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Economic growth and environmental degradation in Ethiopia: An environmental Kuznets curve analysis approach

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This study aimed to study the relationship between economic growth and environmental degradation in Ethiopia by questioning the existence of environmental Kuznets Curve. The study uses time series data from 1969/70 to 2010/2011 in a VECM analysis approach. The finding indicates existence of EKC hypothesis in Ethiopia. Like any agrarian country economic growth in Ethiopia inevitably contribute for environmental degradations at the early stage. Later on environmental degradation start to decline with increasing economic growth this might be due to an increase in share of service sector in the economic growth and application of environmental law with economic activity. To sustain the current trend the country should have to follow the existing environmental friend economic policy.

Key words: Environmental Kuznets Curve, economic growth, VECM, CO2.

INTRODUCTION

The question of sustaining the economic growth without despoiling environment, resource constraint, steady state of income and environmental quality is an issue for both social and natural science scholars. The growth in economy requires more capital and other resources which in turn generates larger quantity of wastage including emission to the environment. The accumulation of wastage and pollutant due to the extraction of resources could lead to degradation of environment, loss of human welfare, with rising in economic growth. When the accumulation of wastage and pollution due to continuous extractions of resources can run beyond the carrying capacity of the environment the whole economic activity will fall at risk.

Contrary to this view, there is an argument that states higher environmental improvement goes along with economic advancement due to the fact that at higher levels of economic growth, there could be an increase in demand for less material intensive goods and services as well as the demand for improved environment which further expect to improve the environment with increasing economic growth (Panayotou, 2003).

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The other scholars hypothesize the relationship between economic growth and environmental degradation is not fixed along with the countries path of economic growth. For instance, the environmental Kuznets Curve (EKC) has argued that there is an inverted U-shaped relationship between economic activity and environmental degradation. Kuznets explains that environmental degradation initially increases with increasing level of economic growth, and reaches a maximum point, and then it starts to decline with further increases in economic growth. In its explanation at early stage source of economic growth is mainly agriculture which costs the environment via agricultural expansion and change in land use pattern. Then when the sources of economic growth transferred to industrial bases environmental degradations reaches at maximum point. And later on the service sector dominates the economy and environmental degradation start to improve with increases in economic growth (Kuznets, 1955).

During the last 200 years the continuous increment in economic growth in the world has led to rising level of employment, income, and promotes both private and public investment in vast sectors. But Sub Saharan Africa has still been dominated by a high percentage of low income and largely rural agrarian communities. Meanwhile, increasing economic growth entails the use of physical, natural, social and human capital in economic activities. 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. Environment is one of natural capital which need to be used sustainably and efficiently in order to secure growth in the long run with the fate of the coming generations (Alex et al., 2010).

According to World Bank (2013) between 2004 and 2011, Ethiopia had achieved high economic growth averaging 10.7 percent per year. As compared to the sub-Saharan African average of 5.4 percent during the same decade, the figure (10.7%) shows existence of great potential for further progress in the country. In 2012, Ethiopia was the 12th fastest growing economy in the World and the Bank forecasts that if the country can be able to continue this impressive growth performance, could potentially reach middle income status by 2025. The composition of economic growth source was through a mix of factors: including agricultural modernization, the development of new export sectors, strong global commodity demand, and government-led development investments (World Bank, 2013).

Considering this in the Ethiopian growth and transformation plan 2010/11- 2014/15 the country's GDP per capita projected to grow from 378 USD in 2010 to 1271 USD in 2025. In addition to this the Clean Renewable Green Energy strategy projects that the contribution of of agriculture in the economy will diminish from 42 to 29%, indicating migration of jobs from the agriculture sector to industry and services. This transformation plan 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).

Even if the above idea underlines economic growth and development in Ethiopia should have to care about environmental sustainability and must compromise with the fate of the coming generation, on the bases of EKC argument reliance on agriculture for economic growth inevitably costs the environment especially at the early stage. In the history of Ethiopian economy agriculture is the backbone and still remains the major sources of economic growth followed by service sector and industry. As indicated above even during the fast economic growth (2004 onward) the source of growth is agricultural modernization, development of new export sector for agricultural output, increases in global demand for agricultural output in addition to government led infrastructure development.

To make consistency between economic growth and environment different actions are taken over time including: the 1992 Rio- Conference concern with national conservation strategy to harmonize the rate of population growth and the capacity of the country for the development and rational utilization of natural resources to the end of that the level of welfare is maximized over time. In 1994 program of action plan is adapted with the objectives of integrating poverty eradication actions with environmental sustainability and meeting current generation need must not at the cost of the coming generations. Later on formal environmental policy ratified in 1997 for sustainable development principles. Considering all the above plans different development programs of the country: agricultural development led industrialization since 1992, poverty reduction strategy papers, a plan for accelerated and sustainable development to end poverty 2005/06 – 2009/10, growth and transformation plan of 2010/11 – 2014/15, and in 2011 the climate resilient green economy strategy was developed (Environmental protection authority of Ethiopia, 2012).

Of course the relationship between economic growth and the environment is complex. This evident from the fact that economic growth entails scale and composition of the economy, particularly the share of services in gross domestic product as opposed to primary industries and manufacturing, and changes in technology that have the potential to reduce the environmental impacts of production and consumption decisions in the economic growth. So, the issue of whether the impact of economic growth on the environment increases monotonically, decreases monotonically, or first increases and then declines along a country's economic growth has critical implications for policy. Therefore, it is also much more

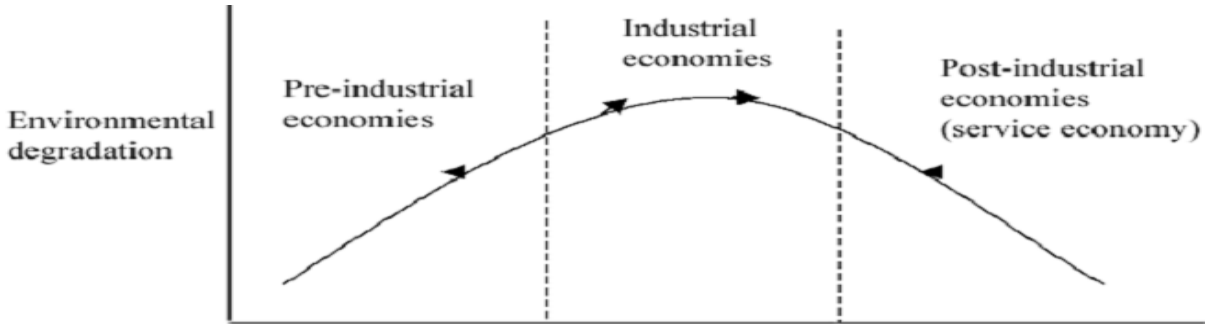

Figure 1. Stages of economic development. Source: Economic growth and the environment (Panayotou, 2003, p. 46).

important and utmost necessary to investigate whether higher economic growth lead to higher environmental damage or not (Jos et al., 2012).

According to the Intergovernmental Panel on Climate Change counties like Ethiopia are likely to suffer extremely from the adverse effect from climate change because of global warming problem which is caused from the environmental degradation. It is further predicted that Ethiopia is likely to experience a high frequency of extreme climate events, like droughts and floods (Environmental Protection Authority, 2012). Understanding the relationship between economic growth and the environment and reacting accordingly to overcome such adverse outcome such as pollution, degradation, climate changes etc. is very important.

Identifying the link between environment and economic growth will provide information to the policy makers to enable them to come up with the appropriate policies regarding the subject area is the main rationale motivated this study. In line with this, the findings of this study have significant policy implications on environmental quality and the economic growth as Ethiopia is also a signatory country in the Kyoto protocol. The study provides answers to the following questions. Is there any relationship between economic growth and environment in Ethiopia? What does the economic growth – environmental quality relationship imply for environmental quality and sustenance of Green Economic growth in the country? Does economic growth leads environmental degradation in Ethiopia?

LITERATURE REVIEW

The Hypothetical Kuznets curve was first developed by Simon Kuznets in 1950s and 1960s to show path of economic development and income inequality. It states that at the early stage when the economy depends mainly on agriculture, income inequality grow with increases in income. The curve suggests that unlike at the early stage of economic development, When a country shift to industrialization through mechanization of agriculture – the center of the nation's economy will shift to the cities, the internal migration of labor from rural to urban by farmers looking for better-paying jobs in urban area affects a significant rural-urban inequality gap. Kuznets believes that inequality would follow an inverted "U" shape as it rises and then falls again with the increase of income per-capita (Figure 1).

Since 1991 the issues of environmental Kuznets curve have become a standard feature in technical literature of environment and economic interaction. The view is that the initial economic activity inevitably hurts the environment. The assumptions are based on static technology, tastes and environmental investments. It states that as incomes rise, the demand for improvements in environmental quality will increase, as well the resources available for investment. And concludes although economic growth usually leads to environmental degradation in the early stages of the process, the only – way to attain a decent environment in most countries is to become rich (Perman and Stern, 1999).

According to the traditional argument the issues of economic growth and environmental qualities are conflicting ideas. With a state of constant technology and constant structure of the economy, pure growth in the scale of the economy would result in a proportional growth in pollution and other environmental impacts. This traditional view reflects the scale effect alone in its definitions of economic growth sources. The proponents of the EKC hypothesis argue that at higher levels of development, structural change towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental regulations, better technology and higher environmental expenditures, result in leveling off and gradual decline of environmental degradation (Panayotou, 1993, p 1).

A number of studies have developed theoretical models about how preferences and technology might interact to result in different time paths of environmental quality. The different studies make different simplifying assumptions about the economy. Most of these studies can generate an inverted U shape curve of pollution intensity. Selden and Song (1995) assume infinitely lived agents,

exogenous technological change and that pollution is generated by production and not by consumption. McConnell (1997) develops models based on overlapping generations where pollution is generated by consumption rather than by production activities as Stokey (1998) allows endogenous technical change. So, the result depends on the assumptions made and the value of particular parameters. And the proximate variables may in turn be driven by changes in underlying variables such as environmental regulation, awareness, and education in the course of economic development.

Ming-Feng and Daigee (2006) for Taiwan finds the inverted U – shaped relationships between NO2 and CO2 with economic growth. As income increase NO2 and CO2 increases later on start to decline with increase in income. Philip and Adeyemi (2013) find absence of ECK hypothesis in Nigeria and failed to attain reasonable turning point. Abesha (2009) studied Domestic Energy Consumption and Deforestation in Hareri region Assessment of Students' Awareness and Views in Ethiopia. And the study finds the views about environmental problems resulted from unsustainable dependence of biomass energy and Air pollution, is a serious environmental problem in developed nation is considered by more than half of students.

MATERIALS AND METHODS

Model specification

To determine the nature of the relationship between environmental quality and economic growth in Ethiopia, the study draw model from both the EKC and the original Kuznets curve literature. The underlying hypothesis is that the relationship between economic growth and environmental quality is not monotonic and may change direction from upward to downward when a country reaches a certain level of income. Typically, the specifications of model in the study considers standard EKC model following Omisakin (2009) which takes the following form,

$$(E/P)_t = \alpha_o + \beta_1(GDP/P)_t - \beta_2(GDP/P)_t^2 + B_3Xt + u_t \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where *E* is environmental degradation captured by CO2 emissions, *P* is population size, hence (E/P) is per capita CO2 emissions. (GDP/P) is per capita real GDP and X_t is a vector of variables that may often affect environmental quality in this regard openness considered, and t is the deterministic time trend, used as a crude proxy for technological progress. With this, the study describes the relationship that may be expected to hold between income and the environment with varying signs of β_i.

If $\beta_1 > 0$, and $\beta_2 = 0$, then, we have the linear case relationship between economic growth and environment.

If $\beta_1 > 0$ and $\beta_2 > 0$ implies monotonically increasing relationship among the variables.

Whereas when $\beta_1 < 0$ and $\beta_2 < 0$ the relationship implies monotonically decreeing among the variables.

If $\beta_1 > 0$, $\beta_2 < 0$, and, then there will be an inverted-U shaped relationship between environment and GDP.

And if $\beta_1 < 0$ and $\beta_2 > 0$ we would have U shaped relationship among the variables. Where β_1 and β_2 are the parameter estimates for the levels and square of per capita GDP respectively and over all possible outcomes of β_3 the parameter of controlled variable expect to affect environment positively over time (Agbai, 2011).

Types and sources of the data

The empirical analysis considers time series data for the following variables over the period of 1969/70 to 2010/11. The variables are Real GDP per Capita in millions at constant price represented a proxy for early stage of economic growth (Y), real GDP per capita squares represent a proxy for later stage of economic growth (Y2), Carbon Dioxide Emissions per capita (E) is measured in metric tons per capita represent a proxy for environmental degradation and openness were considered as controlled variables. GDP per capita is calculated by dividing real gross domestic product at constant price in million to total population. The variables are sourced from MoFED 2012/13 except CO2 which collected from World Development Indicators of the official website of World Bank (2014). All the variables are transferred to log form except the early stage of economic growth (Y) to reduce heteroscedasticity in the model.

Methods of data analysis and estimation techniques

In the econometrics model the methodology based on secondary data analysis of Johnson co-integration analysis framework: it includes lag length selection, unit root test, and co-integration, identification of long run model and diagnostic test of validity which includes the test for the serial autocorrelation in the residual. And if it finds any evidence of any serial autocorrelations the paper tries to fix it buy adding or removing lags of the variables. All the analysis in the study was conducted using STATA 12 version software.

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. 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:

$\Delta y_t = \alpha + \beta t + \delta yt - 1 + \sum_{i=1}^{p} \gamma i \Delta yt - i + \varepsilon t$, intercept and time trend item……..2

$\Delta y_t = \alpha + \delta yt - 1 + \sum_{i=1}^{p} \gamma i \Delta yt - i + \varepsilon t$, intercept and no time trend item……..3

$\Delta y_t = \delta yt - 1 + \sum_{i=1}^{p} \gamma i \Delta yt - i + \varepsilon t$, no intercept and no time trend items.....……4

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, ε is an independently, identically distributed residual term, yt is the variable of interest (Y, E, Y^2 and Openness). 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 2 the null hypothesis is H0: δ = 0 β ≠ 0, yt is non-stationary, against the alternative HA: δ < 0 β ≠ 0, yt is trend stationary, represents a least restricted ADF model i.e. including trend. For equation 3 excludes trends H0: δ = 0 α ≠ 0, yt is non-stationary, against the alternative HA: δ < 0 α ≠ 0, yt is level stationary and For equation 4 H0: δ = 0 yt is non-stationary, against the alternative HA: δ < 0, yt is stationary and excludes both trend and constant (ibid).

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 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. Johansen (1992) suggests 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:

$$\Delta y_t = \alpha + \sum_{i=1}^{p} \alpha_i \Delta y_{t-l} + \sum_{j=1}^{p} \beta j x_{t-j} + \emptyset e_{t-1} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots 5$$

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).

RESULT AND DISCUSSION

As shown in Tables 1 to 3, lag length selection criteria of Akaike Information Criterions (AIC), Hanna-Quinn Information criterions (HQIC) and Schwarz Information Criterions (SBIS) strongly advise us of inclusion of one lag in the analysis. Based on this outcome the study had included one lag for all of the variables in the model.

All the variables in the study are non-stationary at level whereas they become stationary at 5% level of significance after taking their first difference as indicated in Table 1 respectively. To proceed with Johnson co-integration analysis it needs the variables of interest must be integrated of the same order I (1), meaning they have to become stationary after taking their first differences as approved in the above result (Tables 4 and 5).

Johnson co-integration test result Trace Statistics

In the Johnson co-integration test both trace statistics and max-Eigen statistics indicates existence of one co-integrating equations among variables of interests. Next by normalizing the VECM on the long run relationship is in support of EKC hypothesis. At the early stage of economic growth when the economy is mainly depending on agriculture economic growth invariably contribute for environmental degradation. As shown below on Y positive sign, there is significant p-value in equation 6. Later on further economic growth starts to reduce environmental degradation with increasing economic growth as indicated with negative sign and significant p-value of Y2 in the same equation.

Table 1. Lag length selections criteria.

Lag	AIC	HQIC	SBIC
0	13.1332	13.1946	13.3056
1	6.88427*	7.19092*	7.74616*
2	6.96316	7.51514	8.51456
3	6.9296	7.7269	9.17051
4	7.1132	8.15582	10.0436

Source: Stata 12 result.

LE = 670.89 + 0.11Y - 56.16 LY2 + 0.80LOpenness
(0.000) (0.000) **(**0.174**)** ……6

Vector AR test chi^2 (23.5247) = 16 (0.10041)

According to carbon budget from 1959-2011 the main source of environmental degradation carbon dioxide emission among all human-produced carbon dioxide emissions 87 percent 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 country's 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 (Deriba, 2012). The composition of the economy is dominated by agriculture so the clearing of forests and other land use change pattern can initially contribute for environmental degradations. Later on adaption of environmental policy and an increase in the service sector economic contribution can reduce environmental degradation with increasing economic growth.

In line with this argument Ethiopia have been doing enormous homework starting from: adoptions of national conservation strategy started in 1993, adaption of environmental policy in 1997, and climate resilient green economy strategy was developed in 2011 and all development plans including agricultural development led industrialization, poverty reduction strategic papers, a

Table 2. Unit root test result at level.

	Intercept			Trend and intercept			None		
	Test statistics	1% critical value	5% critical value	Test statistics	1% critical value	5% critical value	Test statistics	1% critical value	5% critical value
LE	-0.642	-3.648	-2.958	-1.353	-4.242	-3.540	-0.746	-2.636	-1.950
Y	1.887	-3.648	-2.958	1.636	-4.242	-3.540	1.529	-2.636	-1.950
LY2	0.839	-3.648	-2.958	0.453	-4.242	-3.540	1.151	-2.636	-1.950
Lopeness	-1.592	-3.648	-2.958	-2.281	-4.242	-3.540	-0.830	-2.636	-1.950

Source: from stata 12 result.

Table 3. Unit root test result at first difference.

	Intercept			Trend and intercept			None		
	Test statistics	1% critical value	5% critical value	Test statistics	1% critical value	5% critical value	Test statistics	1% critical value	5% critical value
dLE	-4.632	-3.655*	-2.961**	-5.090	-4.251*	-3.544**	-4.609	-2.638*	-1.950**
dY	-3.233	-3.655	-2.961**	-4.662	-4.251*	-3.544**	-2.948	-2.638*	-1.950**
dLY2	-4.583	-3.655*	-2.961**	-5.943	-4.251*	-3.544**	-4.350	-2.638*	-1.950**
dlopennes	-4.647	-3.655*	-2.961**	-4.586	-4.251*	-3.544**	-4.633	-2.638*	-1.950**

Source: from stata 12 result* and ** indicates the rejection of the null hypothesis at 1% and 5% level of significance, respectively.

Table 4. Johnson co-integration test result Trace Statistics.

Rank _Ho	Ha	Eigen value	Trace statistic	5% critical	decision
0		-	121.5407	47.21	
1		0.91535	20.3000*	29.68	accept
2		0.25993	7.9585	15.41	
3		0.16298	0.6641	3.76	
4		0.01607	-	-	

Source: Stata 12 result.

Table 5. Johnson co-integration test result Max Statistics.

Rank_Ho	Ha	Eigen value	Max statistic	5% critical	decision
0		-	101.2408	27.07	
1		0.91535	12.3415	20.97	accept
2		0.25993	7.2943	14.07	
3		0.16298	0.6641	3.76	
4		0.01607	-	-	

Source: Stata 12 result.

plan for accelerated and sustainable development to end poverty, and the growth and transformations plan underlines implementing environmental low is part of building green economy. According to climate resilient green economic strategy of Ethiopia the country aimed to achieve middle income economy as of 2020 to 2023 within this range the contribution of agriculture projected to diminish from 42 to 29%. This indicates dramati

Table 6. Short run dynamics.

Variables	Coefficient	Std. error	Z value	p-value
constant	-0.4119546	0.1761642	-2.34	0.019
DLE_1	-0.0429387	0.1611621	-0.27	0.790
DY_1	-.0546553	.0205369	-2.66	0.008
DY2_1	27.38179	10.46675	2.62	0.009
Lopenness_1	-.1198051	.4261965	-0.28	0.779
EMC_1	-.1379049	.0540189	-2.55	0.011

R^2 = 0.7990; AR test Chi^2(16) = 16 (0.08837). Source: Stata 12 result.

change of factors of production mobility to industry and service sector. Even the expected industrial development doesn't increases environmental degradation like other developed nation because in Ethiopia the current vast hydro power investment secures the source of energy for human, industrial and partly for transportation service could be from renewable source (FDRE, CRGE, 2011).

In the vector error correction model the study found the significant and correct signed error correction term. The sign of error correction term indicates convergence to the equilibrium in case of shock occurs in the model. The magnitude of the error correction term which is 13.79% indicates in case of shock occurs it adjust itself by this amount. In the process of adjustment initial level and further economic growth can play crucial rules and their significance bolds the long run relationships result. The diagnostic test of serial autocorrelation to examine if data series residual have autocorrelation or linearly dependence exists? In this case it justifies there is no serial autocorrelation problem in the model (Table 6).

Short run dynamics

Conclusion and Policy implication

This study aimed to assess the relationship between environmental degradation and economic growth in Ethiopia by questioning the existence of environmental Kuznets curve. It also finds existence of statistical significance relationship in support of the existence of environmental Kuznets curve hypothesis in Ethiopia: Which means, like any agriculturalist economy at the early stage economic growth inevitably contribute for environmental degradation. Later on environmental degradation starts to decrease with increasing economic growth. The argument could be justified on the bases of expected increases on the share of service sector in the economy, ratification of environmental friend development policies and currently started environmental rules and regulation can contribute for improvement in environmental degradation in the future.

On the bases of this finding when other things remain constant, the future economic growth in Ethiopia can contribute positively for environmental improvement. To realize this argument the country should have to sustain the current situation which projects increasing share of service sector in the economy, sustaining the current green economy targeted development policies, sourcing energy from climate resilient green energy and implementing environmental policies roles and regulation in the right way.

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