approach using annual data from 1981 to 2006. The study defines GDP at market prices at constant 2000 US$, Gross fixed capital formation, Labor force 15+ year's total and Energy use kt of oil equivalent. The variance decomposition analysis reveals that energy was no more than a minor contributing factor to output growth and certainly not the most important one when compared to capital and labor.

While, the interests of this study were: to examine the aggregate relationship between energy consumption, carbon dioxide emissions and economic growth in Ethiopia. In the analysis modern econometric technique of Johnson co-integration were employed. The consideration of carbon dioxide emissions help to find energy consumption pattern and economic growth implication on the environment Ceteris paribus.

$$V_t = \sum_{i=1}^{k} \delta_i V_{t-1} + \eta_t \text{ .... equ. (4)}$$

Where V_t = (Y, C, E) and $\eta_t = (\eta_Y, \eta_C, \eta_E)$, $\delta_i - \delta_k$ are three by three matrices of coefficients and η is a vector of error terms. Of course, the VAR methods outlined here have some disadvantages. One of the main limitations is that, without appropriate and correct modification, standard VARs miss nonlinearities, conditional heteroskedasticity, and drifts or breaks in parameters. Thus it is crucial to specify VAR model correctly. A critical element in the specification of VAR models is the determination of the lag length of the VAR. Three tests are used in order to choose the optimal lag length p in the VAR model, the Akaike (AIC), Schwarz (SBIC) and the Hanna-Quinn (HQIC) criterions. If the conflicting results are obtained then the paper choose a lag length suggested by majority of criterion tests. Post-estimation tests for Residual Heteroskedasticity, stability and normality of residuals are carried out after estimating each VAR model. In addition the study also test for the serial autocorrelation in the residual if it find any evidence of autocorrelations the paper try to fix it buy adding or removing lags of the variables (Ibid).

3.2.2 Unit Root Test

This is to ascertain whether the time series are stationary or not. Moreover, stationary is required so as avoid spuriousness of the regression results. A variable is said to be stationary if it's mean, variance and auto-covariance remains the same no matter at what point we measure them. The null hypothesis of non-stationary is tested against alternative hypothesis of stationary. A number of tests are available in the literature to check the existence of the unit root problem both in the level of the variables as well as in their first difference, i.e. to determine the order of integration. The Dickey Fuller (DF) test is applicable if error terms (Ut) are uncorrelated. In case the error terms (Ut) are correlated, DF test is useless. Augmented Dickey Fuller (ADF) test takes care of this problem by "augmenting" the equation(s) of DF test by adding the lagged values of the dependent variables (Pantula, 1989). To test the unit root property of the variables, the paper employed Augmented Dickey Fuller test (ADF).The Augmented Dickey-Fuller (ADF) regression model has a form:

$\Delta y_t = \alpha + \beta t + \delta y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t$, intercept and time trend item........... equ. (5)

$\Delta y_t = \alpha + \delta y_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \varepsilon_t$, intercept and no time trend item................ equ. (6)

Chapter Three

Data Source and Methodology of analysis

3.1.1 Data Type and Sources

The type of data used in this paper is secondary data annual observations from 1970/71 to 2010/11. The data for energy consumption and carbon dioxide emission is obtained from World Development Indicators of the official website of World Bank. While for urbanization and economic growth data were from the Ministry of Finance and Economic Development (MoFED) annual report. This particular period was chosen simply because one of the required data energy consumption was not available for earlier periods. The use of quarterly data could have allowed a more sophisticated analysis, however such statistics are not available for carbon dioxide emissions variable in the selected time.

3.1.2 Definition and Measurements of the variables

The study used the following proxy variables: real GDP per capita measured in Birr as economic growth, kilogram of oil equivalent per capita for energy consumption, carbon dioxide emissions is measured in metric tons per capita and urbanization as controlled variables.

Real Gross domestic product per capita is the main and mostly used growth indicator, Co_2 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. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport as stated in the world development indicators. Finally in case of urbanization most cities are growing at a faster rate than the national average, as the endurance workers are migrating from rural area to urban area for better jobs, better life, better education, better treatment, etc. Thus urban populations pressure on urban resources and environment as a result environment is polluted (WB, 2012).

The functional equation is based on the assumption that economic growth is driven by high energy consumption that is likely to produce CO_2 driven economic growth in the country following (Ozturk and Acaavci, 2010). The basic form of the relationship between the variables can be expressed as:

Y = f (COP, ENP, URB) where, (Y) represents GDP, (COP) represents CO_2 emissions, (ENP) represents energy consumption and (URB) urbunization. The relationship can be expressed in equation as follows:

$Y = \alpha + \beta_1 COP_t + \delta_2 ENP_t + \delta_3 URB + \varepsilon_t$ ....equ. (2)

3.2 Econometrics models

The data will first transfer in log, then unit root test proceed, existence of co integration can test if there causality can done. All the analysis in the study will conduct using STATA 11 version software. In the rest of this studies discussion the following letters are used for the simplicity purpose to represent the defined variables above. (ry) Represents real GDP per capita, (Co_2) for CO_2 emissions per capita, urbanization (urb) and (ec) for energy use per capita will be used. Hence, in the methodological approach of this paper includes the following steps: first it need to check for a unit root in CO_2 emissions per capita, energy use per capita, real GDP per capita in levels. Second, if the variables are I (1) then they may have a long run relationship. VAR will be inappropriate. Hence, it needs to test them for co integration. If the variables are co integrated, i.e. C (1, 1), a vector error correction (VEC) model will be used to discover the long run relationship. So, the last step is to test for causality by employing the granger causality tests. If the co integration relations between the variables are absent, the study can run them in a unrestricted VAR.

3.2.1 Vector Auto regression

The Vector Auto regression (VAR) models were first proposed by Sims (1980) who argued that "it should be feasible to estimate large macro models as unrestricted reduced forms, treating all variables as endogenous". This help to analyze multiple relationship between variables in an accurate and simple way without specifying which variables are endogenous or exogenous (Verbeek, 2004).Based on this a VAR system for this study may establish in one of the following form;

$\Delta y_t = yt - 1 + \sum_{i=1}^{p} \gamma i \Delta yt - i + \varepsilon t$, no intercept and no time trend items................equ. (7)

Where t is the time index, α is an intercept constant, β is the coefficient on a time trend, δ is the coefficient presenting process root (i.e. focus of the test), ε is an independently, identically distributed residual term, yt is the variable of interest (Y, E, C). The aim of test is to see whether the coefficient δ equals zero, which would imply that process is non-stationary, thus for the equation 5 the null hypothesis is H0: $\delta = 0\ \beta \neq 0$, yt is non-stationary, against the alternative HA: $\delta < 0\ \beta \neq 0$, yt is trend stationary, represents a least restricted ADF model i.e. including trend and constant.

For equation 6excludes trends H0: $\delta = 0\ \alpha \neq 0$, yt is non-stationary, against the alternative HA: $\delta < 0\ \alpha \neq 0$, yt is level stationary and For equation 7 H0: $\delta = 0$ yt is non-stationary, against the alternative HA: $\delta < 0$, yt is stationary and excludes both trend and constant. If the plot of the series does not start from the origin and if there is some kind of visible trend then probably model should include constant and trend as in equation 5 but if e.gthe trend is not apparent (e.g deference series) then it should not be included in the model as in equation 6 Whereas in order to determine the lag length the VAR procedure will be inspected (Ibid).

3.2.3. Co-integration test

The concept of co-integration can be described as a systematic co-movement among the selected time series over the long-run. If two or more series are each non-stationary, but a linear combination of them is stationary then it can be said that the series are co integrated. It is necessary to test for co-integration if we want to provide meaningful results. One of the most widely used approaches to test for co integration is VAR based Johansen test. Divergently from other co integration tests like Engle-Granger test which permits only one co integrating relationship, Johansen test allows for more than one co-integrating relationship to be tested and thus is more applicable in this study. General VAR (p) model can be written as:

$y_t = \alpha_o + \sum_{j=1}^{p} A_j y_{t-j} + \varepsilon_t$...equ. (8)

Where yt is the variable of interest in the study economic growth(Y), energy consumption (E), and carbon dioxide emission(C). αo is a vector of constant terms or $[\alpha_Y \alpha_E \alpha_C]$,and A_j is a matrix of VAR parameters for lag j, ε_t represents vector of error terms $[\varepsilon_Y \varepsilon_E \varepsilon_C]$. During the implementation of Johansen's test it is important to choose deterministic components (trend, constant, both or none etc. correctly. Johansen (1992) suggest the use of Pantula principle developed by Pantula (1989). The procedure involves the estimation of three models, starting from the most restrictive model which includes restricted constant and no trends, to the least restrictive model with unrestricted intercept and restricted trends comparing trace test statistic to its critical value at each stage. The test is complete when the null hypothesis is not rejected for the first time (Johansen, 1992).

If the co-integrating relationship is found then in order to account for non-stationary variables VECM model has to be estimated. General VECM can be denoted as:

$$\Delta y_t = \alpha + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \sum_{j=1}^{p} \beta j x_{t-j} + Ø e_{t-1} + \varepsilon_t \text{.................................equ.9}$$

Where Δ is the deference operator, p is the number of lags, α and β are parameters to be estimated, ε is serially uncorrected error term, and e_{t-1} is the error correction term (ECM) (Cheung, and Lai, 1993).

3.2.4 Causality test

Granger causality is one of the most widely used econometric techniques to investigate the relationship between two or more variables. The simple definition of Granger causality can be given as: "X is said to Granger-cause Y, if Y can be better predicted using the past values of both X and Y than it can be by using the history of Y alone." Granger causality tests are considered at different level. Firstly, Granger non-causality test is carried out following the Toda and Yamamoto (1995) (T-Y) long- run causality test. Which involves determining order of integration of times series, then adding additional lag for each variable based on their integration e.g if the both series are I(1) then we add 1 lag for each variable in the VAR model but not account for this additional lag in the Wald test. This procedure involves testing for Granger non-causality in the levels of time series so there is no loss of information due to differencing. The VAR model to be tested has a form of:

$$y_t = \alpha + \sum_{i=1}^{m} \alpha_i y_{t-i} + \sum_{i=1}^{m} \beta i x_{t-i} + \varepsilon_t \text{...equ. (10)}$$

$$x_t = \alpha + \sum_{j=1}^{n} \alpha_j x_{t-j} + \sum_{j=1}^{n} \beta j x_{t-j} + \varepsilon_t \text{...equ. (11)}$$

The test is for $H_0 : \beta_i$ (i =1, 2...m) = 0, against H_A : Not H_0, that "X does not Granger cause Y" the rejection of null it implies that variable X Granger-cause Y. In the same it can't test for $H_0 : \beta_j$ (j =1, 2...m)=0, against HA : Not H_0, that "Y does not Granger- cause X" rejection of null in this case would mean that variable Y Granger-cause X. This Granger non-causality can be perceived as a pretest which allows for a cross-check of overall results. For instance, if we find that time series are co-integrated then there must be a causality between them in either one way, or in both directions but the opposite is not true.

This implies that if we find co integration among variables but T-Y procedure reveals that there is none, then it is very likely that it could have miss specified the VAR model when testing for co integration. Furthermore, the T-Y procedure involves testing for Granger causality in levels, thus there is no information loss due to differencing of the data (Granger, 1981).

In order to support the Granger causality test results obtained from T-Y approach and obtain some insights about the interaction between variables in the short-run it consider two other Granger causality tests. Which other Granger causality test will be carried out depends on whether the variables are co integrated or not. If the variables are found to be co integrated then causality can be tested in the following error correction models (ECM):

$$\Delta y_t = \alpha + \sum_{i=1}^{m} \alpha_i \Delta y_{t-i} + \sum_{i=1}^{m} \beta i \Delta x_{t-i} + \O_i e_{t-1} + \varepsilon_t \text{..................................equ. (12)}$$

$$\Delta x_t = \alpha + \sum_{j=1}^{n} \alpha_j \Delta x_{t-j} + \sum_{j=1}^{n} \beta j \Delta y_{t-j} + \O_j e_{t-1} + \varepsilon_t \text{..................................equ. (13)}$$

Where e_{t-1} is the error correction term and (ECT). The short-run causality from x_t to y_t can be examined by conducting F-test, the null hypothesis of Granger non causality is $H_0 : \beta_i = 0, i = 1, 2...m$. The long run causality from x_t to $y_t$is examined by conducting t-test, the null hypothesis of Granger non causality is $H_0 : \O_i = 0$. To examine the strong short and long causality from x_t to y_ta joint F-test is conducted, the null hypothesis of Granger non causality in this case is $H_0 : \beta_i = 0$ and$H_0 : \O_i = 0$. Similar procedure can be carried out to test causality from y_t to x_t in equation 12.

If the variables are found to be not co integrated then the study will test for causality by using deference time series and testing for a Granger non causality in the following VAR model:

$$\Delta y_t = \alpha + \sum_{i=1}^{m} \alpha_i \Delta y_{t-i} + \sum_{i=1}^{m} \beta i \Delta x_{t-i} + \varepsilon_t \text{..equ. (14)}$$

$$\Delta x_t = \alpha + \sum_{j=1}^{n} \alpha_j \Delta x_{t-j} + \sum_{j=1}^{n} \beta j \Delta y_{t-j} + \varepsilon_t \text{...equ. (15)}$$

Similarly as in T-Y approach it test for $H_0 : \beta_i$ (i = 1, 2...m) = 0, against H_A : Not H_0, that "X does not Granger-cause Y" if we reject null it implies that variable X Granger- cause Y(Ibid).

Chapter Four

Results and Discussion

For the empirical analysis Real GDP per Capita (real local currency units, various base years) represented by ry, and urbanization by (urb) from 1971 up to 2011 were collected from MoFED (2012). Kilogram of oil equivalent per capita for energy consumption represented by ec and carbon dioxide emissions is measured in metric tons per capita represented by co_2 over the same period collected from World Development Indicators of the official website of World Bank. The choice of the starting period was constrained by the availability of data on Kilogram of oil equivalent per capita for energy consumption. While over the same period urbanization measured by urban population growth considered as controlled variable.

4.1 Unit Roots Tests

All the data were transferred in to logarithmic form to reduce the problem of heteroskedasticity. As log transformation compresses the scale in which the variables are measured do not advice in case of percentage variables. The next step is to test for stationary of all variables used in the study in order to avoid misleading statistical inferences.

Table 4.1 unit root test result at level

Results of a unit root tests based on ADF at level						
	Constant and no time trend			Constant and time trend		
	Test statistics	1% critical value	5% critical value	Test statistics	1% critical value	5% critical value
LEC	0.299	-3.662	-2.964	-2.969	-4.260	-3.548
LCO2	-1.619	-3.655	-2.961	-3.374	-4.251	-3.544
LRY	0.789	-3.662	-2.964	0.778	-4.260	-3.548
LURB	-2.960	-3.662	-2.964	-2.919	-4.260	-3.548

Source: from stata 11 result

A variable is said to be stationary if it's mean, variance and auto-covariance remains the same no matter at what point we measure them. The null hypothesis of non-stationary is tested against alternative hypothesis of stationary. Decision role: -The null hypothesis can be rejected if ADF statistics greater than the relevant critical value in absolute Pantula (1989), for this study 1% and 5% were considered. As seen from the above table 4.1 ADF test at level with intercepts and time trend, intercept and no time trend all variables are non stationary. On the another hand all the variables are stationary after taking their first difference as indicated in table 4.2 below, with constant and time trend, constant and no time trend.

Table 4.2 unit root test result at first difference

Results of a unit root tests based on ADF at first difference							Order of integration
	Constant and no time trend			Constant and time trend			
	Test statistics	1% critical value	5% critical value	Test statistics	1% critical value	5% critical value	
DLEC	-3.574	-3.668	-2.966**	-4.344	-2.614*	-2.964	I(1)
DCO2	-4.577	-3.662*	-2.964	-4.549	-4.260*	-3.548	I(1)
DLRY	-4.586	-3.655*	-2.961	-5.247	-4.251*	-3.544	I(1)
DLURB	-3.659	-3.668	-2.966**	-3.621	-4.270	-3.552**	I(1)

*** And ** indicates the rejection of the null hypothesis at 1% and 5% level of significance, respectively**
Source: from stata 11 result

The results of unit root tests reveal that after differencing the variables once, all the variables were confirmed to be stationary. So, It is worth concluding that energy consumption, carbon dioxide emission, and economic growth are integrated of order one, I(1). All the I(1) variables can only be regressed on each other if they are co integrated. Thus, co-integration testing of the variables using the Johansen co integration approach is present as follow.

4.2 Lag length selection

According to Granger (1981) without appropriate and correct modification, standard VARs miss nonlinearities, conditional heteroskedasticity, and breaks in parameters. Thus, it is crucial to specify VAR model correctly. A critical element in the specification of VAR models is the determination of the lag length of the VAR. Three tests are used in order to choose the optimal lag length in the VAR model, the Akaike (AIC), Schwarz (SBIC) and the Hanna-Quinn (HQIC) criterions. If the conflicting results are obtained then the study choose a lag length suggested by majority of criterion.

Table 4.3 lags order selection

lag	AIC	HQIC	SBIC
0	-2.858	-2.79667	-2.68562
1	-14.9107	-14.604	-14.0488
2	-16.5476	-15.9957	-14.9962
3	-17.5969*	-16.7996*	-15.356*

Source: from stata 11 result

The Obtained results are presented in Table 4.3, where all tests suggest inclusion of three lags in a VAR model. Since JJ test is found to be sensitive to lag length chosen for the analysis. When the order of VAR i.e., lag length is too short, problem of serial correlation among the residuals arises and test statistic will become unreliable. Conversely, if lag length (order of VAR) is too high there will be an upward bias in the test statistics, again causing doubts on the reliability of the estimates of parameters (Johansen, 1992). So, the diagnostic test should have to approve for the validity of the model.

4.3 Co integration Test

The VAR model with three lags, as suggested by AIC, HQIC and SBIC is considered to test long run co movement. We compare the trace statistics and max statistics with the critical values and stop only when the null hypothesis is not rejected for the first time.

Table 4.4 Johnson test of co integration

Rank_Ho	Ha	Eigen value	Trace statistic	5% critical	decision
0			52.2096	47.21	
1		0.51871	24.4203*	29.68	accept
2		0.33817	10.9138	15.41	
3		0.20143	2.1487	3.76	
4		0.00494	-	-	
Rank_Ho	Ha	Eigen value	Max statistic	5% critical	decision
0			27.7892	27.07	
1		0.51871	15.6846	20.97	accept
2		0.33817	8.5475	14.07	

3		0.20143	0.1882	3.76	
4		0.00494			

Source: from stata 11 result

Johansen co integration test result presented in both trace statistics and max-Eigen statistics indicates that there is one co integrating vector. The statistic not rejects the null hypothesis at one rank. The finding is confirming existence of long run association among energy consumption, CO_2 emission, and economic growth in the country. The result is in line with Mohammed (2013), and Sakib *et al.*, (2012).

4.4 long run relationship

As indicated in the result of co-integration test, there is one co-integrating relationship between the variables of interest. Next, normalizing the vector on lry the estimation result of long run relationship is presented below.

Lry = -125.42 + 15.34lec + .0748co2 + 2.43LURB

(0.000) (0.505) (0.000)

Vector diagnostic test

Vector AR test chi^2(25) = 25.48237(0.4356)

Vector normality test: chi^2(10) = 0.592(0.74362)

Hetro test chi^2 = 307.8802(0.3646)

For the validity of the model: vector diagnostics tests confirmed no problem of serial autocorrelation in the error terms in the model, error term normality distributed and have constant variance. The long run relationship shows as regular economic phenomena energy consumption stimulates economic growth. The result strongly support that the relationship between economic growth and energy consumption in Ethiopia is support for growth hypothesis. That means unidirectional causality from energy consumption to economic growth. And further economic growth does not lead carbon dioxide emission to the environment. As supported by insignificance of co_2 emission in explaining economic growth in the long run. The significant and positive sign of Urbanization shows importance of urban centers contribution for further economic growth.

4.5 Short run dynamics

The vector error correction model captures both the long run and short run relationship. The short run dynamics shows speed of adjustment, variables plays important role in the adjustment process.

Table 4.5. Coefficients of short run dynamics

variables	coefficient	Std. error	p-value	
constant	.0137954	.1204968	0.909	
DLEC_1	-9.185199	1.511107	0.000	
DLEC_2	-3.429445	2.234862	0.125	
DLEC_3	2.452612	1.944826	0.207	
DLURB_1	-9.185199	1.511107	0.000	
DLURB_2	-3.429445	2.234862	0.125	
DLURB_3	2.452612	1.944826	0.207	
DCO2_1	-.1846046	.1387472	0.183	
DCO2_2	-.0393665	.0976405	0.687	
DCO2_3	-.143992	.0972232	0.139	
DLRY_1	.4643805	.1847063	0.012	
DLRY_2	.4464742	.2105435	0.034	
DLRY_3	.4251581	.1910706	0.026	
EMC_1	-.2184389	.0724143	0.003	
R^2 = 0.8292 Vec diagonistic test1-3 AR test Chi^2(25) = 19.58049(0.76848) Normality test chi(^) 2 = .507(0.77599) Hetro test chi^(22) = 28.36542(.1639)				

Source: from stata 11 result

The error correction term, measures the devotions of the series from the long run relationship. The dynamic equation reported in table 4.4 above. In the process of adjustments first period of energy consumption and urbanizations, and all period lagged values of economic growth are significant. In the same argument with the long run all lagged variables of co_2 are not significant. As shown in the appendix of VECM estimation model the error correction term in the equation is statistical significant at 1% significance level. The negative sign indicates convergence to the equilibrium. This coefficient indicates speed of adjustment is 21%. This implies when there is a shock in one year lry adjusts itself to the equilibrium by 21 %.

4.6. Granger causality

All variables under Equations are dependent and the excluded variables are independent or source of causality. Decision rule null hypothesis rejected when probability value less than 5%. As shown below in the table 4.6 as a regular economic phenomenon there is causality from energy consumption to co_2 and economic growth. Energy consumption affects economic growth both in the short run and long run. Whereas there is no causality between co_2 and economic growth both in the short run as well as in the long run. The causality from urbanization to energy consumption indicates urban expansion necessitate further energy consumption. And the causality from urbanization to economic growth supports the argument of urban centers importance for further economic growth. All the finding is in support of existing economic theory of growth hypothesis.

Table 4.6. Granger causality result

Equations	Excluded	Chi^2	Df	prob> Chi^2	decision
lco2	lec	31.936	3	0.000	reject
lry	lurb	14.71	3	0.002	reject
lry	lec	39.84	3	0.000	reject
lec	lurb	21.501	3	0.000	reject

Source: from stata 11 result

CHAPTER FIVE

Conclusion and Implications

5.1 Conclusions

This study aimed to examine the relationships between energy consumption, carbon dioxide emission and economic growth in Ethiopia in A VAR framework. To examine; the relation between energy consumption and economic growth, the relation between economic growth and carbon dioxide emission, the relation between energy consumption and carbon dioxide emission. And to identify existence of co-movement among energy consumption, carbon dioxide emission and economic growth in the long run, finally to propose possible recommendation based on the finding that may promotes green economic growth in the country.

The unit root test result indicates all the variables are non stationary at level whereas they become stationary after taking their first difference it shows that the variables under consideration are integrated of the same order one I (1). Co-integration analysis was conducted using Johansen co-integration testing approach with lag three as suggested by lag length selection criteria. The obtained results suggest that there is one Co integrating relationships among variables. Co-integration test shows that there is a long run relationship between the variables under consideration in Ethiopia. Diagnostics test approves validity of the result.

From the long run result energy consumption stimulate further economic growth which support growth hypothesis, when energy consumption stimulates further economic growth. And that economic growth does not relate with carbon dioxide emission both in the short and long run. From the short-run results it found a correctly signed and statistically significant coefficient of ECM (-1). The negative sign indicates convergence to equilibrium whereas the coefficient shows speed of adjustment in case of a shock.

From the causality there is causality from energy consumption to co_2 and economic growth in the short run. Energy consumption affects economic growth both in the short run and long run. Whereas there is no causality between co_2 and economic growth both in the short run as well as in the long run. The causality from urbanization to energy consumption indicates urban expansion necessitate further energy consumption. And the causality from urbanization to economic growth supports the argument of urban centers importance for further economic growth. All the finding is in support of existing economic theory of growth hypothesis.

5.2 Implications of the findings

According to the global carbon budget from 1959-2011, 87 percent of all human-produced carbon dioxide emissions come from the burning of fossil fuels like coal, natural gas and oil, while from the clearing of forests and other land use changes 9% and as well as from some industrial process such as cement manufacturing 4% (IEA, 2013) .

In case of Ethiopia, Energy consumption in the country is dominated by sort of hydro and biomass. Biomass sourcing over 80% of the countries energy and Fossil fuel energy consumption which is a major source of co_2 emission comprises coal, oil, petroleum, and natural gas products measured at 5.72 % of total energy consumption in Ethiopia for 2011.

The pessimistic theorists viewed that reliance on biomass resources for basic energy need deprives health and other wellbeing of users, leads inefficient use, also degrade the environment and its production may causes competition over scarce resources. On the other hand Optimist insisted that sustainable harnessing of biomass with the aid of modern technology offer renewable energy with the potential advantages of reduce emissions, reduce indoor air pollutions, decreases per capita energy consumption and add various societal welfare benefits (Deriba, 2012). The study points out that there is no causal relationship between Economic Growth and CO2, ensuring that economic growth in Ethiopia can be achieved without degrading the quality of the environment coming from co_2 emissions.

5.3 possible Recommendation

The use of renewable energy sources like biomass and hydro unlike high- cost and environmental damaging fossil fuels helped Ethiopia to built non carbon dioxide emitter economy. To secure the sustenance of green economic growth in Ethiopia, cost effective, carbon free, and efficient utilization of renewable energy consumption based on the country comparative advantage that consider alternative use of resources are advisable like:

-Hydro and Geothermal.

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Appendix 1 Johnson test for cointegration

```
. vecrank lec lry lco2 lurb, trend(constant) lags(3) max
```

Johansen tests for cointegration

Trend: constant Number of obs = 38

Sample: 1974 - 2011 Lags = 3

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	36	497.59873	.	52.2096	47.21
1	43	511.49334	0.51871	24.4203*	29.68
2	48	519.33565	0.33817	8.7357	15.41
3	51	523.6094	0.20143	0.1882	3.76
4	52	523.7035	0.00494		

maximum rank	parms	LL	eigenvalue	max statistic	5% critical value
0	36	497.59873	.	27.7892	27.07
1	43	511.49334	0.51871	15.6846	20.97
2	48	519.33565	0.33817	8.5475	14.07
3	51	523.6094	0.20143	0.1882	3.76
4	52	523.7035	0.00494		

Appendix 2 cointegrating result equation

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	3	473.4916	0.0000

Identification: beta is exactly identified

Johansen normalization restriction imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
lry	1	.	.	.	.	.
lec	-15.34158	4.389073	-3.50	0.000	-23.94401	-6.739156
co2	-.0748683	.1122112	-0.67	0.505	-.2947981	.1450616
lurb	-2.436176	.2871715	-8.48	0.000	-2.999022	-1.87333
_cons	125.4243	.	.	.	.	.

Appendix 3 Vector error correction model result

```
. vec lry lec lco2 lurb, trend(constant) lags(4)

Vector error-correction model

Sample:  1975 - 2011                            No. of obs      =        37
                                                AIC             = -19.02912
Log likelihood =  411.0386                      HQIC            = -18.12351
Det(Sigma_ml)  =  2.64e-15                      SBIC            = -16.46035
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
D_lry	14	.080314	0.8292	111.6964	0.0000
D_lec	14	.012327	0.4140	16.24673	0.2985
D_lco2	14	.116687	0.7388	65.03839	0.0000
D_lurb	14	.001857	0.9990	24103.09	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
D_lry						
_ce1						
L1.	-.2184389	.0724143	-3.02	0.003	-.3603682	-.0765095
lry						
LD.	.4643805	.1847063	2.51	0.012	.1023629	.8263981
L2D.	.4464742	.2105435	2.12	0.034	.0338164	.8591319
L3D.	.4251581	.1910706	2.23	0.026	.0506667	.7996496
lec						
LD.	-9.185199	1.511107	-6.08	0.000	-12.14691	-6.223484
L2D.	-3.429445	2.234862	-1.53	0.125	-7.809694	.9508049
L3D.	2.452612	1.944826	1.26	0.207	-1.359176	6.264401
lco2						
LD.	-.1846046	.1387472	-1.33	0.183	-.4565442	.087335
L2D.	-.0393665	.0976405	-0.40	0.687	-.2307383	.1520053
L3D.	-.143992	.0972232	-1.48	0.139	-.334546	.0465619
lurb						
LD.	9.126539	9.785292	0.93	0.351	-10.05228	28.30536
L2D.	-7.391071	15.40718	-0.48	0.631	-37.58858	22.80644
L3D.	10.4167	9.806773	1.06	0.288	-8.804222	29.63762
_cons	.0137954	.1204968	0.11	0.909	-.222374	.2499649

Appendix 4 causality result

```
. vargranger
```

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
lurb	lco2	4.9523	3	0.175
lurb	lry	3.5994	3	0.308
lurb	lec	4.405	3	0.221
lurb	ALL	13.118	9	0.157
lco2	lurb	4.1847	3	0.242
lco2	lry	7.4247	3	0.060
lco2	lec	31.936	3	0.000
lco2	ALL	42.227	9	0.000
lry	lurb	14.71	3	0.002
lry	lco2	5.3401	3	0.149
lry	lec	39.84	3	0.000
lry	ALL	74.11	9	0.000
lec	lurb	21.501	3	0.000
lec	lco2	6.9797	3	0.073
lec	lry	.50118	3	0.919
lec	ALL	27.534	9	0.001

Appendix 5 stability condition

```
. varstable, graph
```

Eigenvalue stability condition

Eigenvalue	Modulus
.9958551	.995855
.7945254 + .3933606*i*	.886568
.7945254 - .3933606*i*	.886568
.8532127 + .1960243*i*	.875441
.8532127 - .1960243*i*	.875441
.2848162 + .6746999*i*	.732353
.2848162 - .6746999*i*	.732353
-.6334095	.63341
-.2992037	.299204
.2956927	.295693
-.06890207 + .08965546*i*	.113073
-.06890207 - .08965546*i*	.113073

All the eigenvalues lie inside the unit circle.
VAR satisfies stability condition.