DETERMINANTS OF DEFORESTATION IN GHANA

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BY

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DECLARATION

This is to certify that this thesis is the result of research undertaken by **MICHAEL KAKU MINLAH** towards the award of the MASTER OF PHILOSOPHY (MPHIL) DEGREE in the Department of Economics, University of Ghana.

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ABSTRACT

Deforestation is one of the major environmental challenges facing Ghana. Today, the impacts of deforestation continue to impinge on livelihoods of rural and urban dwellers, disrupting important environmental functions and severely destroying forest ecosystems. Some studies have analyzed factors that influence deforestation in Ghana. However, none have placed emphasis on the occurrence of the Environmental Kuznets Curve for deforestation in Ghana. This study employs the Auto Regressive Distributed Lag (ARDL) Bounds Testing approach to cointegration to empirically investigate the factors that cause deforestation in the long and short run as well as investigating the occurrence of the Environmental Kuznets Curve (EKC) for deforestation using time series data from 1970 and 2009.

The long run estimation results indicate that variables such as urbanization, rural population pressure, globalization, Structural Adjustment Program (SAP), and agricultural technology affect deforestation in Ghana positively, while agricultural production index, forest exports value as a percentage of GDP, enforcement of property right and forest protection and exchange rate influence deforestation negatively. The impact of total external debt on deforestation Ghana was positive but not significant implying a weak confirmation of the Debt Resource Hypothesis in Ghana. Analysis of the EKC for deforestation in Ghana indicate that the phenomenon is real in Ghana with the per capita income turning point being at $ US 364.99 (in constant 2000 $ US) which will occur in 2011 at a deforestation rate of 1.5%. General and specific recommendations aimed at reducing deforestation are provided.

DEDICATION

This work is dedicated to my parents, siblings, MPhil colleagues, friends and all those who have in diverse ways contributed to the success of this work.

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My greatest thanks and praise goes to Jehovah God Almighty for giving me the direction, strength, wisdom and courage to finish this work successfully. I would like to thank my supervisors; Dr. S.K.K Akoena and Dr. Daniel K. Twerefou whose rich advice guided me through the thesis process.

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Though I received a lot of guidance and support from my supervisors and colleagues I claim sole responsibility for any errors, omissions or misrepresentation that may be found in this work.

Michael Kaku Minlah JUNE, 2011

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LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
ADI	African Development Indicators
AIC	Akaike Information Criteria
ANOVA	Analysis Of Variance
API	Agricultural Production Index
ARDL	Auto Regressive Distributed Lag
BOD	Biological Oxygen Demand
CEA	Country Environmental Analysis
CREMA	Community Resource Management Area
CUSUM	Cumulative Sum of Square Residuals
CUSUMQ	Cumulative Sum of Squares of Recursive Residuals
DRH	Debt Resource Hypothesis
ECM	Error Correction Model
EKC	Environmental Kuznets Curve
EMT	Ecological Modernization Theory
FAO	Food and Agricultural Organization
FOSA	Forest Outlook Study for Africa
FRA	Forest Resource Assessment
GDP	Gross Domestic Product
GLS	Generalized Least Squares
GNI	Gross National Income
GNP	Gross National Product
GSBA	Globally Significant Biodiversity Area

HDI	Human Development Index
IMF	International Monetary Fund
IPE	International Political Economy
LM	Lagrange Multiplier
LPG	Liquefied Petroleum Gas
NAFTA	North American Free Trade Agreement
OLS	Ordinary Least Squares
PP	Phillips Perron
SAP	Structural Adjustment Program
SBC	Schwartz Bayesian Criteria
SNR	Strict Nature Reserve
SOFO	State Of the world's Forests
WRI	World Resource Institute
WDI	World Development Indicators

CHAPTER ONE

INTRODUCTION TO THE STUDY

1.1 Back ground to the study

Deforestation, globally recognized as a very serious environmental concern is a vast and complex phenomenon that is occurring around the world at an alarming rate -13 million hectares per year (Global Forest Resources Assessment, 2005). The impacts of deforestation have threatened the environments and economies of many countries in the world as well as the very economic likelihood of forest dependent communities. Valuable forests throughout every continent are virtually being destroyed by people either for purposes of living or trade.[1] In many countries over the world, forests have become primary targets for agricultural and urban expansion (Global Forest Resources Assessment, 2005). Concerns are rising about the impacts of deforestation on the environment and the economy, which are best understood in terms of the benefits lost when forests are removed.

Forests support considerable biodiversity and are known to be a valuable habitat for wildlife. Direct economic benefits accrue from the harvest of forest resources such as wildlife, non-wood forest products like wild mushrooms and medicinal herbs and also

[1] http://www1.american.edu/ted/projects/tedcross/xdefor21.htm

from the sale of hunting and camping equipment. Forests have also been known to play an important role in watershed protection, soil conservation and ecotourism.

Notwithstanding the fact that deforestation occurs all over the world, it must be emphasized that it is more concentrated in developing countries, which collectively lost 9.4 million hectares of forest during the 1990s (FAO, 2001). The factors leading to the destruction of forests, direct and indirect are complex and interrelated. The complexity of the factors makes it difficult to anticipate future trends or to evaluate the likely impact of policy measures aimed at promoting conservation and sustainable forest use (Geist and Lambin, 2002). Deforestation, it must be said, is however caused by a wide intricate set of factors chief among which are human activities.

Kallbekken (2000) asserted that the direct causes of deforestation: the conversion of forested land to agricultural land by shifted cultivators, conversions to plantations, commercial logging and forest destruction for roads, mining and hydropower dams are fairly well known and understood; however, the underlying causes, such as economic incentives and structural changes in the economy are less understood, and much more controversial.

Like many of the environmental ills that plague economies, deforestation can have very damaging environmental consequences. The repercussions of deforestation can be very severe, ranging from country specific or geographic effects such as permanent loss of animal species, soil degradation, long term resource depletion, loss of biodiversity, flooding to impacts on the global climate change (Kallbekken, 2000; Ehrhard-Martinez et al., 2002). The impacts of deforestation on global climate change can be traced to the release of carbon dioxide (CO_2) stored in trees as CO_2 emissions. The United Nation's Food and Agriculture Organization (FAO) in a report in October 2006 revealed that contrary to people's perception that global warming was caused by burning oil and gas, in fact between 25 and 30 percent of the greenhouse gases released into the atmosphere each year – 1.6 billion tonnes – was caused by deforestation.[2]

At a workshop on "Underlying causes of deforestation and Forest Degradation in Ghana" held at the Teacher's Hall, Accra on March 20 and 21, Samuel Dotse of the Hatof Foundation revealed that globally 238 Giga tonnes (Gt) of carbon is stored in forest vegetations, 38 Giga tonnes (Gt) in dead wood and 317 Giga tonnes (Gt) in soil and litter. He confirmed that in 2005, the total carbon content of forests, estimated at 638 Giga tonnes (Gt) was more than the quantity of carbon in the entire atmosphere, implying the virtual impossibility of the sustenance of life without the existence of forests.[3]

Deforestation, as has been explained is of a global nature, but is more concentrated in developing economies. Deforestation seriously affects the economies of developing countries, of which Ghana is no exception. There are various definitions of deforestation, the popular one being the definition adopted by FAO as "the conversion of forests to

[2] http://www.fao.org/newsroom/en/news/2006/1000385/index.html
[3] http://performancesystem.globalforestcoalition.org/img/userpics/File/UnderlyingCauses/Ghana-report-Underlying-Causes.pdf

another land use or the long term reductions of the true canopy cover below the minimum of 10 %".[4] There are three types of deforestation namely; Boreal deforestation, Temperate deforestation and Tropical deforestation, however this study is concerned with Tropical deforestation.

Approximately 40% of the total Land area of Ghana is covered by natural forests which occur in two ecological zones: the tropical high forest which covers one-third of the country and provides the major source of logs for the wood products industry; and the savannah zone which covers the remaining two-thirds of the country's total land area and plays an important function in the supply of building poles, firewood and charcoal.[5]

Deforestation in Ghana has been attributed to high population growth, rapid encroachment by agriculture and live stock, uncontrolled and indiscriminate cutting of wood for fuel wood. The Loss of forest cover in Ghana is estimated by the FAO to adversely affect agricultural productivity and the environment.[6]

Between 1990 and 2000, Ghana lost an average of 135,400 hectares of forest per year. This loss amounted to an average annual deforestation rate of 1.82%. Between 2000 and 2005, the rate of forest change increased by 4.2% to 1.89% per annum. In total, between 1990 and 2005, it is estimated that Ghana lost 25.9% of its forest cover, translating into a loss of approximately 1,931,000 hectares of forest.[7]

[4] ftp://ftp.fao.org/docrep/fao/003/y0900e/y0900e05.pdf
[5] *http://www.fao.org/forestry/country/57478/en/gha/*
[6] *http://www.povertyenvironment.net/?q=ghana_in_the_fight_against_desertification_and_drought*
[7] *http://rainforests.mongabay.com/deforestation/2000/Ghana.htm*

Deforestation is a very serious problem to the Ghanaian economy as it affects the very economic livelihoods of local people. The impairments of deforestation can be observed from its disruption of important environmental functions and destruction of the original forest ecosystem. Factors hypothesized to influence deforestation in Ghana are demographic, microeconomic, macroeconomic and socio-political in nature. Demographic factors include high population growth and rapid urbanization. Rural poverty, lack of employment opportunities and the clear absence of properly defined and enforced property rights constitute the microeconomic factors accelerating deforestation in Ghana. Macro economic variables such as debt burden, international trade and global economic pressures, and socio-political factors such as inadequate institutional capacity and low level of awareness of environmental awareness have been catalogued as factors influencing deforestation in Ghana.[8]

The negative repercussions of deforestation have ignited the interest of many researchers in forestry issues, leading to the development of various deforestation models. It is in this respect that this study attempts to empirically investigate the determinants of deforestation in Ghana. This study believes that its recommendations will improve on policies designed to correct the ills of deforestation in Ghana. Following Kallbekken (2000), this study will proceed to analyze deforestation in Ghana using the Environmental Kuznet Curve (EKC) hypothesis.

[8] http://performancesystem.globalforestcoalition.org/img/userpics/File/UnderlyingCauses/Ghana-report-Underlying-Causes.pdf

The study proceeds on the premise that past literature on deforestation which have primarily investigated deforestation from the micro-level considering such factors as household decisions to convert or conserve forest and the accessibility of forests have not been successful in explaining deforestation (Kallbekken, 2000). According to Kallbekken (2000), cross sectional studies that have been applied at the macro level have also been less successful in explaining deforestation. The author thus recommended the Environmental Kuznets curve (EKC) hypothesis for analyzing deforestation, which is adopted by this study for investigating the determinants of deforestation in Ghana.

1.1.1 Introduction to the Environmental Kuznets Curve (EKC)

A Kuznets curve is a graphical representation of the Simon Kuznets' hypothesis which postulates that economic inequality increases over time while a country is developing, and then after a certain average income is attained, inequality begins to decrease. A graphical exposition of the Simon Kuznets' hypothesis depicting the relationship between income per capita and income inequality (measured by the Gini-co efficient) was therefore hypothesized to follow an inverted "U" shape as depicted in Figure 1.1.

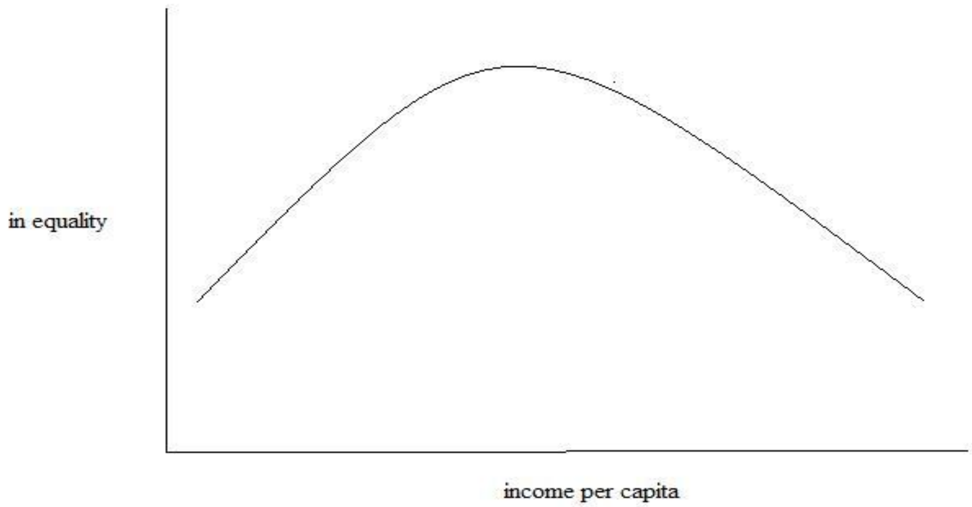

Figure 1.1: A theoretical Kuznets curve

Proceeding on the same analogy, the Environmental Kuznets Curve (EKC) was developed to explain the relationship between economic development and environmental degradation. The EKC is simply a hypothesized relationship between various indicators of environmental degradation and income per capita. Stern (2003) reports that the EKC concept emerged in the early 1990s with Grossman and Krueger's (1991) path breaking study of the potential impacts of North Americana Free Trade Agreement (NAFTA) and Shafik and Bandyopadhyay's (1992) background study for the 1992 World Development Report.

In accordance with the original Simon Kuznets' hypothesis, the EKC asserts that in the early stages of economic growth, environmental degradation and pollution increase, reaches a threshold, and then the trend reverses, so that at high-income levels economic growth leads to environmental improvement (Stern, 2003). The EKC hypothesis thus theorizes that a graph of environmental degradation versus income often approximates an inverted "U" shape. Figure 1.2 depicts a theoretical EKC.

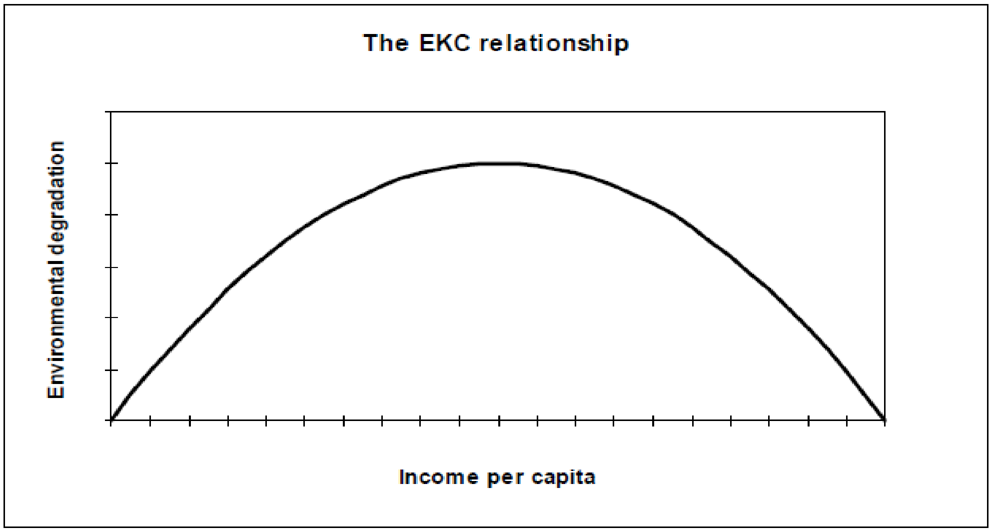

Figure 1.2: A theoretical Environmental Kuznets Curve

Source: Adapted from Kallbekken (2000)

The EKC hypothesis has been tested for a wide variety of environmental indicators such as air and water pollutants. Researchers have estimated EKC's for various measures of air quality such as Carbon Dioxide (CO_2), Carbon monoxide and Sulfur Dioxide. EKC's have also been estimated for measures of water quality such as Biological Oxygen Demand (BOD). A number of studies have been done on the existence of the EKC for deforestation. These studies include works done by Kallbekken (2000), Ehrhard-Martinez et al., (2002), Cropper and Griffiths (1994), and Culas (2006).

According to Kallbekken (2000), studies that have attempted to estimate an EKC for deforestation have found very inconsistent results. Although many EKC studies on deforestation have employed panel data regressions, the superiority of time series analysis on the EKC for an individual country over panel data EKC studies has been upheld by Iwata et al., (2009). Iwata et al., (2009) proposed that the effects overlooked by panel data EKC studies may be better clarified by time series analysis on an individual country for the same study.

This study will attempt to empirically investigate the determinants of deforestation in Ghana within the frame work of the Environmental Kuznets curve (EKC) for deforestation.

1.2 Statement of the problem

The importance of forests to the economy of Ghana cannot be over emphasized. Ghana's forests produce both tangible and intangible benefits. The tangible benefits include timber and non-timber products meant for domestic use and export while the intangible benefits include control of erratic rainfall, climatic stability, soil improvement, agricultural productivity and windbreaks (Seneadza, 2010).[9]

Ghana's economic development is largely natural resourced based due to the fact that most of the main foreign exchange earners of Ghana such as agricultural produce, timber and natural minerals form the significant proportion of the country's GDP (Aning, 1999). The implication is that any threat to the natural environment of Ghana will have serious bearing

[9] http://www.articlesbase.com/national-state-local-articles/deforestation-in-ghana-new-challenges-and-new-strategies-1954711.html

on its economic development. One such phenomenon that is threatening the very survival of Ghana's natural environment is deforestation. The United Nation's Food and Agricultural Organization (FAO) estimated that the rate of deforestation in Ghana has increased by 50% over the last ten years.[10]

The impacts of deforestation on the Ghanaian economy have been severe ranging from the rapid extraction of many of Ghana's hardwood like Mahogany and Odum to deterioration of soil quality. It is also asserted that the indiscriminate cutting of trees in Ghana for fuel wood and illegal wood export has led to the loss of many indigenous trees and plants with medicinal properties. According to Aning (1999), fuel wood nearly provides all the household energy used for cooking and water heating. The surging demand for fuel wood is exerting severe pressures on Ghana's forests.

The study recognizes the seriousness of the nature and repercussions that deforestation has had and will continue to have on the Ghanaian economy if its effects are not curtailed. Extinction beckons many of Ghana's wood species given the current state of deforestation in Ghana. Baah–Nuakoh (2003) projected the total forest area of Ghana to be totally depleted in 31 years given the prevailing rate of deforestation, unless serious re-afforestation efforts are undertaken. In monetary terms, Baah–Nuakoh (2003) estimated the total cost of deforestation to Ghana in terms of wood lost, not accounting for losses from biodiversity and minor forest products to be a substantial 17.2 billion cedis (Old Ghana cedis) or US $ 17.63 million.

[10] http://www1.american.edu/TED/ghana.htm

In the light of these threats from deforestation, the study proposes to provide an in depth overview of deforestation in Ghana; with the aim of empirically investigating the causes of deforestation in Ghana and adding to the stock of policies prescribed to fight deforestation in Ghana.

1.3 Research questions

The study is based on a number of research questions which are hoped to be resolved at the end of the study. The following research questions are paramount to the study:

1. What are the sources of an EKC that produces an inverted "U" relationship between economic growth and deforestation in Ghana?

2. What are the drivers of deforestation in Ghana?

3. What policies should be prescribed to mitigate the problem of deforestation in Ghana?

1.4 Objectives of the study

The study will be carried out against the background of some objectives to be achieved. This research has the aim and objective of seeking to explain the determinants of deforestation in Ghana. In particular the study objectivizes the following:

1. Empirical verification of the Environmental Kuznet Curve for deforestation in Ghana.
2. To empirically determine the various factors which are significant in influencing deforestation in Ghana.

3. To provide policy recommendations that will help to mitigate the ills associated with deforestation in Ghana.

1.5 Contributions / Significance of the Study

The study will prove to be useful as it will contribute to the existing literature on deforestation in Ghana. By so doing it will increase the awareness of the nation towards the negative consequences of deforestation. The study will also aim to improve upon policies designed to mitigate the ills of deforestation in Ghana. As far as the methodology is concerned the study will introduce a new approach to the study of deforestation in Ghana. A number of studies have been undertaken to theoretically and empirically investigate the causes and consequences of deforestation in Ghana. These studies placed very little or no explicit emphasis on the Environmental Kuznets Curve for deforestation in Ghana. This study closes this gap in deforestation literature on Ghana by empirically investigating the various factors theorized to cause deforestation in Ghana within the framework of the Environmental Kuznets Curve (EKC) hypothesis.

1.6 Hypothesis of the study

In line with the objectives of the study to explore the various factors that affect deforestation in Ghana, the study will test the hypothesis that the Environmental Kuznets Curve (EKC) for deforestation exists for Ghana. The null and alternative hypotheses of the study are given as:

H_0: The Environmental Kuznets curve for Deforestation exists in Ghana

H_1: The Environmental Kuznet curve for Deforestation does not exist in Ghana.

1.7 Organization of the study

This study is divided into six chapters carefully laid out in the following manner. Chapter one, representing the introduction to the study presents an overview of the whole study. It explains the rationale for the study and its objectives to be achieved. In chapter two, an overview of deforestation in Ghana is presented. Chapter three presents a review of theoretical and empirical literature on deforestation. The methodology adopted by the study is discussed in chapter four. In this chapter, the data sources, model used and the main econometric technique used by the study are elaborated upon. Chapter five contains the analysis and interpretations of the estimations from chapter four. Chapter six provides a summary of the content of the whole study and draws out recommendations for policy.

CHAPTER TWO

OVERVIEW OF DEFORESTATION IN GHANA

2.0 Introduction

Ghana's forestry sector has played and continues to play a very important role in the economic development of Ghana as well as in the welfare of its citizens. The direct economic and indirect benefits derived from forests in Ghana cannot be overemphasized. However, the forestry sector is in a serious crisis as the over exploitation of forest resources is putting serious pressures on forests, aggravating the deforestation problem in Ghana. Paradoxically, the deforestation problem in Ghana persists despite the existence of well structured, comprehensive laws, policies, regulations and institutions governing the forestry sector. This chapter presents an overview of deforestation in Ghana; considering the state of forests and its benefits, causes and negative consequences of deforestation in Ghana. A review of the chronology of forest policies and legislation in Ghana is presented, highlighting on the impact and effectiveness of the policies on reducing deforestation in Ghana. The chapter closes with a conclusion.

2.1 State of forestry in Ghana

Approximately 40% of Ghana's total land area is covered by natural forests which occur in two ecological zones: the tropical high forest zone and the savannah zone. The tropical high forest zone covers one – third of the country, providing the major source of logs for the wood products industry whiles the remaining two –thirds are covered by the Savannah zone which is very implemental in supplying building poles, firewood and charcoal.[11] Hawthorne (1995), cited in Domson and Vlosky (2007) categorized the High Forest Zone of Ghana into nine distinct vegetation zones namely: Wet Evergreen zone, Moist Semi – Deciduous North East, Moist Semi-Deciduous South East, Upland Evergreen, Dry Semi-Deciduous Inner Zone, Dry Semi- Deciduous Fire Zone, Southern Marginal and Southern Outlier. The Deciduous forests are notable for timber species such as Triplochiton scleroxylon (Wawa), Mansonia altissima (Mansonia), Nesogordonia papaverifera (Danta) and Khaya ivorensis (Mahogany) whiles the Evergreen forests are noted for such timber species as Tieghemella heckelii (Makore), Tarrieta utilis (Niangon) and Guarea cedrata (Domson and Vlosky, 2007).

Within the context of natural forest formations, the Food and Agricultural Organization (FAO) has classified forests in Ghana into open, closed forests, other wood land and other land cover.[12] The closed forests in Ghana constitute the Rain forests, moist deciduous forests, River rain forests and Mangroves. Baah –Nuakoh (2003) found that the Western region contained the largest rain forest in Ghana representing approximately 44 % of Ghana’s closed forests. The open forests in Ghana have been defined by FAO to include the Savanna wood land, river rain woodland and Sudan Savanna wood land whereas the other wood lands include shrubs and forest fallows. Figure 2.1 depicts the forest cover map of Ghana, showing the distribution of the total forest cover into open, closed forests, other wood lands and other Land cover.

[11]http://www.fao.org/forestry/country/57478/en/gha/
[12] http://www.fao.org/forestry/country/18314/en/gha/

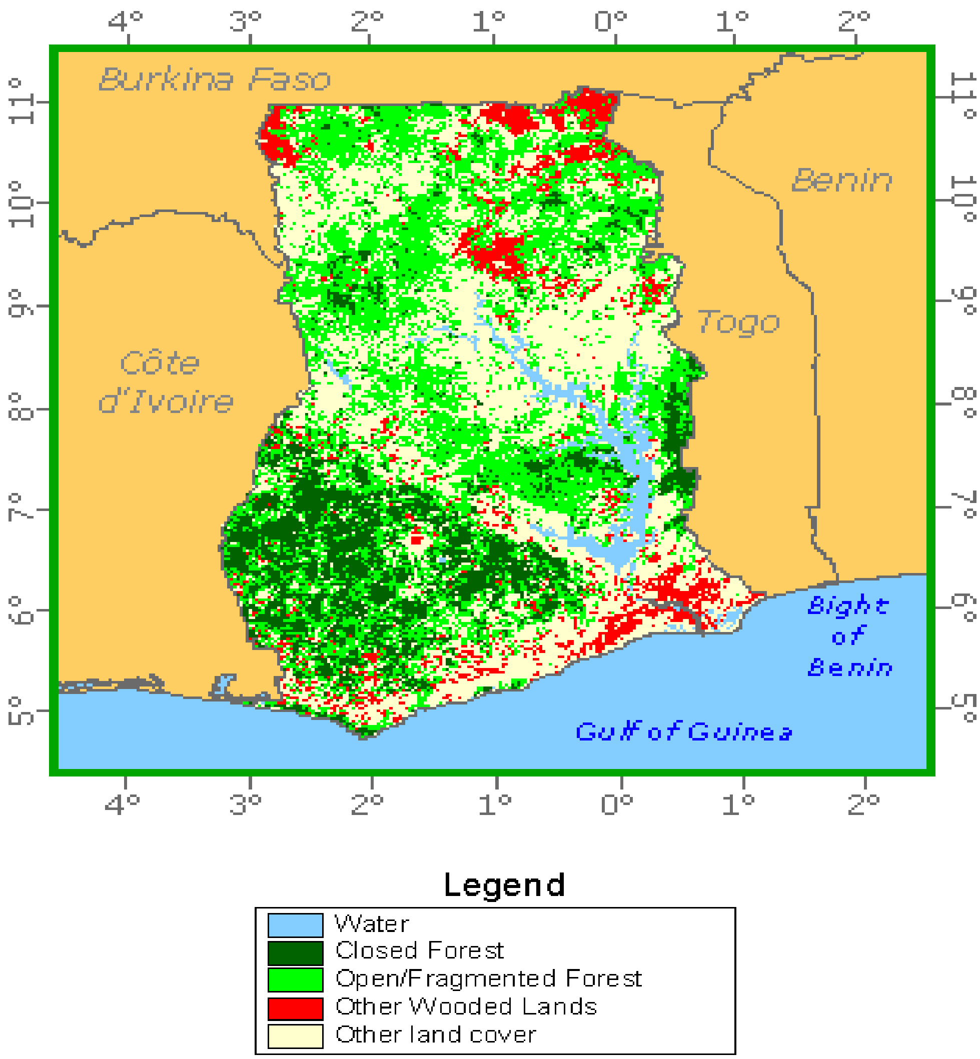

Figure 2.1: Forest cover map of Ghana showing the forested areas of Ghana. Source: FAO, website (2010), cited from Global Forest Resources Assessment 2000, base map: ESRI

In assessing the socio –economic impacts of chain sawing in the natural forests in Ghana, Odoom (2005) evaluated the forest resource base of Ghana in relation to the vegetation zones and forest reserves in the High Forest Zone of Ghana. In a graphical display, Odoom

(2005) presented an elaborate overview of the vegetation zones and forest reserves in the High Forest zone of Ghana (Figure 2.2).

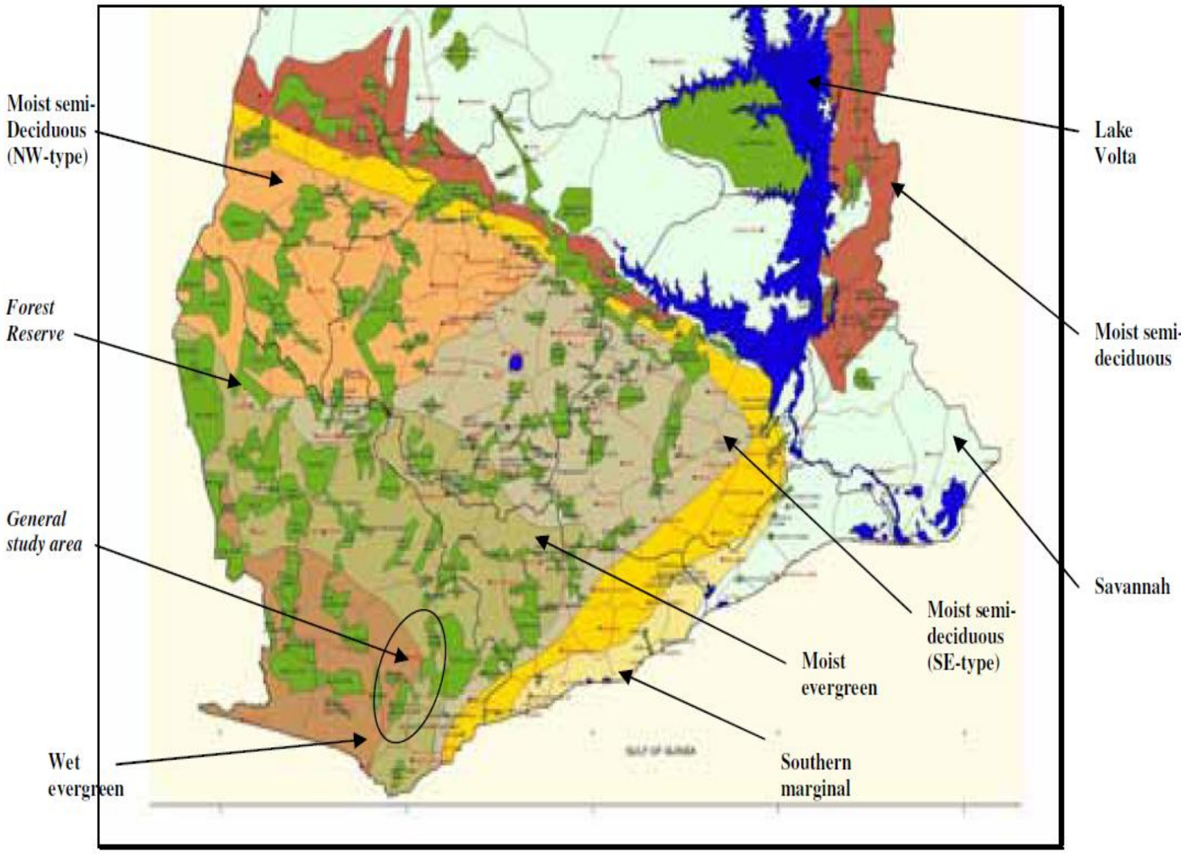

Figure 2.2: Vegetation zones and forest reserves in the high forest zone of Ghana (Source: Odoom, 2005)

2.1.1 Current forest conditions

A Country Environmental Analysis (CEA) report of Ghana undertaken by World Bank (2007) found that the long held assumptions about Ghana's forests wealth are no longer valid. The report found that the off –reserve forests in Ghana have largely gone and most forest reserves and off- reserves remain under a traditional form of land management. The report further provided a typology of forest areas in Ghana (Table 2.1).

Table 2.1: Typology of forest areas in Ghana

TOPOLGY	AREA (km^2)
Off-Reserve areas	201,000
Forest reserves	26,000
Dedicated Forests	4
Sacred Groves	Unknown
Protected areas (National Parks)	10,500
Resource Reserves (Game production reserve)	1,664
Forest reserves	26,000
Wild life Sanctuaries	66
CREMA	30
Globally Significant Biodiversity Area (GSBA's)	2,302
Strict Nature Reserve (SNR)	385
RAMSAR	1,784

Source: World Bank (2007)

Ghana has a total of 266 forest reserves of which 219 are located within the High Forest Zone (Blay, 2008; Opoku, 2009:1, cited in Ledger, 2009). Total land area of Ghana in 2010 is estimated at 22,754 ('000 total square kilometers) with a total forest area of 4940 ('000 hectares), representing a forest cover of 22%. The areas covered by the various forest types in Ghana in 2010 are distributed in the following manner: The primary forest cover was estimated at 395 ('000 hectares) representing 8% of the total forest area, other natural regenerated forests constituted 4285('000 hectares) representing 87% of the total forest area and planted forests constituted 260('000 hectares) representing 5 % of the total forest area[13] (Table 2.2 and Figure 2.3).

[13] http://rainforests.mongabay.com/deforestation/2000/Ghana.htm#01-cover

Table 2.2: Distribution of areas covered by the various forest types in Ghana in 2010

Forest types	(1000 hectares)	% OF (TOTALFOREST AREA)
Primary forest	395	8
Other naturally regenerated forest	4285	87
Planted Forest	260	5

Breakdown of forest types in Ghana, 2010 (Source: mongobay.com, 2010)

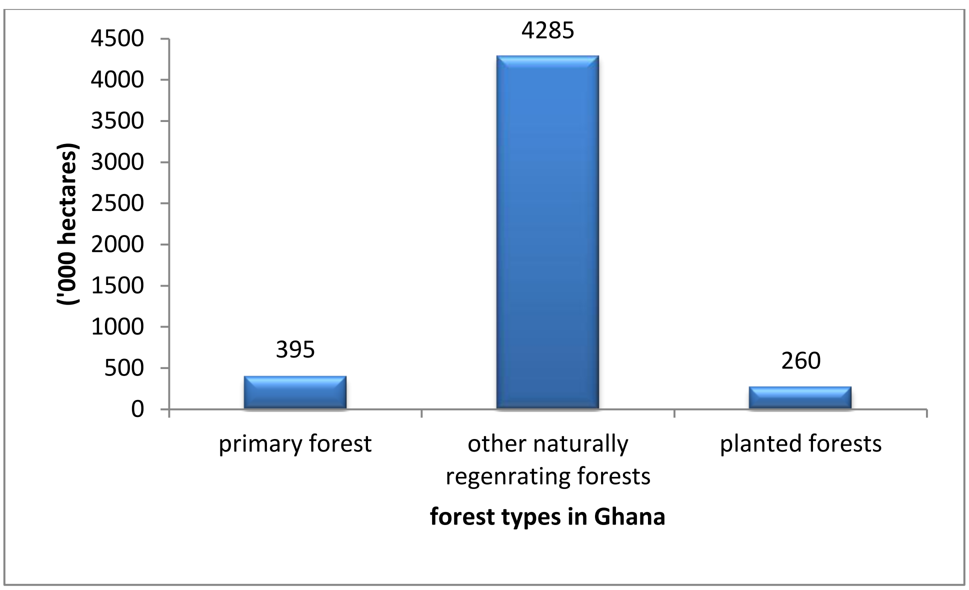

Figure 2.3: Breakdown of forest types in Ghana, 2010 (Source: mongobay.com, 2010)

2.2 Contribution of forests to Ghana's development

The Forestry sector plays a very significant role in the economy of Ghana as well as the social welfare of the people of Ghana. It can be said that the forestry sector remains a very important pillar in the economic development of Ghana by sustaining the revenues of the state and providing a wide range of employment opportunities to the people of Ghana. The contributions of the forestry sector can be analyzed from the view point of direct and indirect benefits. In terms of the direct benefit, economic benefits that the state enjoys from the forestry sector in terms of revenues and employment are considered.

Ghana's tropical high forest, according to Baah –Nuakoh (2003) is rich as a source of foreign exchange from timber, fuel wood, bush meat, medicinal plants, wood for exports and minor forest products. The timber industry, a very important component of the Forestry sector contributes significantly to the total foreign exchange earnings in Ghana. Table 2.3 and Figure 2.4 show trends in total foreign exchange earnings in the agricultural sector from 1999 to 2006. Foreign exchange earnings from timber have been fairly consistent over the years accounting for 4.5% to 9.1% of total foreign exchange earnings between 1999 and 2006.

Table 2.3: Foreign exchange earned by the agricultural sector, 1999-2006 (US $ million)

	AGRICULTURE					
Year	**COCOA**		**TIMBER**		**NON TRAD.COMMODITIES**	
	$	**%**	**$**	**%**	**$**	**%**
1999	550	26.2	174	8.3	85	4.1
2000	437	22.5	175	9	75	3.9
2001	381	20.4	169	9.1	82	4.4
2002	463	22.4	183	8.9	86	4.2
2003	818	34.9	174	7.6	138	6
2004	1,071	32.4	212	7.7	160	5.9
2005	908	39.2	227	8.1	151	5.4
2006*	1,004	30.4	149	4.5	203	6.1
Average						
1999-02	458	22.9	175	8.8	82	4.2
2003-06	724	34.2	191	7	163	5.9

***provisional figures**

Source: The State of the Ghanaian economy in 2006

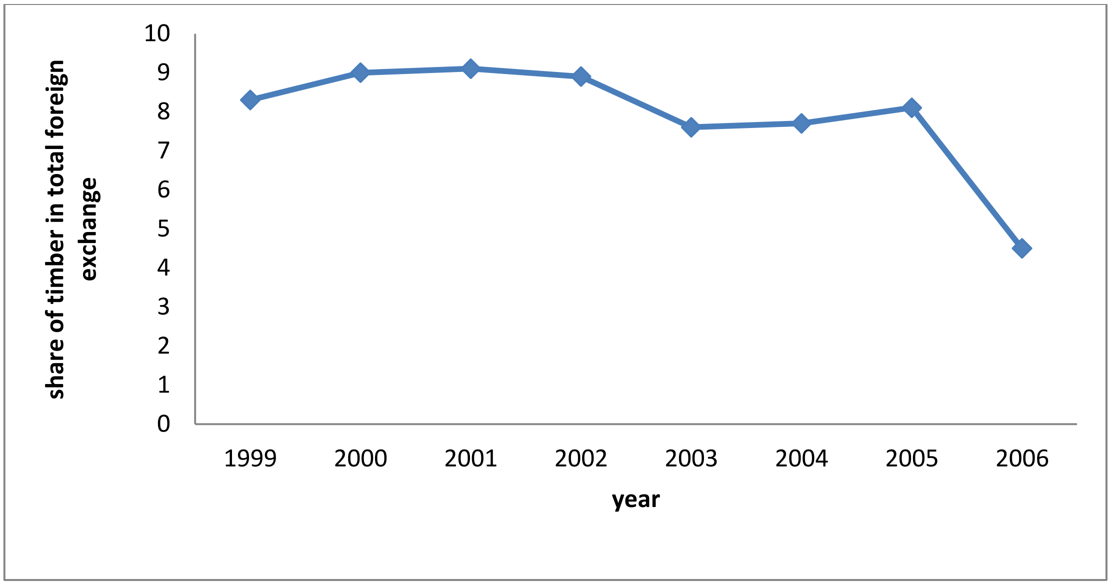

Figure 2.4: Share of timber in total foreign exchange earnings

According to the FAO, the High forest zone of Ghana is concentrated with most of the country's economic activities such as cocoa, oil palm, timber and mineral production. However, majority of households in the Savannah zone, are engaged in the intensive production of food crops, cotton and livestock.[14]

Although the Forestry sector contributes significantly to the economy of Ghana, with the exception of the timber industry, the contributions of the forest sector has been greatly undervalued.[15] According to the FAO, the undervaluation of the contributions of the forestry sector can be attributed to the lack of reliable statistics on the contribution of non-wood forest products to the incomes of forest dependent communities.

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[14] http://www.fao.org/forestry/country/57478/en/gha/

[15] http://www.fao.org/forestry/country/57478/en/gha/

Forests in Ghana are an important source of non wood forest products and services for the rural economy. Non wood products such as bush meat, cola, shea butter, canes, plant and animal products used for medicinal, cosmetic and cultural purposes are significant in their serving as subsistence use and also as a very important use of income generation as the rural communities greatly rely on bush meat for their source of protein and also make a living out of supplying bush meat to the urban areas.[16] The World Bank (2007) estimated that in 2003 animal and wild plant yielded US $18 million to the Ghanaian economy. However, the lack of recognition of non –wood forest products has led to forest policies in Ghana being overly "timberized" without any recourse to non –timber or non wood forest products in policy formulation and regulation (World Bank, 2007).

In terms of employment, World Bank (2007) estimates that the Forestry sector employs about 120,000 people in the timber industry and public institutions. In the informal sector, it is estimated that many households in Ghana make their livelihoods from forest activities through small scale carpentry, illegal chain saw operations, fuel wood collections and hunting of bush meat (World Bank, 2007).

Ghana's forests do not only provide economic benefits but indirect or environmental benefits as well. With respect to the environmental/indirect benefits of forests in Ghana, Baah –Nuakoh (2003) identified the storage of water, reduction in floods, reduction in erosion, provision of shelter and shade, protection of rare and endangered species and genetic diversity and also the recreational purposes served by forests. Forests in Ghana remain an important source of fuel for cooking. FAO (2010)[17] asserts that fuel wood and

[16] http://www.fao.org/forestry/country/57478/en/gha/
[17] http://www.fao.org/forestry/country/57478/en/gha/

charcoal accounts for about 75% of Ghana's fuel needs. In addition, forests in Ghana serve as a sink for Carbon stock, although the stock of carbon in living forest biomass has shown a decreasing trend from 1990 to 2010 (Figure 2.5).

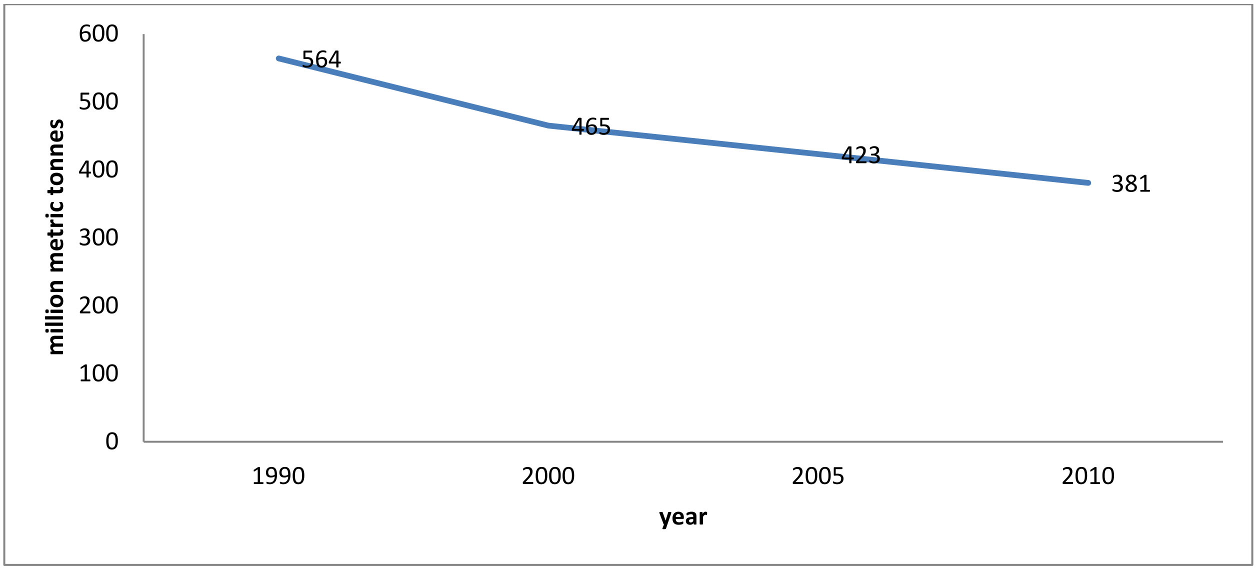

Figure 2.5: Trend in the stock of carbon in living forest biomass in Ghana, 1990-2010 (Source: mongobay.com, 2010)

Recently, the attention of policy makers is being shifted from the function of forests as providing wood supply to the protective and environmental services that they provide as these have proven to be very essential for effective sustainable forest management.[18] The FAO's Global Forest Assessment country report for Ghana in 2010 evaluated the primary designated functions of Ghana. The report found that approximately 1124 ha of forests in Ghana are used for protection purposes,353 ha for protection of soil and water, 43 ha for

[18] http://www.fao.org/docrep/013/i1757e/i1757e06.pdf

conservation of biodiversity, 59 ha for social services and 3361 ha used for unknown purposes (FRA, 2010).

In percentage terms the primary designated function of forests in Ghana was distributed in the following manner: 23% for production purposes, 7 % for protection of soil and water and 1% for social services. Interestingly, a substantial 68% of the primary designated functions of forest in Ghana are unknown (Table 2.4).

Attempts have been made to quantify the economic importance or value of forests in Ghana. Baah- Nuakoh et al., (1995), cited in Brew (1998) estimated the total economic value of forests in Ghana to be US $ 1,313,000,000.

Table 2.4: Percentage distribution of primary designated function of forests in Ghana

PRIMARY DESIGNATED FUNCTION	PERCENT (%)	AREA('000)ha
Production	23	1124
Protection of water and soil	7	353
Conservation of biodiversity	1	43
Social services	1	59
Multiple uses	0	0
Other	0	0
None or unknown	68	3361

Source: FRA COUNTRY REPORT- GHANA (2010)

2.3 Rate and extent of deforestation in Ghana

Although it is acknowledged that the forestry sector plays a very important developmental role in the economy as well as the welfare of the population, for various reasons such as illegal logging and indiscriminate cutting of wood for firewood, forests in Ghana are rapidly being depleted. It is estimated that an average of 125,400 ha or 1.68 % of forest cover in Ghana was lost per year between the period 1990 and 2010. In total, over the same period approximately 2,508,000 ha, translating into 33.7% of the forest cover of Ghana was lost[19]. Ghana's total forest area has shown a gradual declining trend. The total forest area of Ghana has been decreasing from 9600('000) ha in 1961 to 7448('000) ha in 1990, 6094 ('000) ha in 2000 and 5517('000) ha in 2005 and 4,940 ('000) ha in 2010 (FAO). Figure 2.6 depicts trends in the total forest area of Ghana from 1961 to 2007. The average annual rate of deforestation in Ghana between 1990 and 2000 was estimated at 18.2 %, implying a deforestation rate of 1.82 % per year.[20]

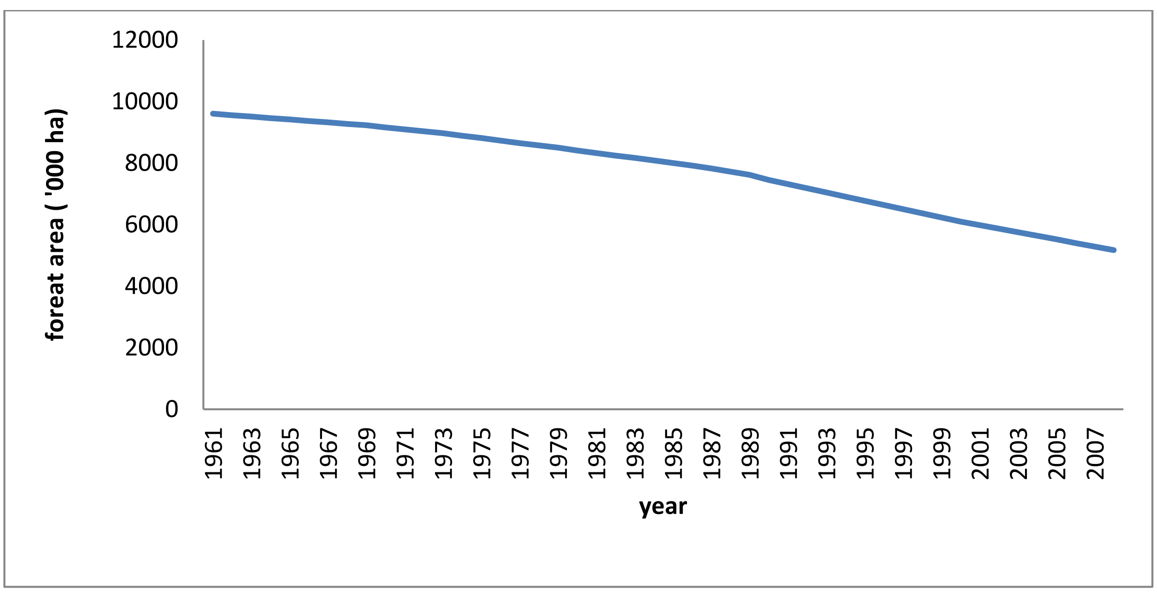

Figure 2.6: Trends in the total forest area of Ghana (1961-2007)

[19] http://rainforests.mongabay.com/deforestation/2000/Ghana.htm#01-cover
[20] http://rainforests.mongabay.com/deforestation/2000/Ghana.htm#01-cover

2.4 Causes of deforestation in Ghana

The general causes of deforestation are acclaimed to be complex with inter related factors; with the case of Ghana not being different. Deforestation is not a new phenomenon to affect Ghana. Asante (2005) recalls that there exists evidence of exploitation of forest resources in very ancient times in the region presently occupied by Ghana. Evidence suggests that even before contact with the Europeans, farming, exploitation of forest resources, mining and urbanization existed in the forest regions of Ghana (Asante, 2005).

The causes of deforestation in Ghana have been classified into direct and indirect causes. Guuroh (2010)[21] asserts that the causes of deforestation in Ghana are numerous, interrelated, complex and mostly linked to livelihood and development. The direct causes are those directly responsible for deforestation while the indirect causes are those factors that trigger the main causes. Guuroh (2010)[22] identified the indirect causes of deforestation in Ghana to be poverty, ignorance, corrupt practices of governments, weak institutions, inappropriate policies, lack of law enforcement and land tenure issues.

Nsenkyire (1998), cited in Guuroh (2010)[23] attributed the main causes of deforestation in Ghana to forest clearing for cocoa and food crops production and logging. The author was of the view that illegal logging, besides being a major cause of deforestation in Ghana, has

[21] http://www.ghanaweb.com/GhanaHomePage/blogs/blog.article.php?blog=3375&ID=1000009309
[22] http://www.ghanaweb.com/GhanaHomePage/blogs/blog.article.php?blog=3375&ID=1000009309
[23] http://www.ghanaweb.com/GhanaHomePage/blogs/blog.article.php?blog=3375&ID=1000009309
[24] http://www.ghanaweb.com/GhanaHomePage/blogs/blog.article.php?blog=3375&ID=1000009309

robbed the state of legal employment and revenue. Legal logging, on the other hand, the author believed could be a threat to forests if the logging was not done in a sustainable way. It is claimed that the over exploitation of timber and non- timber forest resources has played a significant role in aggravating the problems of deforestation in Ghana. Baah – Nuakoh (2003) found logging to the most deforesting activity in the Western region of Ghana, resulting in 21,699 hectares of total forest area being converted to logging and agricultural purposes each year.

Traditional land use in Ghana takes various forms among which are small and large scale farming, forestry, wood fuel, cattle grazing, urbanization, planting of exotic and indigenous species and game parks / reserves (FOSA, 2001). Afriyie (1995) asserts that the various land use forms in Ghana exert different pressures on the nation's forests. A distribution of the major categories of Land use forms in Ghana is presented in Table 2.5. The table depicts that unreserved forest accounts for only 2% of the total land area of Ghana whiles Savannah woodland and Bush Fallow account for 30 and 21 % respectively.

Table 2.5: Land use categories in Ghana

Land use	Land area ('000ha)	% of total area
Savannah woodland	7,100	30
Unimproved pasture	3,600	15
Bush fallow etc	5,000	21
Water bodies and wetlands	1,000	4
Forest reserves	2,600	11
Wildlife reserves	1,200	5
Tree crops	1,700	7
Annual crops	1,200	5
Unreserved forests	500	2
TOTAL	23,900	100

Source: FAO Forest Plantations working paper, 2002

Agricultural clearing for farming remains a dominant land use in Ghana and is very significant in accelerating deforestation in Ghana. This is confirmed by the Forestry Outlook Study on Africa (FOSA) report (2001) on Ghana which found that the main agricultural system of farming practiced in Ghana, shifting cultivation or the extensive type of farming accounted for 70% of deforestation in 1987.

Appiah et al., (2007) found that to some extent inadequate knowledge of sustainable farming practices had influenced deforestation in Ghana. One of such unsustainable practices is the Slash and Burn practice of agriculture. The Slash and Burn technique of agriculture, also known as swidden agriculture is defined as "the process of cutting down the vegetation in a particular plot of land, setting fire to the remaining foliage, and using the ashes to provide nutrients to the soil for use of planting food crops".[24] The slash and Burn technique utilizes little technology as its main purpose is for local consumption. The procedure for Slash and Burn procedure is given as:[25]

- The field is prepared by cutting down the vegetation. In some cases, plants that provide food or timber may be left standing.
- The vegetation which is cut down is allowed to dry until just before the rainiest part of the year to ensure an effective burn.
- The plot of land is burned to remove vegetation, drive away pests, and also to provide nutrients for planting.
- After burning, planting is done directly in the ashes.

The extent to which the slash and burn agricultural technique practiced in Ghana influenced the rate of deforestation was investigated by the World Bank (2007). The World Bank (2007) in a Country Environmental Analysis (CEA) report on Ghana estimated that more than 50 % of the original forest area of Ghana has been converted to agricultural land by slash and burn agricultural practices.

FOSA (2001) recognized that every two years the size of agricultural land in Ghana increases by 9% putting serious pressures on forestry development in Ghana. Dei (1992) estimated the rate of loss of vegetation cover due to agricultural activities in Ghana over the period 1970-1980. The result from the study is summarized in Table 2.6.

[24] http://geography.about.com/od/urbaneconomicgeography/a/slashburn.htm
[25] http://geography.about.com/od/urbaneconomicgeography/a/slashburn.htm

Table 2.6: Periodic mean rate of loss of vegetation cover to agricultural activities per annum (over a 10 year period, 1970-1980)*

Vegetation	**%**
National forests (secondary)	1.18
High forests (pure, reserves)	0.85
Savannah	1.24

**loss to other activities such as bush fires, overgrazing, cutting of fuel wood and timber felling is 35 per annum.* Source: Department of Forestry, Ghana in Dei (1992)

Besides logging and agricultural expansion, most researchers claim that high population growth and economic development has had a somewhat negative impact on forests in Ghana. Population growth explosion increases the demand for forest resources and food. The resulting effect is the increased clearing of land for agricultural purposes in order to feed the increased population. FAO (2010)[26] attributes deforestation in Ghana to high population growth, rapid encroachment by agriculture and live stock, indiscriminate logging and previous government policies. Subsistence agriculture and use of fuel wood in Ghana is worsening primarily due to increases in population growth[27]. Codjoe (2007) bemoaned the impacts that rapid population growth and low economic standard of living was having on agricultural land and forest resources in Ghana. Codjoe (2007) asserts that as population increases rapidly, the need to increase land for infrastructure and other social utilities like building of stadia and schools increases, invariably leading to forest clearing.

[26] http://www.fao.org/forestry/country/57478/en/gha/
[27] http://rainforests.mongabay.com/20ghana.htm

Firewood and charcoal production for energy has been cited as one of the main causes of deforestation in Ghana. Nketia et al., (1988), cited in Codjoe (2007) found that Ghana's dependence on fuel wood was a contributing factor to deforestation in Ghana. The study found that 500,000 metric tonnes of charcoal was consumed annually in Ghana, representing 3.6 million tonnes of wood extracted each year from forests and farmlands for purposes of charcoal production. A report by Climate care (2009) found that about 80% of Ghanaian households use wood or charcoal as their main cooking fuel. The report indicated that 1.3 million households representing approximately 31% of all families in Ghana relied on charcoal as their cooking fuel. Interestingly, the report found that in Accra, approximately 70% of households depend on charcoal for cooking. The report indicated that wood fuel consumption in Ghana exceeded the growth of forests and was having serious effects on forests, leading to deforestation in Ghana.

According to FOSA (2001) direct factors responsible for deforestation in Ghana include excessive logging; legal and illegal, unsustainable farming methods, annual bush fires, illegal or surface mining and infrastructural development. The indirect factors identified by the study included forest policy failures, unrealistic forest fee regimes, external price of timber, weak institutional structures and population pressures. Illegal or surface mining, popularly referred to as "galamsey" is a devastating cause of deforestation in Ghana as its operations inevitably results in the entire removal of the vegetation of the mining area in order for the extraction process to take place.

A Forest Watch on Ghana report by Opoku (2006) estimated that the rate of logging in Ghana, 4 million m^3 was four times the environmentally sustainable rate. On the causes of deforestation in Ghana, the Forest Watch on Ghana report asserted that although traditionally the Forestry Commission has blamed bush fires, farmers and chain saw operators for aggravating the problem of deforestation in Ghana, the true culprit of deforestation is the timber industry "which is able to suborn national policy processes to protect its profits and systematically violate permit regulations with complete impunity".[28]

Appiah et al., (2007) studied the causes of deforestation in the Dormaa, Offinso and Begoro forest districts of Ghana. The main causes of deforestation identified in the study area were poverty –driven agriculture, lack of alternative rural wage employment other than farming, household population levels and conflicts in traditional land practices. Other factors identified by the study included poor logging practices, in adequate knowledge of sustainable farming practices and conflicting government policies.

Yiridoe and Nanang (2001) in an econometric analysis of deforestation in Ghana found deforestation in Ghana to be influenced negatively by cocoa production and positively by fuel wood consumption, forest products exports and food crop production. Okrah (2002) assessed the impact of the wood carving industry in Ghana on forest depletion and found that although the wood carving industry provided employment and income, its continued growth and accompanying over exploitation of forest resources was exerting pressures on forests in Ghana.

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[28] Forest Watch Ghana (2006: 9)

2.5 Effects of deforestation in Ghana

Deforestation is having a serious toll on the Ghanaian economy. According to Guuroh (2010)[29], the Ghanaian economy is being deprived of fibre, legal employment and tax revenues as a result of deforestation. The author asserted that due to the loss of soil fertility resulting from deforestation, increasing areas of land will have to be cleared for agricultural purposes in order grow sufficient food. Seneadza (2010)[30] assessed the impact of deforestation on Ghana from two perspectives: the impact on the natural environment and on sustainable development. With respect to the natural environment, the author found that deforestation in Ghana has led to soil erosion and soil nutrients depletion, climate change, flooding and landslides, loss of wild life habitat and also drying up of streams and rivers. On sustainable development the author found the consequences of deforestation to be food insecurity, poverty, disease and death. The author cautioned that unless rapid measures are put in place to stop the current trends of deforestation in Ghana, the extinction of thousands of plant and animal species in the very near future will be practically inevitable.

Baah –Nuakoh (2003) asserts that although forests have direct and indirect benefits to the economy of Ghana, the unplanned exploitation of forests has led to deforestation with its accompanying consequences. According to Baah –Nuakoh (2003), the dangers of deforestation include increased soil erosion, global warming, decreased biodiversity,

[29] http://www.ghanaweb.com/GhanaHomePage/blogs/blog.article.php?blog=3375&ID=1000009309

[30] http://www.articlesbase.com/national-state-local-articles/deforestation-in-ghana-new-challenges-and-new-strategies-1954711.html

increasing the probability of desertification on fragile soils and the decline of traditional cultures of forest dependent communities.

Ghana stands the chance of losing many of its wood species to extinction, given the prevailing rate of deforestation in Ghana. Projections show that given the present rate of extraction Ghanaian hardwood like Mahogany, Odum and Afromosia will go extinct within the next 10 years. Deforestation in Ghana is slowly transporting disease carrying insects from the savannah regions into the areas of cleared forests of Ghana. The pharmacopeia sector in Ghana is not left out of the repercussions of deforestation as many medicinal and herbal plants are being lost to deforestation.[31]

The slash and burn technique of farming practiced in Ghana is not without its negative consequences such as soil erosion, nutrient loss, biodiversity loss and deforestation. The Slash and burn technique is expected to lead to temporary or permanent loss of forest cover if lands are not given enough time to grow back. On biodiversity loss, it is estimated that the slash and burning technique of agriculture could lead to the extinction of some important plant and animal species in Ghana.[32]

Baah –Nuakoh (2003) estimated the total cost of deforestation to Ghana in terms of wood lost and found that not accounting for losses from biodiversity and minor forest products,

[31] http://www1.american.edu/TED/ghana.htm
[32] http://geography.about.com/od/urbaneconomicgeography/a/slashburn.htm

deforestation costs Ghana a substantial 17.2 billion cedis (Old Ghana cedis) or US $ 17.63 million.

2.6 Forest policies and legislations in Ghana

Various policies and legislations have been implemented in Ghana aimed at improving the state of forests. In Ghana, the Ministry of natural resources, land and forestry is vested with the responsibility of policy formulation and co-ordination of programs pertaining to the forestry sector. The implementation of forest policies and programs is however carried out by the autonomous Forestry Commission.

Forest policies and legislations designed to protect the forestry sector in Ghana date back to the colonial era. Boon et al., (2009) recalls that as far back in 1906, policies and legislations were implemented in Ghana to protect forests and natural resources in order to control the indiscriminate felling of commercial tree species. Forestry policies in Ghana has gone through several phases, from preserving forests for timber extraction during the colonial era to genuine forest conservation with the introduction of the Forest and wild life policy in 1994.

2.6.1 Colonial forestry policies in Ghana

Colonial forestry policies were instituted by the British colonial authorities to control the exploitation of forest resources and reduce the pressures of farming on forest areas (Asante, 2005:5). Providing an overview of the colonial forestry policies, Asante (2005:5) recounted the main features of the colonial policies to be preservation of forests and detailed cataloguing of rules and penalties for infringements. Asante (2005) in assessing colonial forestry policies in Ghana designated certain policies as "Pseudo- Conservation" as those policies were mainly concerned with preserving forests for timber extraction rather than genuine conservation. A summary of forestry policies in the Ghanaian colonial era is provided in Table 2.7.

Table 2.7 COLONIAL FOREST POLICIES IN GHANA

FORESTRY POLICY	CATEGORY	FUNCTION
The crown Land's Bill 1894	Land tenure policy	Colonial control over lands and forestry
The Land's Bill 1897	Land tenure and Pseudo-conservation policy	Colonial control over lands and forestry
The Concessions Ordinance 1900	Pseudo-conservation policy	Colonial administration of contracts between the government and British timber merchants
The Forestry Ordinance 1901	Extractive policy and Pseudo-conservation policy	Appointment of forestry officers, constitution of reserve acquisition of lands and appointment of forestry commissioner

Timber Protection Ordinance 1907	Extractive policy and Pseudo-conservation policy	Prevent cutting of immature timber for the purpose of guaranteeing future supplies of timber
The undersized Timber Trees Regulation 1910	Pseudo-conservation policy	Enforcement of the Timber protection Ordinance
The forestry ordinance 1911	Extractive policy and Pseudo-conservation policy	Creation, control and management of forest reserves
The forestry ordinance 1927	Extractive policy and Pseudo-conservation policy	Involvement of traditional rules and enforcement of forestry laws and regulations

Source: Asante (2005)

2.6.2 Post colonial forestry policies in Ghana

The Post colonial era has seen the enactment of various policies aimed at building upon the colonial forestry policies. History records that the emphasis of colonial forestry policies were primarily on ensuring sustained supply of timber for the wood industry, the effect of which was the over exploitation of forest resources leading to the eventual demise of unreserved forests. The negative effects of the colonial policies prompted government to place about 3,267,250 ha of forests under permanent forest estate by the end of 1978 (Boon et al., 2009).

Ghana’s strategies aimed at addressing the challenges of natural resource management have been largely based on three important Legislations: National Environmental Action Plan (1990-2000), Forest and Wildlife Policy (1994) and the Forestry Development Master Plan (1996-2000), with the most important being the Forest and Wildlife Policy (1994) considered to be the overarching policy document of the government of Ghana (FAO Website, 2010; Ahenkan and Boon, 2010).

In assessing the impact of forest policies and strategies with respect to promoting the development of non–timber forest products, Boon and Ahenkan (2010) provided a summary of various forestry policies and strategies in Ghana over the years. The authors provided brief objectives of forest policies and legislations undertaken in Ghana between 1948 and 2002 (Table 2.8).

Table 2.8: Summary and brief description of Forestry Policies and Legislations in Ghana between 1948 and 2002

	Forest Policies and legislations	Major objectives
1	1948 Forestry policy	• Creation of permanent forest estate • Protection of forests • Protection of forest catchment areas • Environment protection for ecological balance
	Forests Ordinance 1951	• Protection of Forests • Protection of Forest reserves
2	Forest improvement Act of 1960	• Forest plantation development • Timber plantation establishment and management
3	Wildlife animals Preservation Act, 1961 (Act 43)	• Conservation of wildlife
4	Wild life Reserves and conservation policy of 1974	• Protection of wildlife resources • Wildlife conservation areas. • Protected areas

		development
5	Forests Protection decree, 1974	• Defined forest offences • Forest protection
6	Trees and timber decree 1974	• Logging guideline for timber industry • Sanctions for non compliance with the guidelines • Promotion of export of processed timber
7	Forest protection decree 1974	• Forest protection • Protection of catchment areas.
8	Trees and timber (chain saw operation) regulation of 1983	• Regulation of felling • Forest plantations • Regulation of logging activities
9	Forest protection (Amendment) Act 1986	• Define forests offences • Forest protection • Protection of water bodies • Species conservation
10	Forest protection (Amendment) Act 2002	• Forest protection • Reviewed forest offences

		fines upwards
11	1994 forest and wildlife policy	• Protection of forests • Species conservation • Regulation of timber harvesting • Development of cottage and agro based industry • Community forestry and forest conservation • Deregulation and streaming of bureaucratic controls on wood export marketing • Involvement of community in conservation of forests and wildlife conservation • Rehabilitation and development of degradation forests
12	Timber resource management Act , 1997-Act 547	• Timber utilization contract • Offences for illegal logging • Protection of logging on

		farms and plantations
13	The forest protection Amendment Act 2002	• Community forestry and forest conservation • Protection of forests and wildlife • Reforestation and afforestation programmes • Forest offences penalties • Protection of water catchment areas
14	Timber resource management(Amendment) Act 2002	• Timber utilization contract • Offences for illegal logging • Protection of logging on farms and plantations • Community forestry and forest conservation • Protect land with farms from logging • Protection of private forest plantations • Duration of timber

	concession rights

Source: Ahenkan and Boon (2010)

Besides the specific forestry policies and legislations, the national constitution of the republic of Ghana imposes on the citizens of Ghana the duty of protecting the environment. Articles 36(9) and 41 (k) of the 1992 Constitution of Ghana require the state to take appropriate measures to protect and safeguard the natural environment for posterity; and also seek cooperation with other states and bodies for the purpose of protecting the wider international environment for mankind.

2.6.3 Forest and wildlife policy of 1994

The Forest and Wildlife policy of 1994 has been described as the overarching forestry policy document of the Government of Ghana (Ahenkan and Boon, 2010). The Forest and Wildlife Policy (1994) provided a basis for conservation and sustainable development of Ghana's forests and wildlife resources, encouraged value addition of wood and developed a national forest estate and timber industry.[33] The Forest and Wildlife Policy (1994) was designed to achieve the following specific objectives:[34]

- Management and enhancement of Ghana's permanent estate of forest and wildlife resources

[33] http://www.tropenbos.org/index.php/en/where-we-work/ghana

[34] http://www.fao.org/forestry/country/57479/en/gha/

- Promotion of viable and efficient forest-based industries, particularly in secondary and tertiary processing
- Promotion of public awareness and involvement of rural people in forestry and wildlife conservation
- Promotion of research-based and technology-led forestry and wildlife management, utilization and development
- Development of effective capability at national, regional and district levels for sustainable management of forest and wildlife resources.

2.6.4 Achievements of the forest and wildlife policy of 1994

A Forestry Outlook Study for Africa (FOSA) report for Ghana in 2001 provided a review of the achievements of the Forest and Wildlife Policy in 1994. The achievements are summarized below:

The Forestry and wildlife policy of 1994 has seen timber leases being replaced by timber utilization contracts which are awarded based on competitive tenders. Another achievement of the Forestry and wildlife policy of 1994 has been the introduction of the new Annual Allowable Cut (AAC) of one million m^3 (on and off reserve) which was implemented in 1996.

Natural resources management was high on the agenda of the Forest and Wildlife policy of 1994 as it served as a launch pad for the Forestry Development Master Plan in 1996. The Forestry Development Master Plan was designed to operationalize the Forest and Wildlife policy of 1994 in the short, medium and long term. The implementation of the Forestry Development Master Plan necessitated the implementation of a ten year National Resources Management Program with the main objective to "protect, rehabilitate and sustainably manage national land, forest and wildlife resources through collaborative management and to sustainably increase the incomes of rural communities who own these resources".[35]

According to the Forestry Sector Outlook Study for Africa (FOSA) report for Ghana (2001), the Forest and Wildlife policy of 1994 facilitated the initiation of a forest management certification system project in 1997. The aim of the forest management certification system project was to "assist Ghana to establish a fully functioning national certification scheme and to establish a comprehensive computer based system for log tracking".[36]

2.6.5 Critique of the Forest and Wildlife policy of 1994

Notwithstanding the achievements of the Forest and Wildlife Policy, Boon et al., (2009) found that the Forest and Wildlife Policy of 1994 failed to address some very important issues in Forest resources management in Ghana such as:

- ❖ The complex land tenure system of Ghana

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[35] *Food and Agricultural Organization of the United Nations, 2001. Country report- Ghana. Forestry Sector Outlook-FOSA. Working paper/WP /12 .*

[36] *Food and Agricultural Organization of the United Nations, 2001. Country report- Ghana. Forestry Sector Outlook-FOSA. Working paper/WP /12.*

- ❖ Weak institutional and governance structure
- ❖ Ineffective involvement of relevant shareholders

Further, the authors revealed that although the Forest and Wildlife Policy of 1994 was well intentioned, many of the activities entailed in the policy were unachievable due to their ambiguity and also because the management of the policy was beyond the capacity of the Forestry commission.

Forestry policies and legislations in Ghana have had their strengths and weaknesses. One of such weaknesses was identified by Seneadza (2010)[37] who stressed that forestry laws and regulations dealing directly with deforestation in Ghana will fail to achieve their maximum policy effectiveness unless they are appropriately coded.

2.7 CONCLUSION

It has been established that the forestry sector of Ghana is very essential in the developmental agenda of Ghana. However, the sector is bedeviled with many problems, chief among which is deforestation. Various causes of deforestation in Ghana have been revealed with their attending negative repercussions. Over the years, Ghana has witnessed various policies, laws and regulations designed to governing the activities within the forestry sector. The main forestry policy developed in Ghana was the Forestry and Wildlife

[37] http://www.articlesbase.com/national-state-local-articles/deforestation-in-ghana-new-challenges-and-new-strategies-1954711.html

Policy (1994). Since then other policies have been developed to help mitigate the ills of deforestation in Ghana. It is expected that forest policies will be adequately implemented to ensure their maximum effectiveness.

CHAPTER THREE

LITERATURE REVIEW

3.1 Introduction

This chapter forms the theoretical and empirical foundations upon which the ideas and thoughts expounded in this study are shaped. The chapter reviews theoretical and empirical literature containing thoughts and ideas shared by various authors and researchers on the nature, causes and implications of deforestation. The chapter will form the basis for the regression model selected in the next chapter for empirical estimation.

3.2 Theoretical literature review

Deforestation is one of the many ills of human activities that have plagued the environments of many economies all over the world. Deforestation literature reveals man to be at the centre of deforestation activities, perpetuating serious impacts that transcend country borders into global territories. Ranging from geographic or country specific problems such as flooding and loss of soil fertility, the impacts of deforestation extends unto the global community through global climate change. The seriousness of the impacts of deforestation have ignited the interest of researchers in studying deforestation to find out what drives it and how its impacts can be reduced. A popular anonymous saying in Ghana goes like: “When the last tree dies, the last man also dies”. This saying epitomizes the important role that trees have played and continue to play in the existence of man. The underlining implication of this saying is that any activity, whether anthropogenic or natural that promotes rapid loss of the vegetal cover should be a major concern to society. Duraiappah (1998) however, allays people's fear of the effects of deforestation by claiming that "deforestation itself is not a problem and in fact may be a necessary condition for economic development" as long as it does not negatively influence the ecology and economies of nations. Appearing very simple though, the causes and processes of deforestation are more often than not, an ironically and intriguingly complex pattern of progressive fragmentation of forests.

The complex nature of deforestation has been asserted to by many researchers on deforestation. Radeamakers et al., (2010) posit that deforestation is not attributed by a single but multiple drivers and pressures which include conversion for agricultural uses, infrastructure development, wood extraction, agricultural product prices, and a complex set of institutional and location-specific factors. This view is supported by Kallbekken (2000) who asserted that the causes of deforestation are very complex and interlinked, and hence have caused researchers to employ varied approaches in studying it.

Reflecting the complex nature of deforestation, the approaches used in deforestation studies have varied, ranging from single country models to Global Equilibrium models. The approaches to studying deforestation are however not without their criticisms. Some researchers have argued that due to the complex, multiform process nature of deforestation, deforestation cannot be represented by a mechanistic approach. The researchers argued that "mechanistic models are built on the belief that we know the processes by which a system operates and that individual processes can be modeled using scientific laws, or rules, described by simple equations". [38] They argued that deforestation cannot be adequately represented by mechanistic models and therefore prescribed systems models as being the most appropriate tools to be applied in studying deforestation.

In deforestation studies, authors try to dichotomize between the direct (or proximate) causes and the indirect (underlining) causes of deforestation. The direct causes by definition are those that have a direct impact on deforestation, whereas the indirect causes are those that affect deforestation indirectly. The proximate causes are primarily anthropogenic, resulting from land use activities which directly impact forest cover.[39]

The driving forces behind the proximate causes are the underlying causes. Geist and Lambin (2001) made a distinction between proximate and underlying causes of deforestation. The authors considered the proximate causes of deforestation to be agricultural expansion, wood extraction, expansion of infrastructure, and the underlying causes to include demographic, economic, technological, institutional and socio-political factors.

In considering deforestation with respect to the distinction between direct and indirect causes, one thing comes out clear; the direct causes are obvious and fairly known whereas the underlying causes are less well understood, and are much more controversial (Kallbekken, 2000).

Agricultural expansion is widely cited as a cause of deforestation because it is primarily anthropogenic and hence easy to control. The role of agricultural expansion in the

[23] *http://sedac.ciesin.org/tg/*
[24] *http://sedac.ciesin.org/tg/*

deforestation process is even more significant within the African perspective where the agricultural sector plays a very important role in serving as a significant contributor to GDP, employment and exports (Culas, 2006). Culas (2006) asserts that many countries embark on agricultural expansion as a means of increasing productivity and income. This expansion in agricultural activities, according to Culas (2006) is attributable to small scale farmers who are mostly involved in subsistence farming and commercial farmers who permanently convert forestlands into commercial farms for exports. In as much as Culas (2006) conceded that agricultural expansion has a negative effect on deforestation, he argued that its effects can be eliminated by putting in place institutions for secure proper rights and better environmental policies.

Kallbekken (2000) identified forest clearing for conversion to agricultural land and logging to be the proximate causes of deforestation. On this basis, Kallbekken (2000) argued for deforestation studies to be focused on the forces driving conversions and logging such as population pressure, international trade and the prices of agricultural prices and forestry products.

In support of the agricultural expansion thesis, Rademaekers et al., (2010) ascribed the increases in agricultural expansion to rising demands for food production and production of bio-fuels. This view of agricultural expansion being significant in influencing deforestation is strongly supported by Angelsen and Kaimowitz (1999) who provided an in depth analysis into various factors influencing the clearing of forests by households and companies for agriculture or timber. The authors argued that agricultural output prices, credit availability, accessibility of roads and land tenure security hastened the clearing of forests by households and companies. On the other hand, they argued that off farm wages reduced forest clearing whiles the effect of agricultural prices on forest clearing was not clear.

Recently, the agricultural expansion effect on deforestation thesis has been supported by Gorte and Sheik (2010), arguing for a significant role of small scale permanent and large scale permanent agriculture in influencing deforestation in Sub Saharan Africa. The authors reasoned that the effects of agricultural expansion on deforestation are mainly channeled through increased cultivation to meet increasing demand for food and also land conversion to cash and estate crops.

Galinato and Galinato (2010) examined the influence of agricultural land expansion on deforestation within the framework of governance. The impacts of governance on deforestation were assessed in terms of corruption control and political stability. The authors argued for a positive and significant effect of political stability on forest cover. On the other hand, they found corruption control to have a negative and significant effect on forest cover. The effectiveness of corruption control in reducing deforestation was attributed to technological development.

Arguing along similar lines, López and Galinato (2005) considered agricultural expansion and road construction to be very influential in the deforestation process. The authors posited that agricultural expansion and road construction influence deforestation through income growth, trade openness, fiscal deficits, domestic inflation, democracy and governance and international commodity prices.

Closely related to the effect of agricultural expansion on deforestation is the role of agricultural technological improvement on deforestation. The effect of technological change in agriculture on deforestation is not clear. While some researchers argue for a positive impact of agricultural technological change on deforestation, others argue that agricultural technological change reduces deforestation. Borlaug (1997), cited in Yanggen and Reardon (1999) argue that agricultural intensification allows production on the same amount of land thus reducing pressures to expand agricultural production. Culas (2006) argues that the effect of agricultural technological improvement on deforestation is not straight forward but depends on the nature of the technological change; whether the improvement is labour and / or capital saving or labour and /or capital intensive. Culas (2006) asserts that labour and / or capital saving agricultural technological improvement is likely to free up more resources for additional farming and accelerate clearing of forest land. On the other hand, labour and /or capital intensive agricultural technological improvement is hypothesized to ameliorate the effects of deforestation.

Deforestation is widely claimed to be mainly anthropogenic as it arises out of the actions or inactions of some actors or agents. The actions or inactions of these actors or agents become the sources of deforestation. Angelsen and Kaimowitz (1999) identified small farmers, ranchers, loggers and plantation companies as the agents of deforestation. Along similar lines, Gorte and Sheik (2010) identified three types of actors involved in the deforestation process: primary, secondary and tertiary. The primary actors were defined as people directly involved in logging activities such as small-scale local farmers using deforestation as a means to gain new land for subsistence farming, industrial farmers, and wood and timber companies “which carry out deforestation either to gain more land for alternative use purposes or to profit from the timber" (Gorte and Sheik, 2010). Secondary and tertiary actors, on the other hand, are those actors indirectly involved in deforestation process. Secondary and tertiary actors according to Gorte and Sheik (2010) include decision-makers and also national and international companies which take decisions on issues such as infrastructure development that exert indirect pressures on deforestation.

A popular debate that lingers on in deforestation studies is the impact of external debt of developing countries on their natural resource extraction. This is referred to as the Debt Resource Hypothesis (DRH). Neumayer (2005) describes the debt-resource-hypothesis as suggesting that "high indebtedness leads to increased natural resource exploitation as well as more unsustainable patterns of resource use". By logical extensions, it is implicitly assumed that countries with high debt burdens will increase their extraction of natural resources as well as cash crops in order to service their debt obligations.

The Debt Resource Hypothesis (DRH), applied in deforestation studies posits that huge debts of developing countries aggravate their environmental problems. It is obvious that developing countries accrue huge external debts which have to be financed. The Debt Resource Hypothesis (DRH) suggests that the way favourable to developing countries which normally abound in natural resources is to exploit their natural resources in order to finance their debt. This view does not ignore the fact that there are alternative ways for developing countries to service their debts. However, due to the various constraints facing developing countries, they find solace in their natural resources as a way of servicing their external debt.

The DRH therefore suggests that theoretically, deforestation in developing countries can be linked to the huge foreign debts that they accumulate. Studies on the DRH on account of deforestation have however produced mixed results. This is evident in the works of Marquart-Pyatt (2004), Culas (2004), Erhardt et al., (2002), Gullison (1993), Bhattarai and Hammig (2001), Neumayer (2005) and Shandra et al., (2008). The DRH suggests that the huge foreign debt drives developing countries to exhibit myopic behaviour in adopting short run policies. Developing countries thus undertake short run policies to solve their external debt problems; however these policies are feasible in the short run but not optimal in the long run. Culas (2004) argues that foreign debt causes high rate of tropical deforestation through forest clearing for agricultural purposes. Culas (2004) further asserts that deforestation is positively influenced by the level of external debt. The study found external debt to influence deforestation through land clearing for agriculture and pasture, logging for timber exports and resettlements.

Evidence in respect of the DRH is not supported by Neumayer (2005). While he does not provide a conclusive proof against the DRH, he brings the validity of the DRH into doubt. In that regard, Neumayer (2005) cautions environmentalists and policy makers against believing too easily that high indebtedness spurs exploitation of natural resources. He advises that care must therefore be taken in formulating deforestation policies on account of the Debt Resource Hypothesis. In contrast, Kallbekken (2000) finds evidence in support of the Debt Resource Hypothesis.

Mahapatra and Kant (2005, p. 20) argued that the "contributions of forest sector to debt service are dominating over the contributions of debt to reduce the pressure on forests in medium deforestation countries, while in high deforestation countries these two effects are almost neutralized”. The authors hypothesized that the level of deforestation might remain unaltered if the level of debt service and economy grow by the same rate. Bhattarai and Hammig (2001) and Shandra et al., (2008) find evidence in favour of the debt resource hypothesis. Arguing on the contrary, Ehrhardt-Martinez et al. (2002), asserted that neither the level nor the rate of debt growth influences the level of deforestation rates. In a summary on the debt resource hypothesis, Angelsen and Kaimowitz (1999) in a review of more than 140 econometric models on deforestation, found that empirical evidence on the impact of foreign debt on deforestation is mixed as evidence in its favour is weak and contradictory.

Population growth is essential for the sustainability of any economy. Nevertheless, it must be emphasized that when population growth exceeds a certain threshold, it begins to have detrimental effects on the environment. This has spurred on the theoretical link between population growth and environmental degradation. According to Anning (1999), population pressure increases the demand for goods and services, which when not checked can have detrimental effects on the environment. He further asserts that increasing rates of deforestation can be attributed to the increasing population growth. In recognition of the important role that population growth plays in influencing tropical deforestation rates, Cropper and Griffiths (1994) recounted how the United Nation’s Food and Agricultural Organization (FAO) estimated deforestation rates using a model of population pressures. Theoretically, population growth is hypothesized to impact deforestation through increased demand for land for food, fuel wood, timber or other forest products.

Agreeing with the population thesis, Cropper and Griffiths (1994) assert that population growth increases the demand for arable land, which in turn promotes the conversion of land for other uses. According to Cropper and Griffiths (1994), population growth can be viewed as the underlying causes of households desire to convert forests and woodland to pasture and cropland, harvesting of logs and gathering of firewood. Concentrating on the rural sector, Cropper and Griffiths (1994) hypothesized rural population density to aggravate deforestation. However, Cropper and Griffiths (1994) posit that modern agricultural development and the pace of industrialization can obscure the relationship between population pressures and deforestation. Though Cropper and Griffiths (1994) reasoned in support of the hypothesis that rural population density influences deforestation, they argued that it is not simplistic to propose reductions in the rate of population growth as a panacea to deforestation amelioration.

Similarly, Ehrhardt-Martinez et al., (2002) argue in support of the classical Malthusian theory that asserts that increase in rural population leads to forest clearing. The authors however contended that rapid deforestation from rural population growth is limited to the early stages of development. Ehrhardt-Martinez et al., (2002) suggested that if population increase aggravated deforestation then analogically any process that removes population from the rural areas will reduce the population pressures on deforestation. In that regard, they proposed that rural – urban migration which reduces rural population will reduce the rate of deforestation. Ehrhardt-Martinez (2002) therefore contended that although rural population growth influences deforestation, rural–urban migration tends to ameliorate the effects of rural population growth on deforestation.

Culas (2006) argues that reducing population growth is not necessarily the best approach to reducing deforestation. Rather, he proposes strengthening institutions for secure property rights and better environmental policies as the proper approach. Nevertheless, most authors cite population growth as a very significant driver of deforestation. Jorgenson (2008), though agreeing that total population change impacts deforestation positively, argues in contrast with most studies that rural population growth has no significant impact on deforestation. Bawa and Jha (2005) contend that though high population growth and low human development may cause high rates of deforestation, increases in human development may reduce deforestation despite high population growth. In a review of over 140 deforestation models, Angelsen and Kaimowitz (1999) found that analytically and empirically, the argument that population density positively influences deforestation was well- founded.

In agreement with the population thesis, Sunderlin and Resosudarmo (1999) though supporting the assertion that population growth is very significant in influencing deforestation in Indonesia, argued that population growth should be seen as an intermediate variable, and not as an independent variable. On the contrary, Needle and Mather (2000) argued for a weak inverse relationship between population growth and forest cover.

The theoretical link between poverty and environmental degradation has been explored for a long time by researchers. Most of the ills of environmental damage have been blamed on the poor; the latest charge against them is that they are responsible for deforestation.

According to Alam (2010), poverty is a “major determinant of poor environmental quality as well as a big hurdle to achieving sustainable economic development”. It is theorized that the poor cut down trees to be used as firewood and charcoal as they cannot afford clean fuels such as Liquefied Petroleum Gas (LPG). The cutting down of trees by the poor for fire wood is hypothesized to influence deforestation. According to Anning (1999), in Ghana, wood fuel constitutes a major source of fuel wood and charcoal makes up 75% of the total national energy consumption. Since fuel wood is mainly used by the poor, its usage can be used to proxy the extent to which poverty can influence deforestation.

Poverty has been hypothesized to hasten the overuse of natural resources by the poor in order to meet their basic needs. On the contrary, Angelsen and Kaimowitz (1999) argue that there is little empirical evidence on the link between deforestation and poverty. They argue that if forest clearing requires investment, then rich people not poor people might be more likely to clear new forest land.

Increased urbanization has been widely acknowledged as a driving force behind deforestation. Theoretically, urbanization is hypothesized to lead to deforestation through the clearing of forests for roads, stadia and housing facilities. According to Ehrhardt-Martinez (2002), in the early stages of urbanization, changing energy use, industrial composition and ecological agglomeration can yield a curvilinear relationship between deforestation and urbanization. However, they assert that advanced urbanization, can reduce pressure on forested areas. On this accord they contended that urbanization increases deforestation up to a threshold, and then increased urbanization leads to a reversal of deforestation rates.

In most recent times, an issue which is receiving much attention in deforestation studies is institutional factors. Deforestation studies have considered the role of institutional factors for secure property rights in reducing deforestation. Theoretically, political institutions, institutions for secure property rights are expected to enforce forestry policies and regulations, ensure the protection of property rights and reduce deforestation. Culas (2006) defined institutions as “constraints that structure political, economic and social interaction”. Institutions, according to Culas (2006) can be of many forms; informal constraints such as taboos, sanctions, traditions and codes of conduct, and formal rules such as constitutions, law and property rights. Improvements in political institutions and governance are hypothesized to significantly reduce the rate of deforestation (Bhattarai and Hammig, 2001).

Institutions for secure property rights and better environmental policies can however significantly reduce the rate of deforestation without hampering the level of economic growth (Culas, 2000; Panayotou, 1997, cited in Bhattarai and Hammig, 2001). Culas (2006) claims that improving institutions for secure property rights and better environmental policies will be more effective in reducing deforestation than reducing economic growth and /or growth in population. Further, Culas (2006) asserted that strengthening institutions for secure property rights neutralizes the effect of agricultural expansion on deforestation.

Arguing on the contrary, Kallbekken (2000) did not find support in favour of the view that secure property rights ameliorates deforestation rates. This is in contrast with theory as countries which have more secure property rights are likely to experience lower deforestation rates.

Democracy has a role to play in the deforestation process. It is hypothesized that in countries where there exists democracy, there will be freedom to form environmental groups; these, it is believed will have an opportunity to protest against illegal logging and acts that promote deforestation (Kant and Mahapatra, 2005). The reverse is true for undemocratic and autocratic countries which have the tendency to condone illegal logging operations which accelerate deforestation. Kant and Mahapatra (2003) however did not find supporting evidence in favour of democracy.

According to Ehrhardt-Martinez et al., (2002), democracies promote freedom of speech and action, and make governments more responsive to environmental accountability from its citizens. Further, Ehrhardt-Martinez et al., (2002) assert that freedom of speech which exists in democracy enhances environmental awareness, and puts pressure on governments to ensure environmental sanity. Theory predicts that if people are made aware of the ills of deforestation they will act in a way so as to prevent acts that promote deforestation. It is thus natural for people to be moved into action when their sense of well being becomes endangered. This is undoubtedly the reason why most people are becoming concerned over the ills of deforestation.

A serious issue that affects the forestry industry is the issue of corruption. Corruption encourages illegal forest activities like illegal chain saw operations and timber smuggling which promote deforestation. Corrupt forestry and government officials collaborate with illegal chain saw operators to undertake unsustainable logging of trees, leading to rapid depletion of forests. Koyounem and Yilmaz (2009) confirmed this assertion when they assessed the impact of corruption on deforestation.

Analytically, deforestation literature has analyzed the problem of deforestation from a micro and macro perspective. On the macro level, variables such as export prices of forest products, inflation, export of forest products, trade openness or globalization, real exchange rate and foreign direct investment have been hypothesized to influence deforestation. Cropper and Griffiths (1994) found the price of tropical logs to have mixed effects on deforestation across countries. They found that though in Latin America deforestation was influenced by the price of tropical logs, the reverse was however true in Africa. Agreeing partly with Cropper and Griffiths (1994), Angelsen and Kaimowitz (1999) cited in Culas (2006) posit that higher timber prices generally hasten forest clearing. Arguing along the scarcity hypothesis, Rudel (1998, p539) cited in Culas (2006) reveals that timber price increases accelerates deforestation in the short run, but may ensure forest conservation in the long run.

Many economies generate a lot of foreign exchange from their export of forest products. Exports of forest products, according to theory measures the extent to which an economy depends on its forest exports and hence assess the relative importance of the forestry sector (Kallbekken, 2000). Yiridoe and Nanang (2001) hypothesized forest exports to affect deforestation indirectly through external debt, export price and GDP. Ehrardt-Martinez et al., (2002) asserts that although the International Political Economy (IPE) theory stresses the dependence of economies on forest products as influencing deforestation, evidence on it is mixed.

Bhattarai and Hammig (2002) assessed the impact of the black market premium on real exchange rate and inflation on deforestation. Bhattarai and Hammig (2002) postulated a negative relationship between the real exchange rate and deforestation implying that "strengthening of the local currency discourages the export of tropical timber and sawn woods, thus decreasing the tropical deforestation level". On inflation, Bhattarai and Hammig (2002) maintained that the incentive to harvest natural forests through logging also by timber companies is severely ameliorated by inflation.

Foreign direct investment flows have been known to improve economies of nations; however their environmental effects have been less explored. Foreign Direct Investment has been hypothesized to influence deforestation in less developed countries. Support of this hypothesis is provided by Jorgenson (2008) and Shandra (2007) who contended that less developed countries with higher levels of primary sector foreign investment exhibit greater rates of deforestation.

Theory posits that education can increase awareness of the ills of deforestation and also create off- farm employment. This, according to theory will inevitably reduce the pressures on forests and hence lower the rate of deforestation. Creation of off-farm employment is expected to reduce dependence on forests. Through environmental awareness enlightenment campaign, people become aware of the consequences of deforestation and undertake steps to reduce deforestation. It is expected that environmental awareness campaigns will make people aware of the benefits of forests and woodland and also aware of how radical forest depletion will change their lives for the worst. Bhattarai and Hammig (2002) were of the view that education can significantly reduce the rate of deforestation. In contrast, Ehrhardt-Martinez (2002) does not find evidence to support the hypothesis that education reduces deforestation rates.

Trade liberalization or Globalization has merged the whole world into one global village. However, some Researchers believe that trade openness has an impact on the environment, especially on deforestation. Globalization has been hypothesized to lead in increases in timber and forest products exports, leading eventually to deforestation.

On the macroeconomic level, Researchers have explored the role of income in the deforestation process. Economic growth has often been linked to environmental degradation. Results of studies on the impact of economic growth and income have been mixed. According to theory, low incomes will result in over utilization of natural resources such as forests leading to deforestation. Mahapatra and Kant (2005) highlighted the immiserization theory which asserts that "resource scarcities due to deforestation make farmers poorer, and push them further into new areas expanding deforestation". Deforestation studies have also analyzed the income –deforestation relationship within the context of the Environmental Kuznet Curve (EKC) framework. The EKC relationship between deforestation and income according to Culas (2006) implies that " at an initial stage, an increase in income will accelerate the rate of deforestation, but that at an income beyond a certain level,(i.e. the turning point) will reduce the rate of deforestation". Various studies that have tested the EKC hypothesis for deforestation include Bhattarai and Hammig (2001; 2002), Van and Azomahou (2005), Marquart-Pyatt (2004), Cropper and Griffiths (1994), Kallbekken (2000) and Culas (2006).

A Forest Watch Ghana report by Opoku (2006) diffused the perception by people that bush fires, farmers, and chainsaw operators are the main drivers of deforestation in Ghana. The report claimed that the main driver of deforestation in Ghana is the timber industry which is "able to suborn national policy processes to protect its profits and systematically violate permit regulations with complete impunity".[40]

In an assessment of the deforestation problem in Ghana, Seneadza (2010)[41], attributed the main causes of deforestation in Ghana to timber logging, outdated agricultural practices, illegal Chain saw operation, urbanization, reliance on forest products, infrastructural development, exploitation of forests for fuel-wood and non-timber forest products, annual bushfires and surface and deep mining of gold, diamonds and other minerals.

In the editorial column of the Ghanaian Chronicle (25th October 2005), Mr. Asin Nyarko, the District Manager of the Forestry Services Division in Nkawie bemoaned the low production of cocoa production in Ghana. He ascribed the low production of cocoa being

[40] Forest Watch Ghana(2006, p 9)
[41] http://www.articlesbase.com/national-state-local-articles/deforestation-in-ghana-new-challenges-and-new-strategies-1954711.html

experienced in Ghana to deforestation. He recounted how illegal chainsaw operations which were on the ascendancy in the country were accelerating deforestation.

Touching on the role of incentives in accelerating deforestation in Ghana, Afriyie (1995) argued that incentives such as lack of subsidies, high input costs, rent seeking activities and absence of manpower in the forestry sector played an important role in accelerating deforestation in Ghana. According to Afriyie (1995) the major contributing factors to deforestation in Ghana, being inefficient agricultural practices, indiscriminate logging, wood fuel consumption, bush burning and mining were facilitated by these incentives. To curb deforestation in Ghana, the study recommended the encouragement of timber processing and the restoration of subsidies. This recommendation for encouraging timber processing is highly supported by Brew (1998) who argued that timber processing is very significant in reducing the rate of deforestation in Ghana.

It is reported by the International Development Research Centre in 1999 that the major causes of deforestation in Ghana could be attributed to forest fires, over logging, shifting cultivation and increasing demands for fuel wood.[42] A Forestry Outlook Study on Africa (FOSA) report on Ghana in 2001 attributed the causes of deforestation in Ghana to agricultural expansion, open cast mining, fuel wood consumption and population pressure. Elaborating on the report, the study attributed 70% of deforestation in Ghana in 1987 to the shifting cultivation technique of farming that was being practiced in the country. The findings of the report was corroborated by Baah-Nuakoh (2003) who attributed the

[42] http://www.idrc.ca/en/ev-9319-201-1-DO_TOPIC.html

degradation of forests in Ghana to agricultural practices, fire, logging, over grazing and open cast mining.

3.3 Empirical literature review

From the theoretical literature it has emerged that due to the complexity of the nature of deforestation, the approaches applied in studying it have varied. These approaches have ranged from single country studies to panel data studies. It has also been observed that the impact of the proximate causes are more direct and clear, however the underlying causes are much more indirect and controversial. This section provides and reviews empirical results of studies by researchers on deforestation.

To review empirical literature on deforestation, it is important to consider the work by Kaimowitz and Angelsen (1998). In a review of about 140 deforestation models, Kaimowitz and Angelsen (1998) categorized modeling of economic models of deforestation into two: scale and methodology. In terms of scale, the study classified deforestation models into household /firm level (micro), regional (meso), national (macro) level models. With respect to methodology, the study classified deforestation models into analytical, simulation and regression models. Household / firm level deforestation models employed analytical open economy models, analytical subsistence and Chayanovian models, and empirical and simulation models. Regional level deforestation models considered by the study employed spatial simulation, spatial regression and non–spatial regional regression models whereas national and macro level models employed analytical models, Computable General Equilibrium (CGE) models, trade and commodity models, and multi -country regression models.

The study further classified variables included into economic deforestation models into five broad types: magnitude and location of deforestation, agents of deforestation, choice variables, agent's decision parameters and macro-level variables and policy instruments. Evidence from the study revealed that higher agricultural and timber prices promoted deforestation by making logging more profitable. Higher rural wages were found to reduce deforestation by making it less profitable to engage in deforestation promotion activities.

The study found greater access to forests and markets to generally lead to more deforestation whereas deforestation was found to be greater under open access regimes as compared to situations with well-defined and secure property rights. Contradictory results were obtained from models that have attempted to evaluate the effect of high income growth on deforestation. Evidence on the relationship between external indebtedness and deforestation was not consistent whereas the impact of political factors on deforestation was not conclusive. In conclusion, the study did not find any clear-cut transmission of the impact of macroeconomic variables and policies on deforestation,

Vreeland et al., (2001) sought to assess the impact of IMF's policies on deforestation. Theoretically, it has been claimed that the policies of the IMF generate a negative impact on the environment. The authors using a data set of 2,258 observations from 112 countries from 1970 to 1990, controlled for random selection of countries into IMF'S programs using a dynamic version of the Heckman selection model. Using a random effects model to control for country specific effects, a regression with net forest depletion as the dependent variable, and GDP per capita, population growth, total debt service as a percentage of GNP, and an IMF participation dummy as explanatory variables was estimated.

The study found that even after controlling for random selection of countries into the IMF programs, deforestation was positively influenced by IMF programs. Specifically, the study found that at a 5% level of significance, a 1% increase in population growth increased deforestation by 0.04%. Though per capita income had a positive effect on deforestation, the relationship was not significant. Whereas a 1% increase in debt service as a percent of GNP increased deforestation by 0.02%, participation in IMF programs was found to increase deforestation by 0.06 %. The inclusion of Hazard rates to account for possible selection bias still led to the conclusion that deforestation rates of countries increased under IMF programs.

In another study, Cropper and Griffiths (1994) analyzed the interactions of population growth and environmental quality; environmental quality measured as the stock of forests. Using cross sectional and time series over the period 1961-1968 for 64 countries, the authors estimated an Environmental Kuznets Curve (EKC) model of deforestation with rate of deforestation as the dependent variable and rural population density, population growth, timber price, GDP per capita growth , per capita GDP and per capita GDP squared as explanatory variables. Fixed effects models with varying intercepts to capture factors influencing deforestation that change slowly over time were estimated separately for Africa, Latin America and Asia.

The study confirmed the EKC hypothesis for Africa and Latin America with income turning points of $4,760 and $5,420 respectively. The EKC hypothesis was however not confirmed for Asia. The study found rural population density to be responsible for upward shifts of the EKC in Africa. The price of timber was found by the study to be statistically significant in Latin America, but not in Africa. The study found that an increase in 100 persons per 1,000 hectares increased the rate of deforestation by 0.33%. The authors however cautioned against the use of any policy regarding reductions in population growth as a simplistic panacea to reducing deforestation.

In a related study, Culas (2006) assessed the impacts of institutions for secure property rights and better environmental policies on the EKC relationship for deforestation for a sample of 14 countries across Latin America, Asia and Africa over the 1972-1994 period. The study employing a panel data EKC model with no feedback from the environment to the economy, hypothesized that institutions for secure property rights and better environmental policies can significantly reduce the rate of deforestation without hindering the level of economic growth. Explanatory variables in the model included agricultural production index, institutional variable, proportion of forest area, export price index, absolute forest area, population density, GDP per capita, GDP per capita squared and debt service as a percentage of GNP.

The institutional variable used by the study was defined as contract enforceability of government, measured on a scale of 0-4 with a higher score depicting greater enforceability. The study carried out a simple pooled regression with and without the institutional variable. The study found an inverted “U” relationship for deforestation in Latin America, however the EKC relationship did not hold for Africa and Asia. The study further found that the institutional variable had a downward effect on the EKC relationship in Latin America. On the effect of the institutional factors on the other regression variables, the study found the effects of agricultural production index to disappear when the institutional factor was included in the model. The net effect (with and without the institutional variable) of absolute forest area (proxy for forest and allied sector policies) and proportion of forest area (proxy for forest exports promotion policies) on deforestation were found to be 2.2853 ha and 11.256ha respectively. The study thus found forest and allied sector policies to work better when complemented with secure institutions for property rights and better environmental policies. In conclusion, the study recommended that strengthening institutions for property rights and better environmental policies will limit the effect of agricultural production and forest products exports on deforestation.

Adding to the institutions-deforestation reduction theory, Bhattarai and Hammig (2001) tested the hypothesis that institution characteristics and macroeconomic policies could help to ameliorate the effects of deforestation. The study used data on 66 countries from the tropical regions of Latin America, Africa and Asia for the period 1972-91. The study conducted within the EKC framework included regressors such as income, institutional variable, technological change, population growth, rural population density, external debt as a percentage of GDP and black market premium on foreign exchange. The study confirmed the existence of an “N” shaped EKC for deforestation model for Latin America and Africa. The debt Resource Hypothesis for deforestation was supported. The hypothesis of institutions reducing deforestation rates was confirmed with a statistically negative and significant coefficient for Latin America and Africa.

Ehrhardt-Martinez et al., (2002) examined the sources of an Environmental Kuznet Curve (EKC) that produces an inverted “U” relation between rate of deforestation and economic development within the framework of the Ecological Modernization Theory (EMT), political modernization theory and International Political Economy (IPE) theory. The study used a sample consisting of all less developed countries with available forest cover that experienced net deforestation between 1980 and 1985. Ehrhardt-Martinez et al., (2002) estimated three different models, one each explaining the structural modernization theory, political modernization theory and International Political Economy theory models. In the structural modernization theory model, explanatory variables included GDP per capita, urbanization, population growth, rural-urban migration and service sector employment. The political modernization theory model included democracy, education, scope of government actions and governmentally protected areas as regressors. The International Political Economy theory model included international debt, trade in forest products and world systems positions as regressors. The dependent variable in all the models was the rate of deforestation for the period 1980-1985.

The study found that after controlling for initial forest stock and data reliability, urbanization rather than GDP per capita was more significant in explaining the EKC hypothesis. Rural population pressure was found to positively impact deforestation rates. Higher urbanization was found to be associated with higher deforestation until it reached a threshold of 36% after which higher urbanization led to reductions in deforestation. Rural–urban population was found to be an important safety valve in relieving demographic pressures on forest stock. It was found that in countries where services constitute a larger share of employment, urbanization retarded deforestation. The political modernization models failed to find evidence on the impact of education and governmentally protected areas on deforestation. Although democracy was found to boost deforestation, its co-efficient was not being significant. The International Political Economy (IPE) models suggested that neither debt nor forest exports was significant in influencing deforestation. A weak but significant effect of global forest exports ranking on deforestation was also found by the study.

Kallbekken (2000) attempted to develop an alternative approach to the EKC for deforestation. The author hypothesized that within the framework of the EKC, the Human Development Index (HDI) could better proxy the level of development than GNP. Using a cross country data set, the study estimated two different sets of EKC models in two variants, simple and extended. In the first set, a simple EKC model was estimated with deforestation regressed on log (GNP) and log (GNP) squared. The extended EKC model added log (Land), log (Debt), log (trade) and log (Export ratio) as regressors. In the second set, testing the hypothesis of HDI better replacing GNP as a measure of economic development, entailed estimating simple and extended EKC models with log (GNP) and log (GNP) squared in the first set of equations replaced with HDI and HDI squared.

Three estimation approaches were followed by the study. The first was a simple multiple regression analysis, the second was a multiple regression analysis excluding the trade intensity variable, whereas the third approach employed a weighted regression with forest area in 1990 as a weighting variable. The study found the coefficient of GNP^2 to be significant at 5% for the weighting regression but not for the original model. With respect to the extended EKC model, the original, reduced and the weighted regressions found the coefficient of GNP^2 to be significant at 5%.

The simple HDI EKC model found the coefficient of HDI^2 to be significant at 0.1% for the original and weighted regressions. The extended HDI model found the coefficient of HDI^2 to be significant at 0.1% for the original and reduced regression, but not the weighted regression. The coefficient of the land area variable, significant at 5%, was negative and consistent across the models, and ranged from -0.43 to -0.56. The debt variable had an insignificant positive sign, and ranged from 0.17 to 0.30, across the region models. Export ratios and civil rights variables were not significant across the models. Whereas the study found the extended HDI not to work too well, the simple HDI model was preferred to the simple EKC model. That notwithstanding did not find the potential for improving EKC models by using the HDI.

Kant and Mahapatra (2005) provided a multinomial logistic model approach to tropical deforestation. The study used deforestation data from FRA (1990) for the period 1980-1995 and State of the World’s Forests (SOFO), 1997 for the 1990-1995 periods. The study was conducted for a sample of 64 countries. The dependent variable, deforestation was defined as a discrete variable. The authors divided the countries in the sample into three categories of deforestation; low (<0.7% per year), medium (0.7 to <1.4% per year) and high (1.45 per year). The multinomial logistic deforestation model included forest size, population growth, GDP growth, debt growth, agricultural growth, road development, democracy and three dummies, IDASIA, IDLAT and IDPERIOD as explanatory variables. DASIA, IDLAT were regional dummy variables for countries representing Asia and Latin America whereas IDPERIOD was a temporal stability dummy. In line with the objectives of the study, the authors estimated two non-redundant logits, High/Low and Medium/Low, with the base line category (low deforestation) assumed to have zero coefficients.

The study revealed that although population growth positively affected deforestation in both logits, it was significant in the High/Low logit but insignificant in the Med/Low logit. A 1% increase in population growth was found to increase the likelihood of a country being in a high deforestation category than in low deforestation by a factor of 4.138. GDP growth was found by the study to be insignificant in both logits.

Further, the study found the coefficient of debt service to be positive in both logits, but significant in the Med/Low logit and insignificant in the High/Low logit. A 1% increase in debt growth increased the likelihood of a country being in a medium deforestation category than in low deforestation by a factor of 1.063. Conforming to theory, agriculture growth and road development variables were positive and significant in the Med/Low logit and the High/Low logit. Democracy, although positive was found to be insignificant in the Med/Low logit and the High/Low logit. In terms of regional differences in deforestation, it was found that countries in Latin America or Asia rather than in Africa had a higher probability of being in the category of high deforestation with respect to low deforestation. Significantly, countries in Asia (rather than in Africa) were found to have a high likelihood of experiencing low deforestation.

Laurence (1999) after carefully reflecting on the tropical deforestation crisis found population growth, weak institutions, poor policies, trade liberalization and tropical logging as the main culprits of tropical deforestation. Based on the findings of the study the author recommended addressing population pressure, promoting education and capacity-building in developing countries and reducing incentives for forest destruction as necessary for reducing tropical deforestation. The author was quick to add that the fight against deforestation will not be fruitful without greater commitment from wealthy as well as developing nations.

In a study by Ewers (2006), the effects of interactions between economic development and forest cover change on deforestation was analyzed. Rates of forest cover change were measured over the period 1990–2000 and defined as per-year percentage change in forest cover. Using a sample of 103 countries classified into three income categories; Low, Middle or High using the World Bank criteria, analysis by two -way ANOVA and multiple regression reached the following results. There was a strong positive effect of GDP on rate of forest cover change, and also a strong interaction between GDP and forest cover, indicating that the effect of forest cover on rates of forest cover change is dependent on economic development. Further, the study revealed that forest cover did not have a direct effect on deforestation, but rather the effect of forest cover on deforestation rate is dependent on national wealth. The study postulated that wealthy nations with little forest cover had the potential of experiencing net afforestation. On the other hand, poor nations with low forest cover had the potential of experiencing an increase in their deforestation rates.

Barbier and Burgess (2001) provided an insight into the economics of tropical deforestation. The study attempted to develop a model of deforestation based on a synthesis of Environmental Kuznets Curve (EKC), competing land use models, forest land conversion models and institutional models. The synthesis model presented change in agricultural land expansion as the dependent variable, with GDP per capita, GDP per capita squared representing the EKC variables, structural variables including crop yield, crop share of total land area, agricultural share of total merchandise export exports and arable land per capita, population, GDP growth and institutional factors as regressors. The study used a sample of countries from Africa, Asia and Latin America. Separate panel data regression models were estimated with and without the institutional factors for all countries in the sample, and also for sub sets of African, Asian and Latin American countries.

The regression model without the institutional factors found agricultural land expansion to be mostly determined by the structural variables across all the models. The study confirmed the EKC hypothesis only for Asia. GDP growth and population were not significant in any of the models. Cereal yield had a statistically negative effect on agricultural land expansion across all the models. The econometric estimations were repeated but with the inclusion of three institutional factors namely corruption index, property rights index and political stability index.

With the inclusion of the institutional variables, the EKC hypothesis was validated for all countries and for the sample of Latin American countries, but not for Africa and Asia. GDP growth, cereal yield and arable land area appeared insignificant across all the regression models. Population growth had a positive significant influence for all countries, Latin America and Asia, but not for Africa. Agricultural export share and crop share of land had a positive significant influence for all countries and Latin America, but not for Africa and Asia. The study revealed that although the property right index was statistically insignificant across all models, the effects of corruption and political stability varied across regions.

Allen and Barnes (1985) undertook a study aimed at unraveling the causes of tropical deforestation. The study employed a panel data model consisting of all developing countries with per capita GNP less than $ 3,000 and forest area greater than 5% of total land area over the period 1968-1978. The study divided the countries into two groups. Group 1 included Africa, Asia, and Latin America and Group 2 included Africa and Asia.

Two regressions were estimated; short and long run models. A short run model with change in forest areas as the dependent variable was estimated as a function of population growth, change in arable land, GNP growth, and change in wood production. The short run regression model found population growth to be negative and statistically significant in Groups 1 and 2. However, change in cultivated land area, change in wood fuel production and GNP growth were statistically insignificant in both groups. The long run model showed deforestation to be negatively and statistically influenced by wood fuel and wood exports, and also by land area under plantations in both groups. The long run regression model found neither GNP nor population growth to be statistically significant in both groups.

Marquart-Pyatt (2004) explored the structural and institutional aspects of deforestation within the framework of dependency/ world systems, ecological modernization theory and statist perspectives. The study employed data on all available developing countries. The dependent variable, deforestation was measured as a positive rate of change in forest area from 1990 to 1995. The explanatory variables included population growth, urbanization, urbanization squared, long term debt, short term debt, debt service payments, state fiscal capacity, regime type, combined political and civil liberties index, and liberal democracy index. Using OLS regressions nine different models were estimated in line with the objectives of the study.

The study reported a curvilinear effect of urbanization on deforestation implying an environmental Kuznets curve for deforestation driven by urbanization. The EKC for deforestation revealed deforestation to increase with urbanization to increase to a threshold of approximately 43 percent and falls with further increase in urbanization. Deforestation rates were neither affected by the magnitude nor the duration of long-term, short-term, or debt service payments. However, long-term debt was significant with the inclusion of state fiscal capacity and regime type in the regression equations. State fiscal capacity was found to have a negative influence on the rate of deforestation. Regime type was found to have a positive influence on deforestation implying that more democratic nations have higher deforestation rates.

Zikri (2009) developed an econometric model of deforestation for Indonesia. The author sought to find out the contributions of the agricultural and timber sectors to deforestation, the macro economic variables exerting pressures on forests and also to distinguish between direct and underlining causes of deforestation. The study found forest export products and change in cereal cropland area to be the main factors driving deforestation in Indonesia. The study further found the international community's growing demand and preference for forest products from Indonesia to lead to over use of Indonesia's forests resulting in forest decline.

Dauvergne (Winter, 1993-1994) analyzed deforestation in Indonesia from a political point perspective. The author attributed tropical deforestation to four main causes; tropical government policy, developmental policy, environmental and public policy. Tropical government explanation cited slash –and – burning farming, whereas the developmental explanation cited poverty, rapid population growth and ignorance as promoting deforestation in Indonesia. The environmental explanation cited foreign debt whiles the public policy explanation considered the destructive impacts of misguided tropical government policies. The study recommended that the solutions to the problems proposed by the four main identified causes of deforestation will not be fruitful except with the appropriate collaboration of the Indonesian elite. To this end the author asserted that the "political forces which both drive and protect destructive forests practices must be recognized for a comprehensive understanding of the process which leads to deforestation".

Mertens et al., (2000) assessed the impact of macroeconomic transformations on deforestation in South Cameroon using an integration of household survey of 552 households in 33 villages and remotely sensed data. The study employed bivariate regressions between deforestation and population growth, technological evolution, marketing and wellbeing. Multiple regressions were employed to identify the combination of variables driving deforestation at the village level.

Results of the bivariate linear regression models showed a positive relationship between population growth and deforestation and no statistical relationship between technological evolution and deforestation. Multivariate regressions were computed over three time periods; the entire period of observation (1986-96) and, second, during the sub periods 1986-91 and 1991-96. The multivariate regressions results from the study found that the period of the economic crisis (1986-91) recorded an increase in the annual rate of deforestation compared to the period preceding the economic crisis (1973-86). The study further concluded that the annual increase in deforestation rates during the economic crisis were driven by population growth, increased marketing of plantain and non plantain food crops, modification of farming systems, and colonization of new agricultural areas in the remote forest zones.

Shandra (2007) tested the hypothesis that repressive nations create an appropriate and serene business climate for multinational capital, which in turn influences deforestation. The study employed OLS estimations using a cross sectional sample of 67 countries. The OLS regression model used deforestation as the dependent variable with gross domestic product, government expenditure, repression, domestic investment, population, total forest stock, export partner concentration, commodity concentration, foreign investment and international monetary Fund conditionality as regressors. The repression variable was defined as the average of Freedom House's (1997) data on civil and political rights for 1990. The study found no evidence of support for the EKC relationship between deforestation and economic development. However, the study found support for the hypothesis that repressive nations create an appropriate and serene business climate for multinational capital, which in turn influences deforestation.

Yiridoe and Nanang (2001) provided an insight into the causes of tropical deforestation in Ghana using econometric analysis. The study, employing a two-stage regression analysis used time series data from FAO(2000) and World Bank reports for the period 1961- 1999. The first stage regression entailed the regression of four first level (direct causes) causes of deforestation on various second level (indirect causes). The four level causes considered were forests products exports, fuel wood energy consumption, cocoa production and food crop production. Deforestation was then regressed on the estimated first level causes in the second stage. The authors estimated a deforestation model using a system of five recursive regression equations. The results of the deforestation model revealed that all the four direct causes of deforestation were statistically significant at 5%.

The study revealed the elasticity of deforestation with respect to fuel wood consumption, forest product export, cocoa product and food production to be 3.634, 0.059, -1.409 and 0.698 respectively. The study revealed the role that fuel wood consumption plays in deforestation in Ghana and hence recommended the development of alternative energy sources as a measure to check deforestation in Ghana. In terms of unit changes, a one cubit meter change in fuel wood consumption was found to lead to a 2.6 hectares loss of forest and /or wood land area. Also, a one tone increase in food crop production was found to cause a loss of forest area of 75ha. Further, macroeconomic, demographic and political factors such as external public debt, population, technology, property rights and GDP per capita were found by the study to influence deforestation indirectly through the first level (direct causes) of deforestation.

Along similar lines, Brew (1998) recognized that in addition to timber processing having a significant role to play in the economic development of Ghana in terms of employment and revenue generation, it also had a positive impact on deforestation. To this end, using descriptive statistics, OLS regressions and surveys over the period 1973 to 1997, he assessed the role of timber processing on deforestation in Ghana. The study estimated an

OLS regression model with forest cover as dependent variable, log exports by volume, timber produced for exports, timber processed for domestic consumption and total Ghanaian population as regressors.

The analysis of the regression model showed that in the long run, the elasticity of forest cover with respect to log exports by volume, timber produced for exports, timber processed for domestic consumption and total Ghanaian population were -0.000783, -0.1085, 0.0087 and -0.00738 respectively. The operative variable, timber produced for exports, had a significant positive impact on forest cover in the long run. The short run analysis showed the coefficient of log exports being negative and significant at 10%. The impact of log exports on forest cover was however greater in the short run than in the long run. Timber produced for exports also had a positive significant value at 1%. Total Ghanaian population and timber processed for domestic consumption, though having the expected signs of positive and negative respectively were not statistically significant. Based on the regression results the author concluded that over the study sample period timber processing had reduced the rate of deforestation in Ghana.

Benhin and Barbier (1998) empirically investigated the impact of the Structural Adjustment Programme (SAP) on forest loss in Ghana over the period 1965-95. Using a dynamic optimal control model and piecewise linear switching regressions, the study distinguished the post SAP adjustment from the pre SAP adjustment period. The study concluded that the significant causes of forest loss in Ghana were cocoa land expansion and timber production.

In a related study, Codjoe and Dzanku (2009) sought to find the long term determinants of deforestation in Ghana by examining the role of the Structural Adjustment Program (SAP) in accelerating deforestation in Ghana. The study considered deforestation as resulting from agricultural expansion and logging. Using annual time series on Ghana for the period 1960-2006, the study estimated a regression model with deforestation measured as change in forest area as the dependent variable. Variables hypothesized to influence agricultural expansion and logging such as real per capita gross domestic product, total external debt, real exchange rate, total Ghanaian population, cocoa production index, fertilizer price and index of food crop price were included as regressors in the model.

The study included an SAP dummy to test the hypothesis that the post SAP adjustment deforestation rate in Ghana was higher than the pre SAP adjustment deforestation rate. The long run results of the study supported the assertion that the impact of the SAP policies adopted by developing countries had been an increase in their deforestation rates. The authors found that Ghana lost more forest during the post SAP adjustment period as compared to the pre SAP adjustment period. Specifically, the study found that the deforestation rates in the post SAP adjustment period was 55.9% higher than the pre SAP adjustment period.

Appiah et al., (2007) assessed the impact of local dependence on forest products on tropical deforestation in Ghana. The study employed personal interviews and focus discussions in the Dormaa, Offinso and Begoro districts of Ghana. From the perspective of the local residents interviewed in the study areas, the continuous depletion of forest resources could be attributed to farming for livelihood, lack of alternative employment other than farming, increasing rural household levels and conflicts in traditional practices respectively. In addition, the study found other factors such as poor logging practices, inadequate knowledge of sustainable farming practices and conflicting government policies as being responsible for the continuous depletion of forest resources. The study recommended that policies designed to curtail deforestation in the study areas should not be oblivious to the agro forestry practices of the local residence.

3.4 Conclusion

From the theoretical and empirical literature it has become clear that the proximate causes of deforestation are clear and obvious whereas the underlying causes are less well known and controversial. The effects of deforestation have been observed to transcend national borders onto the global level. Actors and agents of deforestation have been clearly identified. The complexity of the nature and causes of deforestation is revealed by the varying approaches that have been adopted towards studying it. It is clear however that though the effects of deforestation vary across countries and regions, the factors hypothesized to influence it remain uniform across countries and regions.

CHAPTER FOUR

METHODOLOGY

4.0 Introduction

This chapter explains the study's methodology. It clearly lays down the tools and various estimation procedures that are used by the study to achieve its set aims and objectives. The chapter concerns itself with among other things, the scope of the study and the sources from which data was sourced for the study. The chapter further specifies the econometric model used by the study and the choice and justification of the variables used in the model. The organization of the chapter is laid out in the following manner. In section 4.1, the conceptual and econometric EKC for deforestation models are specified. Arguments for the choice and justification of the variables used in the econometric model are made in section 4.1.1. Section 4.2 considers the scope and sources of data for the study. Finally, in Section 4.3, the estimation procedures followed in estimating the econometric EKC for deforestation model selected in Section 4.1 are elaborated. The chapter ends with a conclusion.

4.1 Conceptual EKC for deforestation model

In this section, the choice and specification of the econometric model used by the study is considered. To empirically and critically analyze and explore the various factors responsible for deforestation in Ghana, the study conceptualizes and estimates an

Environmental Kuznets Curve (EKC) for deforestation. From the conceptual model, the econometric EKC for deforestation model used by the study, chosen based on economic theory and various models used by researchers to study deforestation is derived. Choice of variables for the study was based on existing literature on deforestation studies and data availability on the variables used. The study uses annual time series data on the regression variables spanning from 1970 to 2009 for the econometric estimation of the EKC for deforestation model. Following Ehrhard-Martinez et al., (2002), Kallbekken (2000), Yiridoe and Nanang (2001) and Culas (2006), the functional form of the model used by the study is expressed conceptually as:

$$DEF = f(GDP, GDP^2, URB, RUPRESS, FOREST, DEBT, SAP, TRADE, API,$$

$$, EXCH, PROPRIGHT, TREND) \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

For purposes of econometric estimation, the conceptual EKC for deforestation is made operational by being modeled as a long run relationship between DEF and the other variables in the conceptual EKC framework. The long run EKC for deforestation model to be estimated in the next chapter is expressed as:

$$LNDEF_t = \gamma_0 + \gamma_1 LNGDP_t + \gamma_2 LNGDP^2{}_t + \gamma_3 LNURB_t + \gamma_4 LNRUPRESS_t + \gamma_5 LNAPI_t$$

$$+\gamma_6 LNFOREST_t + \gamma_7 LNTRADE_t + \gamma_8 PROPRIGHT_t + \gamma_9 LNDEBT_t + \gamma_{10} SAP$$

$$+\gamma_{11} LNEXCH_t + \gamma_{12} TREND + \varepsilon_t \quad \ldots\ldots\ldots \text{(2)}$$

where the subscript “t” denotes a time period, i.e. year in this case as annual data is being considered. All the variables are expressed in natural logarithm; therefore the coefficients can be interpreted in terms of elasticities. ε_t is defined to be a stochastic error term assumed to be white noise, whereas γ_i, for i=0,1,2 ….,12 are regression parameters to be estimated. The inclusion of the square of per capita GDP in Equation 2 is to validate the EKC hypothesis. Bhattarai and Hammig (2001) included a cubic term of GDP in their EKC for deforestation model to test the hypothesis of an inverted "N" shape or "N" shaped relationship between deforestation and GDP. Following Kallbekken (2000) the study does not find any reason to include a cubic term of Gross Domestic Product Per Capita into the long run EKC for deforestation model.

This Environmental Kuznets Curve used by the study postulates no feedback from deforestation to the economy. It is thus assumed that while economic growth affects the environment, the reverse is not true. In other words causality runs from economic growth to deforestation only. Theoretically, the EKC hypothesis implies that as the economy grows, deforestation increases up to a certain threshold and falls with further increases in income, exhibiting an inverted "U" shape relationship between economic growth and deforestation.

4.1.1 Choice and justification of regression variables

Rate of Deforestation (DEF)

Different definitions of deforestation have been used by various researchers in deforestation studies. Brew (1998) and Anning (1999) used the level of forest cover in Ghana as a negative proxy for deforestation. Yiridoe and Nanang (2001) defined deforestation as the annual average reduction in forest and woodland area. Deforestation has also been defined in deforestation literature as the percentage annual decrease in forest area (Cropper and Griffith, 1994; Culas, 2006; Ehrhardt-Martinez et al., 2002). The rate of deforestation, used by the study as the dependent variable in the EKC regression model, is calculated based on the standard formula used by researchers to estimate deforestation. Though there are various definitions of Forest area, the most cited definition is the one by FAO. Forest area is defined by FAO as forest cover that includes forests and all woody vegetation. The FAO production year book, according to Culas (2006) defines Forest cover to include closed and open forests, woodlands, plantations, and land from which forests have been cleared (deforested) but will be reforested in the near future. The rate of deforestation used by the study is calculated as:

$$DEF_t = \frac{F_{t-1} - F_t}{F_{t-1}}$$

Where F_t , F_{t-1} represents the total forest area in Ghana in time "t" and time "t-1" respectively. The study adopts FAO's definition of forest area.

Gross Domestic Product per Capita (constant 2000 $US) (GDP)

The Environmental Kuznets Curve for deforestation postulates an inverted "U" relationship between deforestation and income per capita. The EKC hypothesis postulates that as the economy grows deforestation rises up to a point, and then begins to fall with further economic growth. This explains the inclusion of Gross Domestic Product per Capita (constant 2000 $US) in the long run EKC regression model. To test the EKC for deforestation hypothesis the square of Gross Domestic Product per Capita (constant 2000 $US) is included in the long run EKC for deforestation model. If the Environmental Kuznet Curve for deforestation is supported, then it is expected that γ_2 *>0 and* γ_2 *<0.* Culas (2006), Cropper and Griffiths (1994) and Ehrhardt-Martinez et al., (2002) included Per Capita GDP and Per Capita GDP squared in their EKC for deforestation models to test the inverted "U" relationship between deforestation and economic growth. Cropper and Griffith (1994) providing a theoretical foundation for the EKC for deforestation contended that logging has a link with income, in that as an economy grows logging increases but reduces later as industrialization takes over. They further asserted that the demand for fuel wood, being a function of income will initially increase with income, but eventually fall as more modern sources of energy are used. Analytically, demand for fuel wood will tend to be substituted for alternative and modern energy sources over time.

Urbanization (URB)

Urbanization is one of the common factors that have been blamed for deforestation. Theory posits that increased urbanization, which ultimately leads to increases in land for infrastructural development and other social utilities like building of stadia, schools, roads and housing projects will invariably lead to forest clearing. There are various definitions of urbanization by different authors. Urbanization has been defined as the percentage of the population living in urban areas (Ehrhardt-Martinez et al., 2002). However, urbanization in this study is defined as annual urban population growth. This definition follows Rudel (1998), cited in Jorgenson (2006) who argued that urban population growth can be used as an indirect measure of industrialization. Jorgenson (2006) asserts that often, a larger urban population accompanies industrialization due to the fact most industrial processes concentrate employment in cities. Deforestation studies therefore postulate that increased urbanization hastens the process of deforestation.

Rural Population pressure (RUPRESS)

Demographic variables have been consistently cited as a very important cause of deforestation. Urban population growth, rural population growth and agricultural population growth are some of the demographic variables claimed to exert pressures on forests. An increase in population is generally expected to put pressures on natural resources. Specifically, an increase in population has been theorized to increase food demand, leading to increase in demand for agricultural land, ultimately leading to deforestation. This study considers the impact of rural population pressure on deforestation. Following Ehrhardt et al., (2002) the study includes rural population pressure rather than rural population growth in the long run EKC model. Rural Population Pressure is defined by Ehrhardt-Martinez et al., (2002) as the geometric mean of rural population growth and rural population density. Rural population pressure measures the degree of demographic saturation of rural districts and captures the dependence of people living in rural areas on forests (Ehrhardt-Martinez et al., 2002). Studies predict that increases in the rural population pressure will exert pressures on forests, and hence hasten deforestation.

Total Forest Exports value as a percentage of GDP (FOREST)

Total forest products exports value is defined by World Resources Institute (WRI) as the value of all forest products transferred out of a particular country or region to be sold. Economic theory suggests that increases in forest products will be expected to have a positive effect on deforestation. Logically, this is plausible if no afforestations schemes are initiated. However, empirical studies have found conflicting evidence on the impact of total forest products value on deforestation. Whereas Yiridoe and Nanang (2001) found a positive impact of forest exports product (in cubic metres) on deforestation in Ghana, Ehrhardt-Martinez et al., (2002) found a negative impact of forest products exports on deforestation. Brew (1998) and Anning (1999) found a positive impact of export of processed timber on forest cover of Ghana. Following Kallbekken (2000), the ratio of total forest product value to GDP is used in the study to capture the relative importance of the forestry sector to the economy of Ghana. Total forest products exports value is thus normalized to GDP (current $US). Empirical evidence on the impact of total forest products value/GDP on deforestation has remained inconclusive.

Trade openness/Globalization (TRADE)

Deforestation literature has considered the impact of trade liberalization or globalization on the environment. Trade openness or Globalization is measured as the sum of exports and imports as a percentage of GDP. Grossman and Krueger (1992), cited in Kallbekken (2000) argued that " a country's level of pollution might be directly related to its openness to trade, perhaps because environmental regulations tend to a least common denominator".[43] The impact of increased trade openness or globalization on deforestation will be assessed with the trade openness variable. The effect of globalization or trade liberalization on deforestation remains inconclusive.

Agricultural Production Index (API)

Agricultural Production index is used to measure the effect of expansion of agricultural lands into forests (Culas, 2006). Agricultural production index is defined as the level of the

[43] *Kallbekken (2000:26)*

aggregate volume of production for a particular year (WRI). The Agricultural Production Index (API) is thus used to explain the effects of agricultural activities on deforestation. Theory predicts agricultural expansion into forests to have a negative effect on forests and thus accelerate deforestation.

Property right (PROPRIGHT)

One variable that is very useful in explaining deforestation is the role of institutions for secure property rights and better environmental policies. It is expected that countries with poorer institutions characterized by higher corruption and lower bureaucratic effectiveness will experience higher deforestation rates than countries that have better institutions. According to Guuroh (2010)[44], indirect causes of deforestation in Ghana include corrupt practices of governments, weak institutions, in appropriate policies and lack of law enforcement. Following Yiridoe and Nanang (2001), PROPRIGHT is defined as a dummy for state capacity to enforce forest protection and secure property rights.

Property rights are said to be better enforced within democratic states, as democracy is said to encourage greater diffusion of information about environmental matters and make the state more responsive to public pressures in protecting the environment. The coefficient of property right is expected to be negative as constitutional regimes are expected to have lesser deforestation rates as compared to unconstitutional ones. Following Frimpong and Marbuah (2010), the PROPRIGHT dummy is defined to take the value of 0 for periods in which there was no constitutional regime and 1 for periods under constitutional rule. The PROPRIGHT dummy takes the value of 1 from 1970-1971, 1980-1981, 1993-2002 and the value of 0 from

[44] http://www.ghanaweb.com/GhanaHomePage/blogs/blog.article.php?blog=3375&ID=1000009309

1972-1979 and 1982-1992.

Time trend

Following Culas (2006), a time trend is included in the regression model as a proxy to capture the effects of other exogenous time dependent variables such as technological changes in agriculture on deforestation. The effect of technological change on deforestation, according to Culas (2006) depends on whether the technological change is labour and /or capital saving or labour and/or capital intensive. Culas (2006) asserts that more resources are freed for additional farming and forest clearing for labour and /or capital saving technological changes, the reverse is true for labour and / or capital intensive technological changes. However, this study recognizes the vagueness in the usage of time trend as a measure of agricultural technological change and cautions people to be cautious in the interpretation of its impact on deforestation.

Structural Adjustment Program (SAP)

Over the last 15 years many developing countries have embarked on stabilization and Structural Adjustment Policies (SAPs). However, the environmental impacts of the SAP have remained controversial (Kaimowitz et al., 1999). With respect to the environmental impacts of the SAP, studies have analyzed the effect of SAP policies on deforestation. In assessing the SAP in Ghana, Benhin and Barbier (2001:67) asserted that “Low timber royalties and subsidized costs of extraction in the pre-adjustment period may have been an incentive for increased logging. In the Structural Adjustment period, macroeconomic policies leading to devalued exchange rates have increased the domestic returns from logging and therefore may have also increased the incentive for indiscriminate and destructive logging activities". Kaimowitz et al., (1999) found that SAP in Bolivia increased forest clearing and degradation related to soybean and timber exports. In Ghana, Codjoe and Dzanku (2009) found the rate at which forestland was converted to agricultural land to be higher during the period after SAP than before the adjustment period. The SAP dummy is thus introduced in the EKC model to test the hypothesis that the post structural adjustment deforestation rate in Ghana is greater than the pre structural adjustment deforestation rate. Following Codjoe and Dzanku (2009) the SAP dummy is defined as:

$$\text{SAP}=\begin{cases} 1 \; if \; year > 1983 \\ 0 \; if \; year \leq 1983 \end{cases}$$

Total External Debt (Debt)

One of the most popular and controversial debates in deforestation studies is the impact that external debts of developing countries have on their natural resource extraction. This is referred to as the Debt Resource Hypothesis. The Debt Resource Hypothesis (DRH) applied in deforestation studies posits that huge debts of developing countries causes them to exhibit myopic behaviour in adopting short run policies, which aggravate their environmental problems in the long run. Culas (2004) asserts that foreign debt causes high rate of tropical deforestation. Evidence on the Debt Resource hypothesis has not been conclusive as researchers have found conflicting results. The Debt Resource Hypothesis in Ghana is tested with the inclusion of total external debt in the long run EKC model.

Exchange rate (EXCH)

The inclusion of exchange rate into the long run EKC model is to examine the impact of exchange rate on deforestation in Ghana. Theoretically, it is plausible to assume that depreciation of the exchange rate incentivizes forest products exports and promotes deforestation. Arcand et al., (2008), argued that depreciation of the real exchange rate serves as an incentive for increased agricultural exports in developing countries.

4.2 Data sources and scope of the study

This Section considers the scope of the study and the sources of data on the variables used in the econometric model. The study, in seeking to explicate the causes of deforestation in Ghana within the framework of the Environmental Kuznets Curve (EKC) hypothesis, uses annual time series data on Ghana spanning the time period 1970 to 2009. This time period is chosen because data on all the variables used by the study is available only for this time period. Data for this study was sourced from World Development Indicators (WDI) (World Bank online, 2011), African Development Indicators (ADI) (World Bank online, 2010) and FAOSTAT (Food and Agricultural Organization online, 2010). Table 4.1 presents a description of the variables used in the study, their source, units of measurement and expected signs.

Table 4.1: Details of regression Variables

Variable	brief description	unit of measurement	Source	Expected Sign
DEF	Rate of	Percentage (%)	www.fao.org	

	Deforestation			
GDP	Per capita GDP (in constant 2000 $US)	US Dollars	WDI, World Bank	Positive
GDP^2	Per capita GDP (in constant 2000 $US) squared	US Dollars	WDI, World Bank*	Negative
URB	Urban population growth : proxy for Urbanization	Percentage (%)	WDI, World Bank	Positive
RUPRESS	Rural population pressure		WDI, World Bank* +	Positive
TRADE	Trade openness or Globalization	Percentage (%)	WDI, World Bank	No prediction
FOREST	Forest exports value as a percentage of GDP	Percentage (%)	WDI +	No prediction
API	Agricultural production index (base period 1999-2001)	US Dollars	ADI+	Positive

PROPRIGHT	dummy variable for state capacity to enforce property rights	Takes a 1 (0) value for periods when there was a constitutional (unconstitutional) government		Negative
TREND	Measures technological changes in agriculture			No prediction
SAP	Dummy variable for Structural Adjustment program	Takes a value of 1 for year>1983 and 0 for year ≤1983		Positive
DEBT	Total external debt	Current $US	WDI	Positive
EXCH	Exchange rate	LCU per $US	WDI	No prediction

**indicates the variable was computed*

+indicates that some values of the variable were predicted. The values for RUPRESS, API and FOREST for 2008 and 2009 were predicted assuming a linear trend from 1970 to 2007.

The data set used by the study is provided as appendix I. The data set comprises annual time series data on all the variables used by the study from 1970 to 2009.

4.3 Estimation procedures

In order for the long run EKC model for deforestation specified in section 4.1, i.e. Equation 2 to be used to achieve the aims and objectives of the study, some estimation procedures must be carried out. Within the framework of The Environmental Kuznets Curve (EKC) for deforestation, the Auto Regressive Distributed Lag (ARDL) Bounds Testing approach to cointegration will be used to analyze the short and long run relationship between deforestation and the factors hypothesized to influence it in Ghana.

Developed by Pesaran et al., (1999) and modified by Pesaran et al., (2001), the ARDL Bounds Testing approach to cointegration has come to be widely accepted as a technique for examining the long and short run relationships between variables in multivariate time series models. Although the study recognizes the existence of conventional approaches to cointegration such as Johansen cointegration approach and the Engle-Granger two-step residual based test for cointegration, the ARDL Bounds Testing cointegration approach is preferred by this study as it is able to circumvent the limitations of the conventional approaches.

4.3.1 Justification of the ARDL approach to Cointegration

Time series econometric literature has over the past decades concerned itself with empirical analysis of the existence of relationships in levels between variables in a multivariate framework. To achieve this purpose, various cointegration techniques have been used. Pesaran et al, (2001) identifies various existing cointegration techniques that have been developed to include : the two –step residual based procedure for testing the null of no co integration (Engle and Granger, 1987; Philips and Ouliaris,1990), the system based reduced rank regression approach by Johansen (1991,1995), Variable addition approach by Park (1990), the residual based procedure for testing the null of cointegration by Shin (1994) and the stochastic common trends approach of Stock and Watson (1988).

These conventional cointegration approaches though useful in establishing the long run and short relations between variables are not without faults. A serious limitation of the conventional cointegration techniques is that they require all the variables used in the regression model to be integrated of order one, i.e. I (1). Implicitly, in the presence of combinations of I (0) and I (1) variables in a time series regression model, these conventional cointegration approaches tend to lose their usefulness and applicability. It was in the light of this short coming that the ARDL approach to cointegration was developed. According to Pesaran et al, (2001), the Bounds Testing approach or ARDL Bounds Testing approach to cointegration is applicable whether the underlying regressors in the model are purely I (0), purely I (1) or mutually co integrated.

4.3.2 Advantages of the ARDL approach to cointegration

As established in section 4.3.1, the ARDL Bounds Test approach to cointegration developed by Pesaran et al., (2001) has advantages over the existing conventional cointegration techniques. The ARDL Bounds testing approach to co integration is adopted by the study due to the following considerations :

- The ARDL approach is preferred to the conventional cointegration techniques with respect to its small sample estimation properties. As compared to the other conventional approaches, the Bounds Testing or ARDL approach is more appropriate for estimation in small samples. Considering the fact that the data used for the study spans the period 1970 to 2009 with over nine variables, the ARDL approach will appear to be more appropriate as compared to the conventional cointegration techniques.

- Ease of use is achieved by the ARDL approach as it is very simple to use and allows the cointegration equation to be estimated by OLS when the lag order of the ARDL model is appropriately determined.

- According to Afzal et al., (2010), the ARDL approach to cointegration is able to simultaneously estimate the long run and short run components of the regression model under consideration. The problem of omitted variable bias is eliminated by the ARDL approach to cointegration. Also, the ARDL approach produces unbiased and efficient estimates because it is able to circumvent the problems of serial correlation and endogeniety (Afzal et al., 2010).

- Lastly, and most importantly, as compared to the other conventional cointegration approaches, the ARDL approach can be applied whether the explanatory variables used in the regression model are purely I(0), purely I(1) or mutually co integrated (Pesaran et al, 2001). Caution must however be taken to ascertain that the dependent variable is I(1) in levels and none of the regressors is I(2) or higher, as the ARDL approach to co integration crashes in the presence of I(2) variables (Afzal et al, 2010). To ensure that no variable which is integrated of order two or more is included in the regression model, the explanatory variables are tested for stationarity.

4.3.3 Steps in using the ARDL approach

Before applying the ARDL approach, it is necessary to satisfy the requirement that the dependent variable is I (1) and no variable which is integrated of order two or higher is included in the regression model as the ARDL approach to co integration ceases to be useful in the presence of I(2) variables. The regression variables are therefore tested for unit roots using the Augmented Dickey Fuller (ADF) test and the Phillips-Perron unit root tests. The main approach used by the study for testing unit root is the ADF unit root test, whiles the Phillips-Perron unit root test is used to confirm the results of the ADF unit root test.

4.3.4 Test for stationarity

Stationarity of variables employed in time series regressions is a very important concept. Time series econometrics literature makes a useful distinction between strictly stationary and weak stationary stochastic processes. A strictly stationary stochastic process is defined as one which has properties which are not affected by a change of time origin, i.e. its joint probability distributions for any set of times are not affected by an arbitrary shift along the time axis (Verbeek, 2004). Statistically, stationarity implies that $Cov\ (Y_t,\ Y_{t-k}\ )$ for any integer K is independent of time t, where Y_t and Y_{t-k} are stochastic time series processes. A weak stationary process is defined by Verbeek (2004) as a series for which the means, variances and co variances are independent of time, rather than the entire distribution.

Time series regressions may yield nonsense or spurious results if explanatory variables are non stationary. Statistically significant but economically meaningless results may be obtained from estimating time series models with non stationary explanatory variables. Tests of stationarity are therefore undertaken to ensure that spurious regressions are not estimated. Most importantly, tests of stationarity are conducted in this study to ensure that the dependent variable is I (1) and no other variable included in the econometric model is integrated of order two or above.

It is usual to obtain a graphical representation of time series variables before proceeding to formally test for stationarity. The graphical representation, though not conclusive on the stationarity of the variables, provides a rough idea of their order of integration. The graphs will show whether the variables are stationary in levels or differences. Time series graphs of the variables included in the econometric models used by the study, in levels and first differences are provided in appendix 3. The main formal test for stationarity employed by the study is the Augmented Dickey Fuller (ADF) unit root test. The Philips- Perron unit root test will be used to confirm the results of the ADF test.

4.3.5 Augmented Dickey Fuller (ADF) test

The procedure for testing unit root using the Augmented Dickey Fuller (ADF) (Dickey and Fuller, 1979) unit root test procedure is laid out as follows. The ADF test begins by considering a simple AR(1) process given by:

$$y_t = \beta y_{t-1} + x_t'\delta_t + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; (3)$$

where y_t is defined to be the variable under consideration, being tested for unit root, and $\boldsymbol{y_{t-1}}$

is the lagged value of $\boldsymbol{y_t}$. x_t represents optional regressors which may consist of a constant, or a constant and trend, whereas the stochastic error term, ε_t is assumed to be white noise. The stationarity of $\boldsymbol{y_t}$ depends on $|B|$. The value of $|B|$ determines whether $\boldsymbol{y_t}$ explodes and approaches infinity or converges to equilibrium. If $|B|>1$, then $\boldsymbol{y_t}$ will be considered to be a non stationary time series as its variance will increase with time and approach infinity. On the other hand y_t will be said to be trend stationary if $|B|\leq 1$ (Eviews 4 user guide).

The standard Augmented Dickey Fuller (ADF) unit root test as laid out by Eviews 4 user guide is carried out by subtracting $\boldsymbol{y_{t-1}}$ from both sides of the equation 3 and augmenting it with lags of Δy_t to obtain:

$$\Delta y_t = \phi y_{t-1} + x_t{}'\delta_t + \sum_{1}^{k} \beta_i \Delta y_{t-i} + v_t \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where;

k is the number of lags of the dependent variable included to correct serial correlation.

ϕ is defined as β -1

V_t is a stochastic error term and Δ is a difference operator.

The hypothesis employed to test for unit root in Equation (4) is given as:

H_0 : ϕ =0 (Y_t is non stationary, has unit root)

H_1 : ϕ <0 (Y_t is stationary)

The null hypothesis of the unit root test in Equation 4 is rejected if the ADF test statistic (***tau statistic***) is less than the ADF critical value at 5%. Rejection of the null hypothesis implies that y_t is stationary, whereas non rejection implies non stationarity (Eviews 4 user guide).

In applying the ADF test for unit roots, two practical problems are sure to be encountered. The researcher is confronted with deciding whether to include a constant, constant and trend or neither in the ADF unit root test regression. The researcher is also confronted with deciding the number of lags (k) to be introduced in Equation 4. The decision as to whether to include a trend, constant and trend or neither is critical as a wrong decision may affect the power of the unit root test. The number of lags included in the unit root test regression is important because if the number of lags introduced is too small the remaining correlation in the model will cause the test to produce biased results whereas introducing too many lags will tend to reduce the power of the test.

Various techniques have been developed to identify the appropriate number of lags to be included in the ADF unit root test regression. Ng and Perron (1995) developed a procedure for deciding on the number of lags to be included in the ADF unit root test regression that will minimize the power of the ADF unit root test. The procedure is as follows:[45]

- An appropriate upper boundary , k max for the optimal lags to be included in the ADF unit test regression model is determined
- After determining the upper boundary k max, the ADF test regression, Equation 4 with lag length k=k max is estimated.
- If, upon running the ADF model with lag length k max, it is observed that the absolute value of the test statistic for testing the statistical significance of the last

[45] http://faculty.washington.edu/ezivot/econ584/notes/unitroot.pdf

lagged difference term is greater than 1.6, then the lag order should be set to k max. If on the other hand, the absolute value of the test statistic for testing the statistical significance of the last lagged difference term is less than 1.6, then the lag length should be reduced by one and the second and third steps repeated.

The calculation of k max is based on the formula developed by Schwert (1989). The formula for K max is defined as:

$$K\ max = \left[12 \left(\frac{T}{100} \right)^{\frac{1}{4}} \right]$$

T is defined as the number of observations

Alternatively, the appropriate number of lags to be included in the ADF unit root test regression can be determined by using the Akaike Information Criterion (AIC) or Schwartz-Bayesian Criterion (SBC). After determining the max lag order, i.e. k max, the rule of thumb is to choose the lag order that minimizes the Akaike Information Criterion (AIC) or Schwartz-Bayesian Criterion (SBC).

4.3.6 Philips-Perron (PP) test for unit root

In addition to the ADF unit root test, the study employs the Phillips –Perron (PP) unit root test developed by Phillips and Perron (1988). The test was developed as an alternative to the Augmented Dickey Fuller (ADF) test. The method employs the original Dickey Fuller regressions; however instead of introducing lagged difference terms into the Dickey Fuller regression to correct for serial correlation in the error terms, the Philips-Perron test uses non parametric statistical methods to adjust the Dickey Fuller statistic to take into account possible serial correlation in the errors (Verbeek, 2004:273; Gujarati, 2004: 818). The Philips –Perron test will be used to confirm the results of the ADF unit root test regressions. By using the Philips –Perron test the probability of non rejection of a false null hypothesis reduces (Baci, 2007).

4.3.7 ARDL Cointegration modelling procedure

After satisfying the requirement that no regression variable which is integrated of order two or higher is included in the model, the ARDL approach to cointegration can be applied. The ARDL Bounds Testing cointegration approach proceeds in three simple procedures:

- Dynamic analysis: The dynamic analysis is structured to test for the presence of long run relationships (cointegration) between the level variables in the model.

- Long run relationships: This aims at finding and estimating the long run relationships between the variables in the model. This step will thus involve estimating the long run co-efficients of the variables in the model.

- Error Correction Modeling (ECM): This is to establish the short run relationships between the variables in the model. The short run co-efficients of the variables in the model are determined at this step.

In the first step of the ARDL Bounds Testing approach, the Unrestricted Error Correction Model (UECM) for the econometric EKC for deforestation model estimated by Ordinary Least Squares (OLS) considering the variable of interest (*LNDEF*) is expressed as:

$$\Delta LNDEF_t = \alpha + \sum_{i=1}^{p} \lambda_{1i} \Delta LNDEF_{t-i} + \sum_{i=0}^{q} \lambda_{2i} \Delta LNURB_{t-i} + \sum_{i=0}^{r} \lambda_{3i} \Delta LNDEBT_{t-i} + \sum_{i=0}^{s} \lambda_{4i} \Delta LNTRADE_{t-i}$$

$$+\sum_{i=0}^{t} \lambda_{5i} \Delta LNRUPRESS_t + \sum_{i=0}^{u} \lambda_{6i} \Delta LNFOREST_{t-i} + \sum_{i=0}^{v} \lambda_{7i} \Delta LNGDP_{t-i} + \sum_{i=0}^{w} \lambda_{8i} \Delta LNGDP^2{}_{t-1}$$

$$+\sum_{i=0}^{x} \lambda_{9i} \Delta LNAPI_{t-i} + \sum_{i=0}^{y} \lambda_{10i} \Delta LNEXCH_{t-i} + \eta_1 SAP_t + \eta_2 PROPRIGHT_t + \delta_1 LNDEF_{t-1} + \delta_2 LNURB_{t-1}$$

$$+\delta_3 LNTRADE_{t-1} + \delta_4 LNRUPRESS_{t-1} + \delta_5 LNFORESTXPT_{t-1} + \delta_6 LNGDP_{t-1} + \delta_7 LNGDP^2{}_{t-1}$$

$$+\delta_8 LNAPI_{t-1} + \delta_9 LNDEBT_{t-1} + \delta_{10} LNEXCH_{t-i} + \varepsilon_t \quad \text{……………..} \ (5)$$

where Δ is a difference operator, p,q,r,s,t,u,v,w,x,y represent the lag length on the regression variables and ε_t is a error term which is assumed to be white noise. The parameters, λ_{mi} for m=1, 2, 3…, 10, represent the short run dynamics of the EKC model whereas the long run relationships are given by the δ ’s. All variables in equation 5 are as defined in sections 4.1.1 and 4.2. The ARDL Bounds Test requires the determination of the maximum lag order of the regression variables. Given the study sample size and the number of regressors used in the model, the maximum lag order of the regression variables is set to one. After setting the maximum lag order to one, determination of the optimal number of lags to be introduced in the ARDL model is based on the minimum Akaike

Information Criterion (AIC). In determining the optimal lag of each variable in Equation 5 using the Akaike Information Criterion (AIC), the ARDL Bounds Test estimates $(p+1)^k$ regressions, where p is the maximum lag order of the variables and k is the number of variables in the model.

The rationale for the Unrestricted Error Correction Model (UECM) of the econometric EKC for deforestation model, i.e. equation 5 is to examine the long run relationships between the variables in the EKC model. In testing for the existence of any long run relationship between the variables, the F test is used to test the joint significance of the coefficients of the lagged level variables. The F –test tests the null hypothesis of no cointegration against the alternative of cointegration. The null hypothesis of no cointegration is given by:

H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \delta_{10} = 0$.

The null hypothesis of no co- integration is tested against the alternative of co integration given by H_1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq \delta_7 \neq \delta_8 \neq \delta_9 \neq \delta_{10} \neq 0$

The F-test used for testing the null hypothesis assumes an asymptotic non-standard distribution (Pesaran et al., 2001). The F statistic for the cointegration test which is normalized on LNDEF is denoted by:

$$F_{LNDEF}(LNDEF \mid LNGDP, LNGDP^2, LNURB, LNRUPRESS, LNTRADE, LNDEBT, LNFOREST,$$

$$, LNAPI, LNSAP, LNPROPRIGHT)$$

The decision rule of the F test depends on the critical values to which it is compared. The critical values however depend on the number of explanatory variables in the model, whether the explanatory variables in the regression model are integrated of order zero or one and also on whether the model contains an intercept, and or trend, or neither (Pesaran et al, 2001). Based on the order of integration of the explanatory variables, two asymptotic critical values are derived: an upper critical value and a lower critical value. The lower critical values are based on the assumption that all the explanatory variables are integrated of order zero, whiles the upper critical values assume that the explanatory variables are integrated of order one (Pesaran et al , 2001). The decision rule for the F test applied in Equation 5 is as follows:

- Reject the Null hypothesis of no co integration if the F statistic is greater than the upper critical value
- Fail to reject the Null hypothesis of no co integration if the F statistic is lesser than the lower critical value.
- If the F statistic lies between the two critical values, then the decision can only be made if the orders of integration of the underlying explanatory variables are known (Pesaran et al., 2001).

The relevant critical values for the F test will be taken from Pesaran et al., (2001) based on Table CI (v), Case V with unrestricted trend and unrestricted intercept, and number of regressors, K=10. Although the study uses 12 variables, critical values for the F test are chosen for K=10 because critical values for the F test taken from Pesaran et al., (2001) are available up to 10 variables only.

Following from the Unrestricted Error Correction Model (UECM) model, if cointegration between the variables is found to exist, the next stage in the ARDL Bound Testing approach will require estimating the long run coefficients of the EKC for deforestation model. The conditional ARDL (*p,q,r,s,t,u,v,w,x,y*) specification of the long-run EKC for deforestation model is estimated as :

$$LNDEF_t = B_0 + \sum_{i=1}^{p} B_{1i} LNDEF_{t-i} + \sum_{i=0}^{q} B_{2i} LNURB_{t-i} + \sum_{i=0}^{r} B_{3i} LNTRADE_{t-i} + \sum_{i=0}^{s} B_{4i} LNRUPRESS_{t-i}$$

$$+\sum_{i=0}^{t} B_{5i} LNFORESTXPT_{t-i} + \sum_{i=0}^{u} B_{6i} LNGDP_{t-i} + \sum_{i=0}^{v} B_{7i} LNGDP^2{}_{t-i} + \sum_{i=0}^{w} B_{8i} LNDEBT_{t-i}$$

$$+\sum_{i=0}^{x} B_{9i} LNAPI_{t-i} + \sum_{i=0}^{y} B_{10i} LNEXCH_{t-i} + B_{11i} PROPRIGHT_t + B_{12i} SAP + B_{13i} TREND \text{.........} \quad (6)$$

The Akaike Information Criterion (AIC) is used to determine the orders of the lags of the regression variables in the conditional ARDL model. From the conditional ARDL model, i.e. equation 6, the long run estimates of the variables are determined. For example, the formula for the long run co-efficient of LNURB is is given by:

$$\theta = \frac{\sum_{i=0}^{q1} B_{2i}}{1 - \sum_{i=1}^{p1} B_{1i}}$$

where p1 and q1 are the lag orders of LNDEF and LNURB respectively chosen by the Akaike Information Criterion (AIC). The long run coefficients of the other variables are determined in the same manner. In the third and final step of the ARDL Bounds Test cointegration procedure, the short-run dynamics associated with the long run estimates are obtained by constructing an error correction model (ECM) as:

$$\Delta LNDEF_t = c_0 + \sum_{i=1}^{a} c_{1i}\Delta LNDEF_{t-i} + \sum_{i=0}^{b} c_{2i}\Delta LNURB_{t-i} + \sum_{i=0}^{c} c_{3i}\Delta LNTRADE_{t-i}$$

$$+\sum_{i=0}^{d} c_{4i}\Delta LNRUPRESS_{t-i} + \sum_{i=0}^{e} c_{5i}\Delta LNFORESTXPT_{t-i} + \sum_{i=0}^{f} c_{6i}\Delta LNGDP_{t-i} + \sum_{i=0}^{g} c_{7i}\Delta LNGDP^2{}_{t-i}$$

$$+\sum_{i=0}^{h} c_{8i}\Delta LNAPI_{t-i} + \sum_{i=0}^{j} c_{9i}\Delta PROPRIGHT_{t-i} + \sum_{i=0}^{K} c_{10i}\Delta TREND_{t-1} + \sum_{i=0}^{l} c_{11i}\Delta SAP_{t-i}$$

$$+\sum_{i=0}^{m} c_{12i}\Delta LNEXCH_{t-i} + \Omega ecm_{t-1} \text{ ....} \quad (7)$$

where ecm_{t-1} is the error correction term, defined as:

$$ecm_t = LNDEF_t - B_0 - \sum_{i=1}^{p} B_{1i}LNDEF_{t-i} - \sum_{i=0}^{q} B_{2i}LNURB_{t-i} - \sum_{i=0}^{r} B_{3i}LBTRADE_{t-i}$$

$$-\sum_{i=0}^{s} B_{4i}LNRUPRESS_{t-i} - \sum_{i=0}^{t} B_{5i}LNFORESTXPT_{t-i} - \sum_{i=0}^{u} B_{6i}LNGDP_{t-i} - \sum_{i=0}^{v} B_{7i}LNGDP^2{}_{t-i}$$

$$-\sum_{i=0}^{w} B_{8i}LNDEBT_{t-i} - \sum_{i=0}^{x} B_{9i}LNAPI_{t-i} - \sum_{i=0}^{y} B_{10i}LNEXCH_{t-i} - B_{11i}PROPRIGHT - B_{12i}SAP - B_{13}TREND$$

The short run dynamics of the model's convergence to equilibrium are given by the coefficients of short-run equation, i.e. C_{mi} for m=1, 2…, 12, with the speed of adjustment to long run equilibrium given by Ω.

4.3.8 Diagnostic tests

Sensitivity analysis is undertaken by performing a number of standard time series econometric diagnostic tests on the Environmental Kuznets Curve (EKC) model estimated. The diagnostic tests carried out include tests for serial correlation, heteroscedasticity, normality test of the error term, model specification and model stability. Depending on the test being carried out the appropriate econometric package will be used, appropriateness here defined as the suitability of the package for the econometric test being carried out. Econometric packages used by the study include EVIEWS 4, STATA 11 and MICROFIT 4.1.

4.3.9 Determination of income turning point of EKC

After econometrically estimating the Environmental Kuznets curve, the study will attempt to graphically depict the Environmental Kuznets curve for deforestation in Ghana using data on GDP Per capita and rate of deforestation. Following from the econometric estimation and graphical depiction of the Environmental Kuznets curve for deforestation in Ghana, the income turning point of the EKC for deforestation will be estimated.

4.4 Conclusion

Annual time series data on Ghana from various data sources are used for the study. Due to its seeming advantages, the ARDL Bounds Testing approach to cointegration is chosen over conventional cointegration approaches such as the Johansen cointegration procedure and Engle Granger two step cointegration procedures to estimate the long and short run relationship between deforestation and its hypothesized causes. To ensure the applicability of the ARDL Bounds Testing procedure and also to avoid spurious regressions, the regression variables will tested for unit root using the Augmented Dickey Fuller (ADF) and the Phillips-Perron (PP) unit root tests. A graphical depiction of the empirical EKC and estimation of its turning point will be carried out.

CHAPTER FIVE

ECONOMETRIC ESTIMATIONS AND DISCUSSIONS OF RESULTS

5.0 Introduction

This chapter presents the results and discussions of econometric estimations of the EKC model discussed in chapter four. The chapter is organized in the following manner. In section 5.1, a preliminary analysis of the data used by the study is conducted. The preliminary analysis includes descriptive statistics, correlation analysis and tests for normality of the regression variables. Section 5.2 presents the results of the stationarity tests. Section 5.3 presents the results of the ARDL Bounds testing cointegration procedures. The long and short run coefficients of the EKC model are then estimated. Various diagnostic tests are applied to the EKC for deforestation model to ensure that it passes all the requisite post estimation econometric tests. Section 5.4 discusses and analyzes the estimation results within the Ghanaian economic framework and literature on deforestation studies. Finally, the study attempts to graphically display the Environmental Kuznets Curve (EKC) for deforestation in Ghana and determine its turning point. The chapter ends with a conclusion.

5.1 Preliminary data analysis

The preliminary data analysis comprises summary statistics of the data, correlation analysis and normality tests on the variables. The results of the preliminary data analysis are shown in appendix 2A, 2B and 2C. The summary statistics of the study data show that the average rate of deforestation in Ghana over the period 1970 to 2009 was approximately 1.4%, the maximum and minimum deforestation rates being 2.2% and 0.7% respectively. The skewness test confirms normality in distributions for all the regression variables except LNURB, LNTRADE and LNFOREST. The pair wise correlation matrix shows high correlations between some variables in excess of 0.8. However, Gujarati (2004:359) asserts that high zero order correlations are a sufficient but not a necessary condition for the existence of multicollinearity.

5.2 Results of stationarity tests

This study employs the Augmented Dickey Fuller (ADF) test and Phillips-Perron (PP) test in order to satisfy the requirement that the dependent variable is I(1) and none of the explanatory variables is I(2) or higher. This requirement is necessary as the ARDL cointegration procedure breaks down with the introduction of variables which are integrated of order I(2) or higher in the econometric model. Though not necessarily required, it is conventional to have a graphical time series display of the regression variables; a cursory look gives the researcher an idea, although not conclusive of the order of integration of the regression variables. Time series graphs of the regression variables in levels and first difference are presented in appendix 3. The time series graphs of the regression variables in appendix 3 depict that the regression variables are likely to be stationary in first difference rather than in levels.

Though the graphical display of the regression variables show that the regression variables are likely to be stationary in first difference, a formal test for Stationarity in the regression variables is appropriate. The results of the ADF and PP unit root tests are presented in Table 5.1. Given that the EKC model contains a trend, the ADF and PP unit root tests are conducted with trend and intercept.

Table 5.1: Results of ADF and PP Unit root tests

	AUGMENTED DICKEY FULLER (ADF) UNIT ROOT TEST	**PHILLIPS-PERRON UNIT ROOT TEST**
	ADF TEST STATISTIC	**ADJUSTED T STATISTIC**
VARIABLE	**Trend And Constant**	**Trend And Constant**
LNDEF	-1.85 [0] (0.6585)	-1.91 (0.6328)
ΔLNDEF	-.700 [0] (0.00)***	-7.06 (0.0000)***
LNGDP	-3.78 [9] (0.0321)**	-0.4644 (0.9812)
ΔLNGDP	-5.532[0] (0.00)***	-7.18174 (0.000)***
LNGDP2^{+}	-3.637647[9] (0.0433)**	-0.379 (0.9850)
ΔLNGDP2	-5.635238[0] (0.0002)***	-7.808926 (0.0000)***
LRUPRESS	-43483[7] (0.00)***	-2.7639 (0.2185)

ΔLNRUPRESS	-5.273[5] (0.00)***	-4.092 (0.013)**
LNFOREST	-1.7254[0] (0.7207)	-1.9078 (0.6314)
ΔLNFOREST	-5.7326[0] (0.00)***	-5.73261 (0.0002)***
LNAPI	-2.245[0] (0.4521)	2.140 (0.5082)
ΔLNAPI	-8.010[0] (0.00)***	-8.003118 (0.000)***
LNURB	-1.3379[4] (0.8614)	-1.85 (0.6606)
ΔLNURB	-4.853[0] (0.00)***	-4.871436 (0.0018)***
LNTRADE	-2.416[1] (0.3662)	-1.95294 (0.6079)
ΔLNTRADE	-4.5424[1] (0.00)***	-3.930 (0.0202)**
LNDEBT	-1.19[0] (0.8968)	-0.9154 (0.9439)
ΔLNDEBT	-6.87730] (0.00)***	-13.8851 (0.0000)***
LNEXCH	-2.033[1] (0.5646)	-1.6493 (0.7544)
ΔLNEXCH	-3.6955[1] (0.035)**	-3.43 (0.0623)**

+LNGDP2 is square of LNGDP

, ** and * above the test statistics indicate the statistical significance of the test statistics at 10%, 5% and 1 % respectively. Figures in parenthesis are p-values; whiles figures in square brackets are the lags of the ADF unit root test regression. 40 observations are used by the study for unit root testing. A maximum lag order of 9 was set for the ADF test according to the Schwert formula for determining the maximum lag order.*

The number of lags selected for the ADF test was selected automatically based on the Schwartz Criterion. In applying the Phillips-Perron test, the bandwidth was selected based on Newey-West. All the results for the unit root were obtained from the Eviews 4.1 econometric software. In both the ADF and PP test, the null hypothesis of non Stationarity is tested against the alternative of Stationarity.

The results of the unit root tests in Table 5.1 indicate that most of the variables are stationary in first difference. The order of integration of the regression variables chosen by the ADF and PP tests are displayed in Table 5.2.

Table 5.2: Order of Integration of the regression variables

Variable	**ADF UNIT ROOT TEST**	**PHILIPS PERRON(PP) UNIT ROOT TEST**
LNDEF	I(1)	I(1)
LNGDP	I(0)	I(1)
LNGDP2	I(0)	I(1)
LNRUPRESS	I(0)	I(1)
LNFOREST	I(1)	I(1)
LNAPI	I(1)	I(1)
LNURB	I(1)	(1)
LNTRADE	I(1)	I(1)
LNDEBT	I(1)	I(1)
LNEXCH	I(0)	I(0)

According to the results of the stationarity tests in table 5.2, the dependent variable, LNDEF is stationary in first difference and none of the regressors is integrated of order two or higher. The results of the stationarity tests therefore imply that ARDL cointegration procedure can be applied.

5.3 ARDL cointegration procedure

The ARDL or Bounds Testing co integration procedure is useful in testing the existence of long run relationships between level variables within a multivariate frame work. It can simultaneously estimate the long and short run components of the model. It can be applied irrespective of whether the regression variables are purely I(0), I (1) or mutually co integrated. The ARDL or Bounds Testing co integration procedure follows three steps:

- Testing the long run relationship between the level variables.
- Estimation of the long run coefficients of the variables
- Estimation of the short run coefficients of the variables

5.3.1 Testing for long run relationship

The testing of long run relationship between level variables in a multivariate framework using the ARDL or Bounds Testing co integration procedure requires the estimation of the Unrestricted Error Correction Model (UECM) or the error correction version of the autoregressive distributed lag (ARDL) model for the EKC for deforestation using Ordinary Least squares. The Bounds test cointegration approach, developed by Pesaran et al., (2001) is simply an F Test for the joint significance of the lagged level in the right hand side of the

UECM. To test for the long run relationship between the variables in Equation 2, the UECM, Equation 5 is estimated by OLS and the F Test for the joint significance of the lagged level variables is carried out. The maximum lag order of the ARDL model was set to one. The results of the long run cointegration test using a variable deletion test are shown in appendix 4. A summary of the results is however provided in Table 5.3. Critical values for the long run cointegration test are taken from Table CI (v), Case V with unrestricted trends and unrestricted intercept in Pesaran et al., (2001). The critical values for the bounds test are selected for K=10, where K is the number of regressors employed in the model.

The Bounds Test involves estimating equation 6 by OLS. To carry out the Bounds Test, equation 6 is estimated using Microfit 4.1 and the cointegration between the regression variables tested by employing a variable deletion test.

$$\Delta LNDEF_t = \alpha + \sum_{i=1}^{1} \lambda_{1i} \Delta LNDEF_{t-i} + \sum_{i=0}^{1} \lambda_{2i} \Delta LNURB_{t-i} + \sum_{i=0}^{1} \lambda_{3i} \Delta LNDEBT_{t-i} + \sum_{i=0}^{1} \lambda_{4i} \Delta LNTRADE_{t-i}$$

$$+ \sum_{i=0}^{1} \lambda_{5i} \Delta LNRUPRESS_t + \sum_{i=0}^{1} \lambda_{6i} \Delta LNFOREST_{t-i} + \sum_{i=0}^{1} \lambda_{7i} \Delta LNGDP_{t-i} + \sum_{i=0}^{1} \lambda_{8i} \Delta LNGDP^2{}_{t-i}$$

$$+ \sum_{i=0}^{1} \lambda_{9i} \Delta LNAPI_{t-i} + \sum_{i=0}^{1} \lambda_{10i} \Delta LNEXCH_{t-i} + \eta_1 SAP_t + \eta_2 PROPRIGHT_t + \delta_1 LNDEF_{t-1} + \delta_2 LNURB_{t-1}$$

$$+ \delta_3 LNTRADE_{t-1} + \delta_4 LNRUPRESS_{t-1} + \delta_5 LNFORESTXPT_{t-1} + \delta_6 LNGDP_{t-1} + \delta_7 LNGDP^2{}_{t-1}$$

$$+ \delta_8 LNAPI_{t-1} + \delta_9 LNDEBT_{t-1} + \delta_{10} LNEXCH_{t-i} + \varepsilon_t \quad \text{……………..} \ (6)$$

The ARDL Bounds Test F statistic tests the null hypothesis of no co integration given by:

H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 = \delta_9 = \delta_{10} = 0$. This null hypothesis is tested against the alternative of co integration given by:

H_1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq \delta_6 \neq \delta_7 \neq \delta_8 \neq \delta_9 \neq \delta_{10} \neq 0$

Table 5.3: RESULTS OF F-STATISTIC FOR TESTING THE EXISTENCE OF LONG RUN RELATIONSHIP BETWEEN REGRESSION VARIABLES

	K=10	
Computed ARDL F- Statistic	**9.7982**	
Bounds Tests Critical Values at 1 %	**Lower bound**	**2.84**
	Upper bound	**4.10**

From Table 5.3, it is observed that the ARDL F statistic of the cointegration test (9.7982) exceeds the upper bound critical value at 1% therefore the null hypothesis of no cointegration is rejected at 1%. The results of the long run cointegration test thus shows cointegration between LNDEF and the regressors in the model.

Since cointegration is established, the next stage in the ARDL cointegration procedure is to estimate the long and short run coefficients of the model.

5.3.2 Estimation of long run coefficients

The estimation of the long run coefficients of the model begins by estimating the dynamic or conditional ARDL specification of the EKC for deforestation model. The dynamic ARDL model is estimated using a maximum lag order of one by Microfit 4.1; the number of lags on each variable included in the dynamic ARDL is determined by Microfit 4.1 based on the Akaike Information Criterion (AIC). The dynamic ARDL model to be estimated in given by:

$$LNDEF_t = B_0 + \sum_{i=1}^{1} B_{1i} LNDEF_{t-i} + \sum_{i=0}^{1} B_{2i} LNURB_{t-i} + \sum_{i=0}^{1} B_{3i} LNTRADE_{t-i} + \sum_{i=0}^{1} B_{4i} LNRUPRESS_{t-i}$$

$$+\sum_{i=0}^{1} B_{5i} LNFORESTXPT_{t-i} + \sum_{i=0}^{1} B_{6i} LNGDP_{t-i} + \sum_{i=0}^{1} B_{7i} LNGDP^2{}_{t-i} + \sum_{i=0}^{1} B_{8i} LNDEBT_{t-i}$$

$$+\sum_{i=0}^{1} B_{5i} LNFORESTXPT_{t-i} + \sum_{i=0}^{1} B_{6i} LNGDP_{t-i} + \sum_{i=0}^{1} B_{7i} LNGDP^2{}_{t-i} + \sum_{i=0}^{1} B_{8i} LNDEBT_{t-i}$$

$$+\sum_{i=0}^{1} B_{9i} LNAPI_{t-i} + \sum_{i=0}^{1} B_{10i} LNEXCH_{t-i} + B_{11i} PROPRIGHT_t + B_{12i} SAP + B_{13i} TREND \ldots\ldots.. (7)$$

The result of the dynamic ARDL estimation is provided in Table 5.4.

Table 5.4: Autoregressive Distributed Lag Estimates.

ARDL(1,0,0,1,0,0,0,1,1) selected based on Akaike Information Criterion			
Dependent variable is LNDEF			
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LNDEF(-1)	.44836	.11003	4.0747[.001]
LNGDP	66.1857	15.4253	4.2907[.000]
LNGDP2	-5.8660	1.3743	-4.2683[.000]
LNURB	-.085926	.22331	-.38479[.704]
LNURB(-1)	.94181	.22578	4.1713[.000]
LNRUPRESS	.51158	.24094	2.1232[.045]
LNAPI	-1.1316	.18588	-6.0876[.000]
LNTRADE	.32117	.093580	3.4320[.002]
LNFOREST	-.096452	.044045	-2.1898[.039]
LNFOREST(-1)	.052251	.036965	1.4135[.172]
LNEXCH	-.11774	.061641	-1.9101[.069]
LNEXCH(-1)	-.12128	.060949	-1.9899[.059]
SAP	.17519	.094059	1.8626[.076]
PROPRIGHT	-.073305	.038826	-1.8880[.072]
LNDEBT	.0029240	.072491	.040337[.968]
INPT	-189.1282	43.5324	-4.3445[.000]
TREND	.11589	.020822	5.5655[.000]
R-Squared	.98773	R-Bar-Squared	.97881
S.E. of Regression	.058881	F-stat. F(16, 22)	110.7238[.000]
Mean of Dependent Variable	.33750	S.D. of Dependent Variable	.40452
Residual Sum of Squares	.076274	Equation Log-likelihood	66.2826
Akaike Info. Criterion	49.2826	Schwarz Bayesian Criterion	35.1423
DW-statistic	2.5820	Durbin's h-statistic	-2.5014[.012]

The estimated conditional ARDL model in table 5.4 provides the dynamic long run relation between deforestation and its hypothesized causes. From this conditional ARDL model the long run coefficients are derived.

5.3.3 Diagnostic tests

Post estimation time series diagnostic tests are carried out to ensure that the EKC model satisfies the classical linear regression model assumptions. The diagnostic tests include tests for serial correlation, heteroscedasticity, normality of the disturbance term and functional form misspecification. The diagnostic tests are carried out using Microfit 4.1 and presented in Table 5.5.

Table 5.5: Results of ARDL Diagnostic Tests

Test statistic	LM Version	F Version
A Serial correlation	CHI SQ (1) = 5.0418[.025]	F(1,21) =3.1179[.092]
B Functional form	CHI SQ (1) = 1.4046[.236]	F(1,21) = .78457[.386]
C Normality	CHI SQ (2) = .98114[.612]	Not applicable
D Heteroscedasticity	CHI SQ (1) = .96419[.326]	F(1,37) = .93793[.339]

Note:

A: Lagrange multiplier test of residual serial correlation

B: Ramsey's RESET test using the square of the fitted values

C: Based on a test of skewness and kurtosis of residuals

D: Based on the regression of squared residuals on squared fitted values

The null hypothesis for the serial correlation, functional form, normality and heteroscedasticity tests are no serial correlation, correct functional form, normally distributed residuals and homoscedasticity respectively. Given p-values of 0.092, 0.386 and 0.339 respectively, the null hypotheses of no serial correlation, correct functional form and homoscedasticity fail to be rejected at 5% level of significance. The results of the diagnostic tests thus reveal the absence of serial correlation and heteroscedasticity. The model is thus correctly specified with normally distributed residuals.

5.3.4 Stability tests

Stability of coefficients of regressors in a regression model is very important for long run policy analysis. Effective policy analysis requires model stability over the long run. To assess the stability of the EKC model over the study time period, the CUSUM (Cumulative Sum) and the CUSUMQ (Cumulative sum of squares) of recursive residuals tests are employed. The CUSUM (Cumulative Sum) and the CUSUMQ (Cumulative sum of squares) of recursive residuals tests are depicted graphically in figures 5.1 and 5.2.

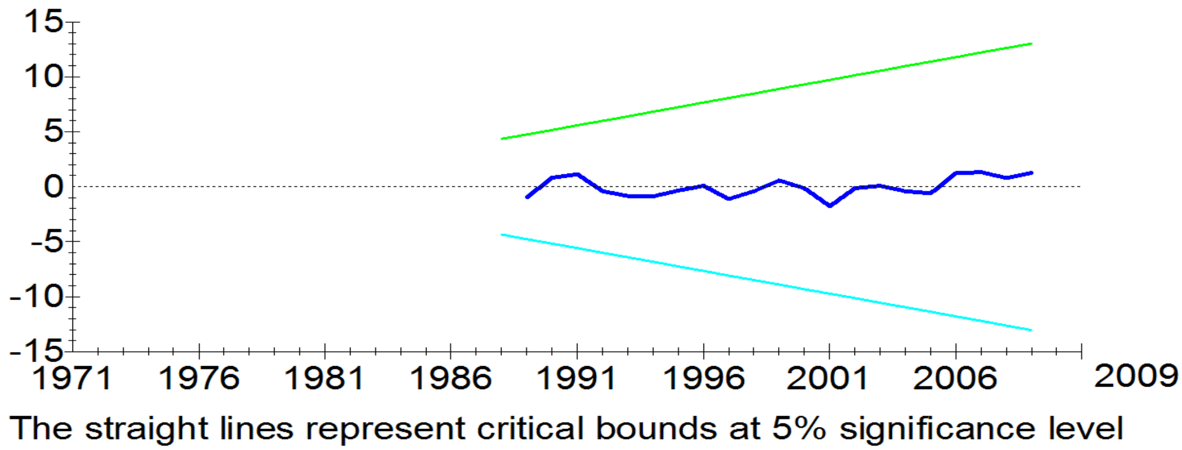

Figure 5.1: Plot of cumulative sum of square residuals

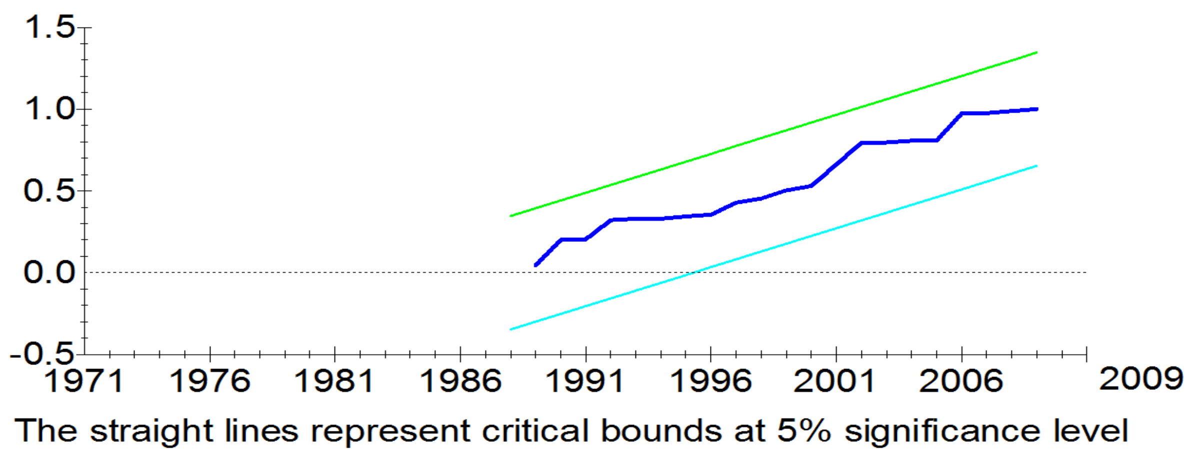

Figure 5.2: Plot of cumulative sum of squares of recursive residuals

From Figures 5.1 and 5.2, it is observed that the model appears stable and also correctly specified showing a significant and stable relationship among the variables in the model. This conclusion is drawn from the fact that neither the CUSUM (Figure 5.1) nor the CUMUSQ tests (Figure 5.1) exceeds the bounds of the 5% significance level (depicted by the two straight lines).

5.3.5 Discussion of Long run results

After establishing model stability and long run relationship among the variables in the EKC model, the long run coefficients of the EKC model are derived from the dynamic ARDL(1,0,0,1,0,0,0,1,1) model. The estimated long run coefficients generated using Microfit 4.1 are produced in Table 5.6.

As can be observed from Table 5.6, most of the long run coefficients of the regression variables have their expected theoretical signs and are statistically significant. Given that the EKC for deforestation model is expressed in logarithms, its coefficients can be interpreted in terms of elasticity. The results from Table 5.6 indicate that the long run coefficients of LNGDP and LNGDP2, 119.9802 and -10.6339 respectively, are statistically significant at 1% achieving the expected theoretical signs, thus validating the Environmental Kuznets Curve (EKC) hypothesis for deforestation in Ghana. The long run coefficients of LNGDP and LNGDP2 indicate that the deforestation rate in Ghana initially increases with per capita GDP up to a threshold of $280.90 and falls with further increases in per capita GDP, thus yielding an inverted "U" relationship between per capita GDP and deforestation in Ghana. The findings of this study, confirming an inverted "U" relationship between income and deforestation confirms the findings of Bhattarai and Hammig (2002), Croppper and Griffiths (1994) and Culas (2006).

Table 5.6: Estimated Long Run Coefficients Using the ARDL Approach.

ARDL(1,0,0,1,0,0,0,1,1) selected based on Akaike Information Criterion			
Dependent variable is LNDEF			
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
LNGDP	119.9802	30.5770	3.9239[.001]***
LNGDP2	-10.6339	2.7124	-3.9205[.001]***
LNURB	1.5515	.42291	3.6687[.001]***
LNRUPRESS	.92738	.48224	1.9231[.068]*
LNAPI	-2.0513	.51404	-3.9906[.001]***
LNTRADE	.58220	.21599	2.6955[.013]**
LNFOREST	-.080127	.091858	-.87230[.392]
LNEXCH	-.43329	.13705	-3.1616[.005]***
SAP	.31758	.18032	1.7612[.092]*
PROPRIGHT	-.13289	.074508	-1.7835[.088]*
LNDEBT	.0053007	.13134	.040359[.968]
INPT	-342.8483	86.6492	-3.9567[.001]***
TREND	.21008	.045890	4.5779[.000]***

, ** and * above the test statistics indicate the statistical significance of the test statistics at 10%, 5% and 1 % respectively. Figures in parenthesis are p-values*

The long run coefficient of rural population pressure is positive and significant at 10%, implying that all other factors of deforestation constant, a 1% increase (decrease) in rural population pressure will lead to a 0.92738% increase (decrease) in the rate of deforestation. This is consistent with the findings of Ehrhardt-Martinez et al., (2002), Shandra et al., (2008), Schneider (2010), Jorgenson (2006) and Cropper and Griffiths (1994). A Forestry

Outlook Study for Africa (FOSA) country report in 2001 on Ghana found that most of the rural population depended on the forests for their survival. The report indicated that for the significant majority of the rural population in Ghana, forests serve as a significant provider of food, clothing, shelter, furniture and bush meat. The implication is that the dependence of the Ghanaian rural population on forests for their economic livelihood is exerting significant pressures on the forests.

Not surprisingly, statistically significant evidence is found on the negative impact that the Structural Adjustment Program (SAP) has had on deforestation in Ghana. The positive long run coefficient of the SAP dummy, 0.3178 is statistically significant at 10% implying that the rate of deforestation in Ghana in the post SAP period is higher than in the pre SAP period. Specifically, the study finds post SAP deforestation rate to be 37.3799% higher than the pre SAP deforestation rate. The findings of this study on the impact of the SAP in Ghana is consistent with Codjoe and Dzanku (2009) who found that the rate of deforestation in Ghana was statistically and significantly higher in the post SAP period than in the pre SAP period. Codjoe and Dzanku (2009) found that post SAP deforestation rate in Ghana was 55.9% higher than in the pre SAP period. This study also confirms the findings of Kaimowitz & Thiele (1999) and Benhin & Barbier (1999) who found a positive impact of SAP on deforestation in Bolivia and Cameroun respectively.

Consistent with theory, the long run econometric estimations reveals that in the long run a 1% increase (decrease) in urbanization will lead to a 1.5515% increase (decrease) in the deforestation rate in Ghana. The finding on urbanization is consistent with the economic reasoning that increased urbanization will ultimately lead to increase in deforestation. The study supports the urbanization thesis of Ehrhardt –Martinez et al., (2002) and Marquart-Pyatt (2004); however, the inverted "U" relationship between urbanization and deforestation was not tested by the study. Wunder and Verbist (2003) assert that countries which have strong road building programs are more likely to have higher deforestation than countries which do not. This assertion by Wunder and Verbist (2003) clearly reflects the Ghanaian scenario.

The Forestry Outlook Study for Africa (FOSA) country report on Ghana (2001) found that the expansion of a unit increase in urban population required an additional 33.3 ha for the provision of additional housing, infrastructure and other social services. The FOSA report found that substantial parts of forest reserves were lost to infrastructural development during road construction, extension of electricity grids and other infrastructural development projects. The report further projected future road infrastructure program in Ghana to reduce the forest resource base, open up more places to migration encroachment and clearance of forests. Using urban population as a proxy for infrastructural development, Yiridoe and Nanang (2010) found a positive but statistically impact of infrastructural development on deforestation in Ghana.

The long run co-efficient of PROPRIGHT dummy, defined as state enforcement of property right and forest protection also has its expected theoretical sign, and is statistically significant at 10%. With a long run co- efficient of -0.13289, the study supports the findings of Bhattarai & Hammig (2002), Van & Azomahou (2007) and Culas (2006) that institutions for secure property rights and better environmental policies can significantly reduce the height of an Environmental Kuznets Curve relationship between income and deforestation.

Evidence on the negative impact of globalization on deforestation in Ghana is found. With a long run elasticity of 0.58220, a 1 % increase (decrease) in globalization will lead to a 0.58220 % increase (decrease) in the rate of deforestation in Ghana. This finding is consistent with Tsurumi and Managi (2010) who found that trade openness slows down deforestation in developed countries but not in developing countries.

The long run impact of technological change on deforestation is found to be positive. A 1% improvement in technological change in agriculture will have a long run impact of a 0.21008% increase in the rate of deforestation. According to Culas (2006), a technological change in agriculture may free up more resources for additional farming and clear more forest land if it is labour and / or capital saving. This result contrasts the findings of Culas (2006) and Bhattai and Hammig (2002) who found a negative impact of agricultural technological change on deforestation.

The ratio of total forest exports value to GDP measures the relative importance or contribution of forests to the economy of Ghana. Though the economic importance of forests in Ghana cannot be down played, its relative importance has been very low. For the sample period used by this study forest exports value as a percentage of GDP averaged 1.94%, with maximum and minimum values of 6.4% and 0.28% respectively. Appendix

5A shows that whiles the rate of deforestation in Ghana has shown an increasing trend, forest exports value as a percentage of GDP has shown volatility with a downward trend. A simulated graphical representation of the relation between deforestation and forest exports value as a percentage of GDP presented in Appendix 5B shows that initially deforestation increases with forest exports value up to a certain threshold and decline thereafter. In the long run, a 1% increase (decrease) in forest products exports reduces (increase) the deforestation rate by 0.080127%. The findings of this study on forest exports value as a percentage of GDP is consistent with Culas (2006) and Ehrhardt-Martinez et al., (2002). The findings of this study on forest products exports strongly support the conclusions of Brew (1998) and Aning (1999) who found a negative and statistically significant impact of exports of processed timber on deforestation in Ghana.

Contrasting with theory, Agricultural production index (API) is found to have a negative and statistically significant impact on deforestation in Ghana. Theoretically, the long run coefficient of LNAPI, -2.0513 is expected to be positive (Culas, 2006). This is in accord with the assertion that agricultural expansion into forest lands is very significant in influencing deforestation. Providing a foundation for the impact of agricultural expansion into forest lands, Bhattarai and Hammig (2002) asserted that the EKC hypothesis assumes implicitly that low income countries clear forests without any replacement. The negative coefficient of LNAPI from the estimation results can be explained by the various forest plantation programs that have been implemented in Ghana.

A national plantation project with the aim of planting up deforested lands was launched in 1970, with another plantation program launched in the northern and upper region in 1976.[46] A Country Environmental Analysis (CEA) report by the World Bank on Ghana in 2007 found forest plantation development to be a high priority to the Ghanaian government. The CEA report by World Bank (2007) found three separate plantation developments schemes currently in operation: The Forestry Commission's modified Taungya system, the Ministry of Lands and Forestry HIPC scheme, which implemented a forest plantation development program in 2003 and a program financed by the Forest Plantation Development Act, Act 583 of 2000 (World Bank, 2007: 33).

The long run impact of exchange rate on deforestation was found to be negative and statistically significant at 1%. From the long run results, a 1% depreciation (appreciation) in the exchange rate was found to reduce (increase) deforestation by 0.43329%. This finding is in sharp contrast with Codjoe and Dzanku (2009) who found a positive and statistically significant effect of exchange rate on deforestation in Ghana. The negative impact of exchange rate on deforestation in Ghana can perhaps be explained by the assertion by Arcand et al., (2002:7) that real exchange rate depreciation reduces deforestation "only when the depreciation is perceived as being permanent and when property rights and forest management practices are well established". The case of Ghana can be said to fit the scenario described by the assertion.

Finally, the long run result of the EKC model confirms the Debt resource hypothesis in Ghana. The study finds evidence, though not statistically that Ghana exploited its forest

[46] http://www.fao.org/forestry/country/18316/en/gha/

resources to service its external debts. The long run coefficient of total external debt, 0.0053007 is positive but statistically insignificant implying a weak confirmation of the Debt Resource Hypothesis in Ghana. This result is consistent with the findings of Bhattarai and Hammig (2002), Marquart-Pyatt (2004) and Culas (2004). The finding on the Debt Resource Hypothesis in Ghana is consistent with the findings of Codjoe and Dzanku (2009). Codjoe and Dzanku (2009) found that external debt had a positive but not significant impact on deforestation through logging in the long run. In explaining their result, they suggested that Ghana's debt servicing have tended to be financed through foreign exchange earnings from export crops rather than export of logs or timber.

5.3.6 Estimation and discussion of short run coefficients

After establishing the long run relationship between the variables and estimating the long run coefficients, the final stage in the ARDL Bounds testing procedure entails determination of the short run dynamics associated with the long run estimates of the variables in the model. This is achieved by estimating the Error Correction Model (ECM) representation of the ARDL (1,0,0,1,0,0,0,1,1) model. Table 5.7 provides the results of the ECM representation of the ARDL (1,0,0,1,0,0,0,1,1) model.

Table 5.7: ECM Representation for the Selected ARDL Model

ARDL(1,0,0,1,0,0,0,1,1) selected based on Akaike Information Criterion			
Dependent variable is dLNDEF			
Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dLNGDP	66.1857	15.4253	4.2907[.000]***
dLNGDP2	-5.8660	1.3743	-4.2683[.000]***
dLNURB	-.085926	.22331	-.38479[.704]
dLNRUPRESS	.51158	.24094	2.1232[.044]**
dLNAPI	-1.1316	.18588	-6.0876[.000]***
dLNTRADE	.32117	.093580	3.4320[.002]***
dLNFOREST	-.096452	.044045	-2.1898[.038]**
dLNEXCH	-.11774	.061641	-1.9101[.068]*
dSAP	.17519	.094059	1.8626[.074]*
dPROPRIGHT	-.073305	.038826	-1.8880[.071]*
dLNDEBT	.0029240	.072491	.040337[.968]
dINPT	-189.1282	43.5324	-4.3445[.000]***
dTREND	.11589	.020822	5.5655[.000]***
ecm(-1)	-.55164	.11003	-5.0133[.000]***

ecm = LNDEF -119.9802*LNGDP + 10.6339*LNGDP2 -1.5515*LNURB -.92738*LNRUPRESS + 2.0513*LNAPI -.58220*LNTRADE + .080127*LNFOREST + .43329*LNEXCH -.31758*SAP + .13289*PROPRIGHT -.0053007*LNDEBT + 342.8483*INPT -.21008*TREND

R-Squared	.76128	R-Bar-Squared	.58767
S.E. of Regression	.058881	F-stat. F(13, 25)	5.3968[.000]
Mean of Dependent Variable	.029645	S.D. of Dependent Variable	.091697
Residual Sum of Squares	.076274	Equation Log-likelihood	66.2826
Akaike Info. Criterion	49.2826	Schwarz Bayesian Criterion	35.1423
DW-statistic	2.5820		

, ** and * above the test statistics indicate the statistical significance of the test statistics at 10%, 5% and 1 % respectively. Figures in parenthesis are p-values*

From the short run dynamic of the model in Table 5.7, it can be observed that consistent with the long run results, all the short run coefficients of the regressors achieve the same signs as their long run coefficients with the exception of LNURB which has the opposite sign as compared to the long run, but is not statistically significant at 10%. Evidence from the short run dynamics of the EKC model indicates that the EKC for deforestation hypothesis is confirmed in the short run with the signs of LNGDP and LNGDP2 being positive and negative respectively, and statistically significant at 1%.

The short run dynamics of the EKC indicate that the impacts of a 1% increase (decrease) in LNRUPRESS and LNTRADE on the rate of deforestation are 0.51158 % and 0.32117% respectively. From the short run dynamics, a 1% increase (decrease) in LNAPI decreases (increases) deforestation by 1.1316%. Though the coefficient of LNDEBT is positive, it is not statistically significant at 10%. Evidence of the negative impact of the Structural Adjustment Program is found in the short run as the coefficient of the Structural Adjustment Program dummy is positive and statistically significant at 10% implying that the post SAP deforestation rate was higher than the pre SAP deforestation rate. The impacts of forest export value as a percentage of GDP and exchange rate are negative and statistically significant at 5% and 10% respectively.

Consistent with the long run results, state enforcement of forest protection and property rights reduce deforestation rate in the short run. The coefficient of the lagged error correction term, -.55164 is negative and highly significant. The implication of the error correction term, according to Afzal et al., (2010) is that in each time period, approximately

55.2% of shocks can be justified as a long run trend. The implication is that deviations in the deforestation rate away from the equilibrium are corrected by 55.2% within a year. The coefficient of the lagged error correction term being negative and significant at 1% provides a confirmation of the result of the Bounds Test for cointegration. The statistical significance of the lagged error correction at 1% supports the conclusion of cointegration between the variables in the long run EKC for deforestation model.

5.3.7 Estimation of income turning point of EKC

The study estimates the income turning point of the EKC for deforestation in Ghana. Kallbekken (2000) asserts that the income turning points EKCs have important policy implications. The EKC for deforestation hypothesis is depicted using the simple EKC which is expressed as:

$$LNDEF_t = \beta_0 + \beta_1 LNGDP_t + \beta_2 LNGDP^2{}_t + \varepsilon_t \quad \text{...(8)}$$

The income turning point of the simple EKC for deforestation occurs at $\frac{\partial LNDEF_t}{\partial LNGDP_t} = 0$.

Solving $\frac{\partial LNDEF_t}{\partial LNGDP_t} = 0$ yields $\beta_1 + 2\beta_2 LNGDP_t = 0$. From $\beta_1 + 2\beta_2 LNGDP_t = 0$, the income turning point of the simple EKC for deforestation model is derived by solving for $LNGDP_t$ .The income turning points of the simple EKC is then calculated as:

$$GDP = e^{\frac{-\beta_1}{2\beta_2}}.$$

Using STATA 11, the equation for the simple EKC for deforestation is given by:

$LNDEF_t = -23.2286 + 8.022513 LNGDP_t - 0.679886 LNGDP^2{}_t + \varepsilon_t$. This implies that β_1 =8.022513, β_2 = -0.679886 and e=2.7183. Solving for the income turning point of the simple EKC yields $GDP = e^{\frac{-8.022513}{(2^*-0.679886)}}$, which equals $364.99 with an associated deforestation rate of approximately 1.5%. The income turning point of the simple EKC is predicted to occur in 2011.[47]

Graphically, the simple EKC for deforestation in Ghana can be depicted by Figure 5.3. The simple EKC for deforestation is illustrated with the rate of deforestation measured on the vertical axis and per capita GDP measured on the horizontal axis. The simple EKC for deforestation in Ghana is generated by STATA 11 using a prediction of the quadratic relationship between the rate of deforestation and per capita GDP. The implication of the income turning point of the simple EKC for deforestation model is that deforestation will increase with per capita GDP up to a threshold of $364.99 (in constant 2000 $ US) and reduce with further increases in per capita GDP.

[47] See Appendix 5c

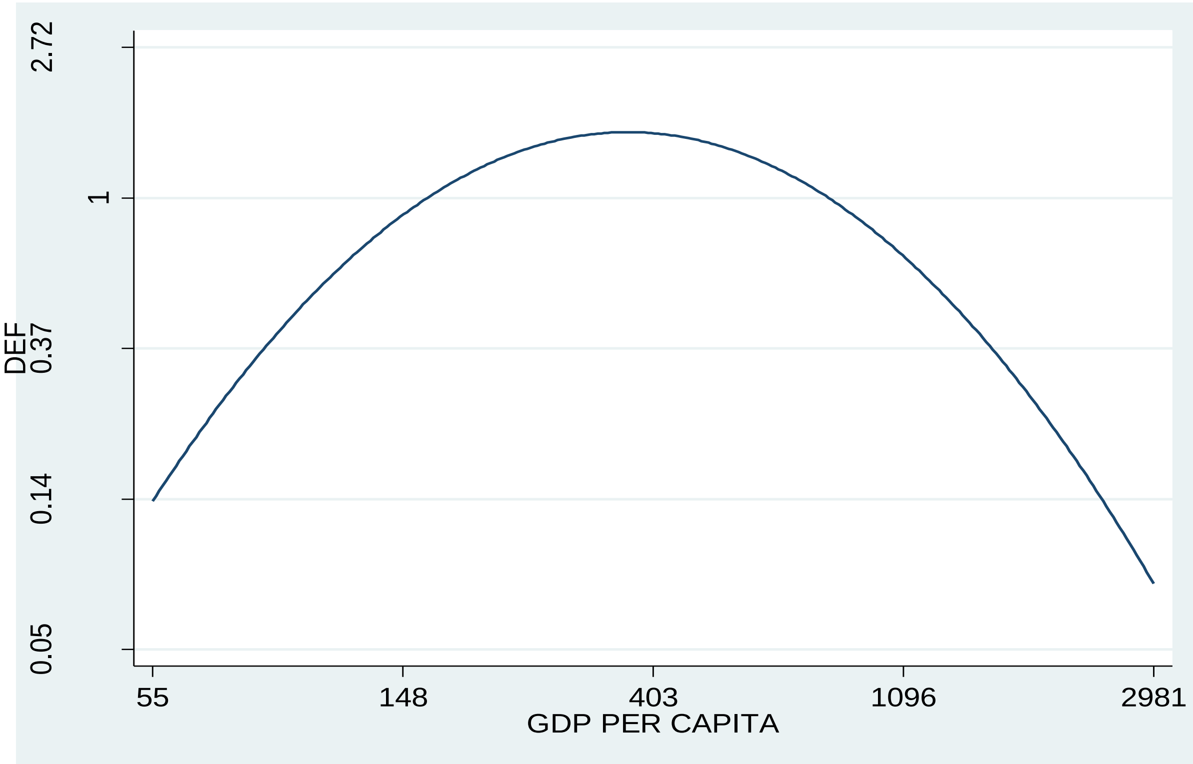

Figure 5.3: empirical Environmental Kuznets curve for deforestation in Ghana.

5.4 Conclusion

The long run estimation results from the study reveals a positive and significant effect of urbanization, rural population pressure, globalization, Structural Adjustment Program (SAP), and agricultural technology improvement on deforestation in Ghana. Agricultural production index, forest exports value as a percentage of GDP, enforcement of property right and forest protection, and exchange rate are found to have a negative and significant impact on deforestation in Ghana. The study found a positive but statistically insignificant impact of total external debt on deforestation implying a weak confirmation of the Debt Resource Hypothesis (DRH) in Ghana.

The short run estimation results reveal that the short run coefficients of the regressors achieve the same signs as their long run coefficients with the exception of LNURB which has the opposite sign as compared to the long run, but is not statistically significant at 10%.

The EKC for deforestation hypothesis is confirmed for Ghana, with an income turning point of $364.99 (in constant 2000 $US) corresponding to a deforestation rate of approximately 1.5%. The income turning point of the simple EKC for deforestation model is predicted to occur in the year 2011.

CHAPTER SIX

CONCLUSIONS AND POLICY RECOMMENDATIONS

6.0 Introduction

This chapter summarizes the whole study, draws out conclusions from the research questions and provides policy recommendations for the study based on the Environmental Kuznets Curve (EKC) for deforestation in Ghana. The chapter is organized in the following manner. Section 6.1 provides conclusions from the study. Section 6.2 provides policy recommendations based on the summary and conclusions. Finally, Section 6.3 draws out the limitations of the study.

6.1 Conclusions from the study

The Auto Regressive Distributed Lag (ARDL) Bounds Testing approach to cointegration revealed a long run relationship between deforestation and its hypothesized causes in Ghana. Stability of the long run EKC for deforestation is confirmed by the CUSUM and CUSUMQ tests.

The study found the long run coefficients of log of per capita GDP and its square to be 119.9802 and -10.6339 respectively, and statistically significant at 1%, thus validating the Environmental Kuznets Curve (EKC) hypothesis for deforestation in Ghana. The implication of the Environmental Kuznets Curve hypothesis for deforestation is that the deforestation rate in Ghana initially increases with per capita GDP up to a threshold of $364.99 (in constant 2000 $US), corresponding to a deforestation rate of 1.5% and falls with further increases in per capita GDP.

The study found post Structural Adjustment Program deforestation rate in Ghana to be 37.3799% higher than the pre Structural Adjustment Program deforestation rate. Rural population pressure was found to be positive and statistically significant at 10%, implying that all other factors influencing deforestation constant, a 1% increase (decrease) in rural population pressure will lead to a 0.92738% increase (decrease) in the rate of deforestation. Urbanization was also found to be positive and statistically significant at 1% with a long run elasticity of 1.5515.

Enforcement of property rights was found to be statistically significant in reducing deforestation at 10% level of significance. With a long run elasticity of 0.58220, the study found evidence on the negative impact of globalization on deforestation in Ghana.

The effect of agricultural activities on forests, proxied by the agricultural production index was found to have a negative and statistically significant impact on deforestation in Ghana. However, theoretically, the impact is expected to be positive as agricultural expansion into forest lands leads to forest clearing and influences deforestation. The negative impact of agricultural activities on forests can be explained by the various forest plantation programs that have been implemented in Ghana. These forest plantation programs, the study believes have muted the negative impacts of agricultural activities on deforestation in Ghana.

The long run results of the EKC model weakly confirms the Debt resource hypothesis in Ghana. The long run coefficient of total external debt, 0.0053007 is positive but statistically insignificant at 10% implying a weak confirmation of the Debt Resource Hypothesis in Ghana. The study therefore finds evidence, though not statistically that Ghana exploited its forest resources to service its external debts.

The long run impact of exchange rate on deforestation was found to be negative and statistically significant at 1% with an elasticity of 0.43329. This finding contrasts the findings of Codjoe and Dzanku (2009) who found a positive and statistically significant effect of exchange rate on deforestation in Ghana.

The short run dynamic error correction model revealed a negative and statistically significant lagged error correction term. The lagged error correction term, significant at 1% validates the long run relationship between deforestation and its hypothesized causes in Ghana.

6.2 Policy recommendations

The study confirms the EKC hypothesis for Ghana implying that deforestation will rise with per capita GDP to a threshold of $364.99 and falls with further increase in per capita GDP. A probable explanation for the EKC for deforestation is that logging initially increases with income but reduces later as the economy industrializes. Another probable reason is that the demand for fuel wood rises initially income, but falls over time as fuel wood is substituted for alternative and modern energy sources.

Given the confirmation of the inverted "U" relationship between deforestation and per capita GDP, the study cautions that it is not simplistic to assume that the economy will self correct in the long run. This implies that the ills of deforestation will not be necessarily corrected by economic growth in the long run. The study therefore recommends the implementation of economic policies designed to boost per capita GDP and project the economy to the decreasing side of the EKC, and well as the adoption of forestry policies to ensure secure property rights, forest protection and better environmental policies to ensure the effective mitigation of the repercussions of deforestation in Ghana.

Rural population pressure is found to have a positive impact on deforestation in Ghana. A probable explanation is that the dependence of the rural population on forests for fuel wood and also as a source of livelihood is exerting serious pressures of forests. To curb this situation, the study recommends that government should design policies to provide alternative rural non-farm income generating activities and also make alternative energy sources cheaper. The study believes that the provision of rural non-farm income generating activities will make agricultural and forestry activities more costly and reduce the dependence of the rural population on forests for their sustenance (Angelsen and Kaimowitz, 1999). The study expects that the provision of cheaper alternative energy sources reduce the dependence of the rural population on fuel wood for cooking and energy and thus reduce deforestation.

The study found agricultural expansion into forests to reduce deforestation in Ghana. A likely explanation is that the impacts of agricultural expansion on forests have been muted by forest plantation development programs that are currently being undertaken in the country. The study thus recommends the strengthening of current forest plantation development programs to reduce the impact of agricultural expansion activities and infrastructural development on forest lands. Tree planting exercise should be encouraged through environmental awareness campaigns. This will increase the awareness of Ghanaians on the ill effects of deforestation and hence strengthen forest conservation efforts.

Though the long and short run coefficients of total external debt are positive, they are not significant implying a weak confirmation of the Debt Resource Hypothesis (DRH). The study is therefore of the view that servicing of external debts by exploiting forest resources is not sustainable and recommends government to find alternative and sustainable means to service the external debts of Ghana.

Trade liberalization/Globalization has become a necessary tool for economic development. Integration of Ghana into the global village has benefited Ghana economically; however Ghana has not been spared the environmental consequences of globalization. The study found globalization to accelerate deforestation in Ghana. The impacts of globalization on deforestation could be traced to the increased trade in forest products that results from globalization. Given that isolating from globalization is practically impossible, the study recommends that the government must fully address the environmental consequences of globalization in order to benefit fully from globalization. The study recommends value addition to the country's forest products.

The study finds a negative impact of exchange rate on deforestation in Ghana. A probable explanation for the negative impact of exchange rate on deforestation in Ghana is the assertion by Arcand et al., (2002:7) that real exchange rate depreciation reduces deforestation "only when the depreciation is perceived as being permanent and when property rights and forest management practices are well established". The study is of the view that the case of Ghana fits the scenario described by the assertion. The study recommends that government should continue its macroeconomic goal of stabilizing the exchange rate as it has important implications for deforestation.

The long run estimation results of the study show that deforestation in Ghana is influenced by urbanization. Rural–urban migration and infrastructural developments such as roads, housing, stadia etc are likely to be responsible for the impact of urbanization on deforestation. The study recommends the developments of policies to address the rural - urban inequalities and thus reduce rural urban migration. The study also recommends that mechanisms should be put in place to ensure that the impacts of infrastructural developments on forest are mitigated.

Timber processing has been found to be very significant in reducing deforestation in Ghana (Brew, 1998). Brew (1998) recommended an intensification of the education on the importance of timber processing on deforestation in Ghana as timber processing for export is undertaken by large firms who through their sophisticated machines reduce wastes, recover a greater percentage of the timber and rely less on forest for their raw materials. It is hereby recommended that timber processing for export should be encouraged to reduce deforestation in Ghana.

6.3 Practical limitations of the study

The study has some limitations. The limitations largely have to do with the unavailability and insufficiency of data on some variables which were considered very useful to the study. These variables include school enrollment which measures environmental awareness and service sector employment which measures service sector dominance. Thus, time series data on school enrollment and service sector employment for the time period considered by the study was insufficient.

Another limitation of the EKC study has to do with the fact that the existence of the inverted "U" relationship between deforestation and per capita GDP does not necessarily provide a concrete explanation of the relationship between deforestation and economic development. The study implicitly assumed an inverted "U" shaped relationship between deforestation and per capita GDP. The shape of the EKC is however shrouded in controversy as some researchers have asserted to an inverted "N" or "N" shaped relationship between deforestation and per capita GDP. Given the controversies regarding the shape of the EKC model, policy makers are advised to be circumspect in deriving deforestation ameliorating policies from the EKC hypothesis.

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APPENDIX 1

STUDY DATA SET USED FOR ECONOMETRIC ESTIMATIONS

YEAR	LNDEF	LNGDP	LNGDP2	LNURB	LNRUPRESS	LNAPI
1970	-0.35668	5.675879879	32.2156124	1.469575	3.15717047	3.73767
1971	-0.35667	5.700409705	32.49467081	1.220066	3.382620323	3.78419
1972	-0.35667	5.646611553	31.88422203	1.283925	3.442227192	3.7612
1973	-0.35668	5.646019958	31.87754136	1.294022	3.463206751	3.78419
1974	-0.10536	5.685224858	32.32178168	1.237344	3.435746743	3.89182
1975	-0.10536	5.528695043	30.56646888	1.135115	3.343216481	3.850148
1976	-0.10536	5.472844355	29.95202534	1.000377	3.247499219	3.73767
1977	-0.10536	5.478167213	30.01031602	0.891721	3.164623004	3.610918
1978	-0.10537	5.542730529	30.72186172	0.874331	3.130691619	3.583519
1979	-0.10536	5.497721402	30.22494061	0.980757	3.230293312	3.637586
1980	4.83E-06	5.478212522	30.01081244	1.140746	3.366306612	3.637586
1981	-2.6E-06	5.413157999	29.30227952	1.392128	3.453878582	3.637586
1982	0.016544	5.308098885	28.17591377	1.482316	3.491827274	3.555348
1983	-0.02956	5.226151137	27.31265571	1.522675	3.539436599	3.555348
1984	-0.0198	5.274429432	27.81960583	1.507583	3.49873563	3.828641
1985	-0.00995	5.291571238	28.00072616	1.456488	3.453240679	3.806662
1986	0	5.312215818	28.21963689	1.631081	3.293117038	3.871201
1987	0.233194	5.33081707	28.41761063	1.58623	3.229902721	3.89182
1988	0.245901	5.358386561	28.71230653	1.555787	3.184456056	3.912023
1989	0.354081	5.3808062	28.95307536	1.547364	3.189183215	4.007333
1990	0.755548	5.385710988	29.00588285	1.553067	3.194843333	3.806662
1991	0.602124	5.408612063	29.25308445	1.582998	3.184231659	4.204693
1992	0.61169	5.417775913	29.35229585	1.581562	3.198319473	4.189655
1993	0.634739	5.436328614	29.5536688	1.571837	3.199918624	4.276666
1994	0.653784	5.440615869	29.60030103	1.550955	3.184417052	4.219508
1995	0.6732	5.453703699	29.74288404	1.522561	3.121368331	4.356709
1996	0.692999	5.472516136	29.94843286	1.514007	3.02921967	4.442651
1997	0.713199	5.488298865	30.12142443	1.486699	2.93515308	4.418841
1998	0.733815	5.509581408	30.35548729	1.463255	2.876986883	4.51086
1999	0.754865	5.528410689	30.56332475	1.445558	2.848019201	4.574711
2000	0.776368	5.540764626	30.70007264	1.431848	2.819000295	4.59512
2001	0.638515	5.556209524	30.87146428	1.408571	2.808639967	4.624973
2002	0.657633	5.576717611	31.09977931	1.3949	2.775694234	4.727388
2003	0.677124	5.604255356	31.4076781	1.379106	2.750550873	4.762174
2004	0.697002	5.636062592	31.76520154	1.36019	2.73889327	4.795791

2005	0.717284	5.671245785	32.16302876	1.339445	2.696488406	4.836282
2006	0.737985	5.711696672	32.62347887	1.306901	2.662401931	4.844187
2007	0.759124	5.753188588	33.09917893	1.287437	2.616374453	4.820282
2008	0.787628	5.813359417	33.79514771	1.27181	2.555154797	4.751381
2009	0.799474	5.838270999	34.08540826	1.261269	2.516395786	4.772793

STUDY DATA SET USED FOR ECONOMETRIC ESTIMATIONS (CONT'D)

YEAR	LNTRADE	LNFOREST	LNEXCH	SAP	PROPRIGHT
1970	3.7846	0.573779106	-9.190683445	0	1
1971	3.58343	0.412677062	-9.176621663	0	1
1972	3.581204	0.877356595	-8.92315233	0	0
1973	3.633477	1.615247584	-9.058157065	0	0
1974	3.692072	1.066618734	-9.071116209	0	0
1975	3.631871	0.976333107	-9.071116209	0	0
1976	3.458101	0.942931544	-9.071116209	0	0
1977	3.093057	0.794567433	-9.071116209	0	0
1978	2.892937	0.523173505	-8.643532317	0	0
1979	3.108788	0.043745957	-8.199277239	0	0
1980	2.869098	-0.133422011	-8.199277239	0	1
1981	2.310457	-0.819837123	-8.199277239	0	1
1982	1.843773	-1.281924065	-8.199277239	0	0
1983	2.446244	-1.07120783	-7.032725968	0	0
1984	2.934635	-0.907778173	-5.627742851	1	0
1985	3.188163	-0.526715718	-5.215157587	1	0
1986	3.603095	-0.371581489	-4.719950401	1	0
1987	3.825335	0.58727265	-4.175658651	1	0
1988	3.743498	0.654880321	-3.900899871	1	0
1989	3.715664	0.377985667	-3.612456192	1	0
1990	3.754858	0.625318003	-3.422963904	1	0
1991	3.749229	0.473848241	-3.303255011	1	0
1992	3.828502	0.836358461	-3.130746654	1	0
1993	4.03723	0.894994413	-2.735351705	1	1
1994	4.127475	1.855742744	-2.347914744	1	1
1995	4.050447	0.973845245	-2.120981519	1	1
1996	4.279509	0.78608082	-1.810653844	1	1
1997	4.447368	0.716971346	-1.58573956	1	1
1998	4.389493	0.634741944	-1.464619642	1	1

1999	4.403116	0.886029777	-1.321844697	1	1
2000	4.754008	1.019743087	-0.607117796	1	1
2001	4.700897	0.962455529	-0.333649005	1	1
2002	4.579742	0.876620639	-0.232667404	1	1
2003	4.577667	0.807755665	-0.142988166	1	1
2004	4.601868	0.679315054	-0.105921947	1	1
2005	4.586716	0.49005745	-0.098408106	1	1
2006	4.188488	0.358059363	-0.087245834	1	1
2007	4.17982	0.311331807	-0.066943709	1	1
2008	4.24153	0.097932207	0.056246424	1	1
2009	4.274567	0.182259298	0.342738278	1	1

STUDY DATA SET USED FOR ECONOMETRIC ESTIMATIONS (CONT'D)

YEAR	POLICY	LNDEBT
1970	0	20.16359
1971	0	20.11777
1972	0	20.21979
1973	0	20.44295
1974	0	20.44671
1975	0	20.41535
1976	0	20.38459
1977	0	20.78776
1978	0	20.96907
1979	0	20.97206
1980	0	21.06099
1981	0	21.1543
1982	0	21.11816
1983	0	21.23365
1984	0	21.39591
1985	0	21.53121
1986	0	21.73363
1987	0	21.91246
1988	0	21.84052
1989	0	21.9155
1990	0	22.04084
1991	0	22.14793

1992	0	22.16748
1993	0	22.24391
1994	0	22.35273
1995	1	22.42708
1996	1	22.479
1997	1	22.46588
1998	1	22.56554
1999	1	22.58267
2000	1	22.53416
2001	1	22.57056
2002	1	22.66368
2003	1	22.74731
2004	1	22.67673
2005	1	22.63013
2006	1	21.8814
2007	1	22.21918
2008	1	22.31809
2009	1	22.46722

APPENDIX 2A

REGRESSION DATA SUMMARY STATISTICS

tabstat lndef lngdp lngdp2 lnurb,stats (mean max min variance sd kurtosis skewness count cv)

```
   stats |     lndef     lngdp    lngdp2     lnurb
---------+----------------------------------------
    mean |   .320141  5.512287  30.40753   1.37309
     max |  .7994744  5.838271  34.08541  1.631081
     min | -.3566838  5.226151  27.31266  .8743306
variance |  .1714917   .022795   2.78804   .038084
      sd |  .4141155  .1509802  1.669743  .1951512
kurtosis |  1.437685  2.385033  2.415377  3.340935
skewness | -.2717254  .2242967     .2783 -1.017013
       N |        40        40        40        40
      cv |  1.293541  .0273898  .0549121  .1421256
```

tabstat lnrupress lnapi lntrade lnexch lnforest,stats (mean max min variance sd kurtosis skewness count cv)

```
   stats |  lnrupr~s     lnapi   lntrade    lnexch  lnforest
---------+--------------------------------------------------
    mean |  3.110236  4.140345  3.767301 -4.321958  .4700891
     max |  3.539437  4.844187  4.754008  .3427383  1.855743
     min |  2.516396  3.555348  1.843773 -9.190683 -1.281924
variance |  .0865503   .200405  .4732951  12.62997  .4550697
      sd |  .2941943  .4476662  .6879645  3.553867  .6745885
kurtosis |  2.037205  1.557505  3.262344  1.460529  3.703222
skewness | -.4389648  .3002744 -.7919743 -.1973159 -.8683762
       N |        40        40        40        40        40
      cv |   .094589  .1081229  .1826147 -.8222817  1.435023
```

tabstat lndebt sap propright,stats (mean max min variance sd kurtosis skewness count cv)

```
   stats |    lndebt       sap  propri~t
---------+------------------------------
    mean |  21.69994       .65      .525
     max |  22.74731         1         1
     min |  20.11777         0         0
variance |  .7194234  .2333333  .2557692
      sd |  .8481883  .4830459  .5057363
kurtosis |  1.874332  1.395604  1.010025
skewness | -.5224677 -.6289709 -.1001252
       N |        40        40        40
      cv |  .0390871  .7431475  .9633073
```

APPENDIX 2B

PAIRWISE CORRELATIONS BETWEEN REGRESSION VARIABLES

pwcorr lndef lngdp lngdp2 lnurb lnrupress lnapi lntrade lnforest lnexch sap propright policy lndebt,sig

	lndef	lngdp	lngdp2	lnurb	lnrupr~s	lnapi	lntrade
lndef	1.0000						
lngdp	0.1839	1.0000					
	0.2561						
lngdp2	0.1832	0.9999	1.0000				
	0.2579	0.0000					
lnurb	0.3987	-0.4376	-0.4345	1.0000			
	0.0108	0.0047	0.0051				
lnrupress	-0.7841	-0.6245	-0.6245	0.0408	1.0000		
	0.0000	0.0000	0.0000	0.8027			
lnapi	0.8592	0.5323	0.5320	0.2133	-0.9068	1.0000	
	0.0000	0.0004	0.0004	0.1864	0.0000		
lntrade	0.7100	0.5086	0.5045	0.2156	-0.7761	0.8560	1.0000
	0.0000	0.0008	0.0009	0.1814	0.0000	0.0000	
lnforest	0.2498	0.3924	0.3827	-0.0922	-0.2888	0.3305	0.6670
	0.1200	0.0123	0.0148	0.5716	0.0707	0.0372	0.0000
lnexch	0.9479	0.2333	0.2345	0.4388	-0.8301	0.9215	0.7740
	0.0000	0.1473	0.1452	0.0046	0.0000	0.0000	0.0000
sap	0.8401	-0.0450	-0.0434	0.6251	-0.5964	0.7352	0.6800
	0.0000	0.7829	0.7902	0.0000	0.0000	0.0000	0.0000
propright	0.5716	0.5174	0.5150	0.0998	-0.6584	0.6999	0.5788
	0.0001	0.0006	0.0007	0.5402	0.0000	0.0000	0.0001
policy	0.7595	0.5092	0.5083	0.0743	-0.8716	0.9029	0.7408
	0.0000	0.0008	0.0008	0.6487	0.0000	0.0000	0.0000
lndebt	0.9419	0.0090	0.0087	0.5004	-0.7068	0.8051	0.6594
	0.0000	0.9563	0.9575	0.0010	0.0000	0.0000	0.0000

	lnforest	lnexch	sap	propri~t	policy	lndebt
lnforest	1.0000					
lnexch	0.1973	1.0000				
	0.2222					
sap	0.1622	0.9051	1.0000			
	0.3174	0.0000				
propright	0.2026	0.5897	0.3516	1.0000		
	0.2100	0.0001	0.0261			
policy	0.2118	0.8130	0.5684	0.7368	1.0000	
	0.1895	0.0000	0.0001	0.0000		
lndebt	0.1451	0.9516	0.8957	0.5155	0.7232	1.0000
	0.3718	0.0000	0.0000	0.0007	0.0000	

APPENDIX 2C

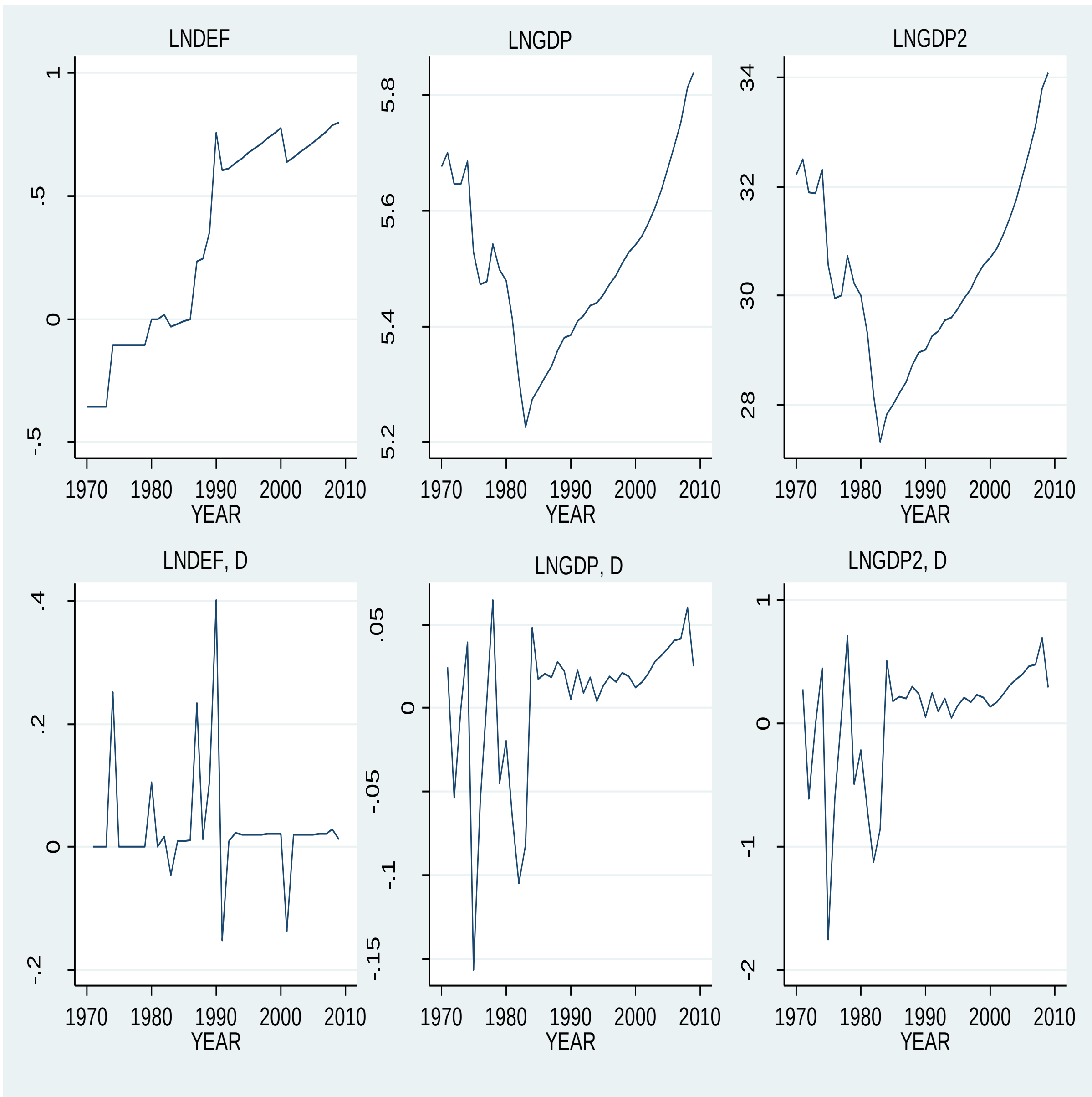
SKEWNESS/KURTOSIS TESTS FOR NORMALITY

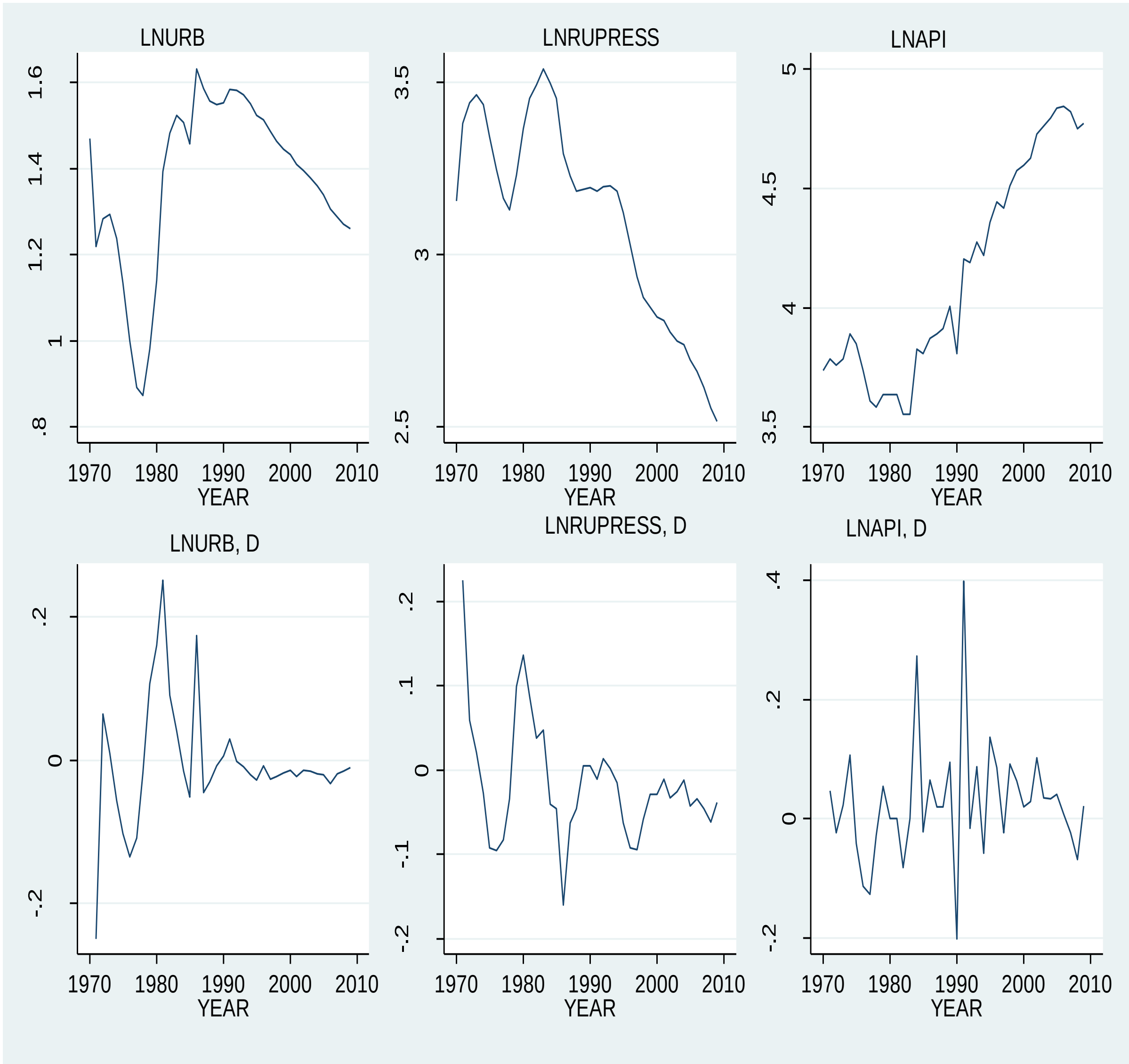
sktest lndef lngdp lngdp2 lnurb lnrupress lnapi lntrade lnforest lnexch sap propright policy lndebt

				joint	
Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
lndef	40	0.4301	0.0000	25.99	0.0000
lngdp	40	0.5134	0.4620	1.02	0.6018
lngdp2	40	0.4192	0.5092	1.14	0.5641
lnurb	40	0.0082	0.3567	7.02	0.0299
lnrupress	40	0.2100	0.0706	4.81	0.0902
lnapi	40	0.3844	0.0000	16.75	0.0002
lntrade	40	0.0319	0.4101	5.15	0.0763
lnforest	40	0.0203	0.1864	6.51	0.0386
lnexch	40	0.5646	0.0000	23.55	0.0000
sap	40	0.0802	0.0000	32.53	0.0000
propright	40	0.7691	.	.	.
policy	40	0.1442	0.0000	60.81	0.0000
lndebt	40	0.1399	0.0122	7.47	0.0239

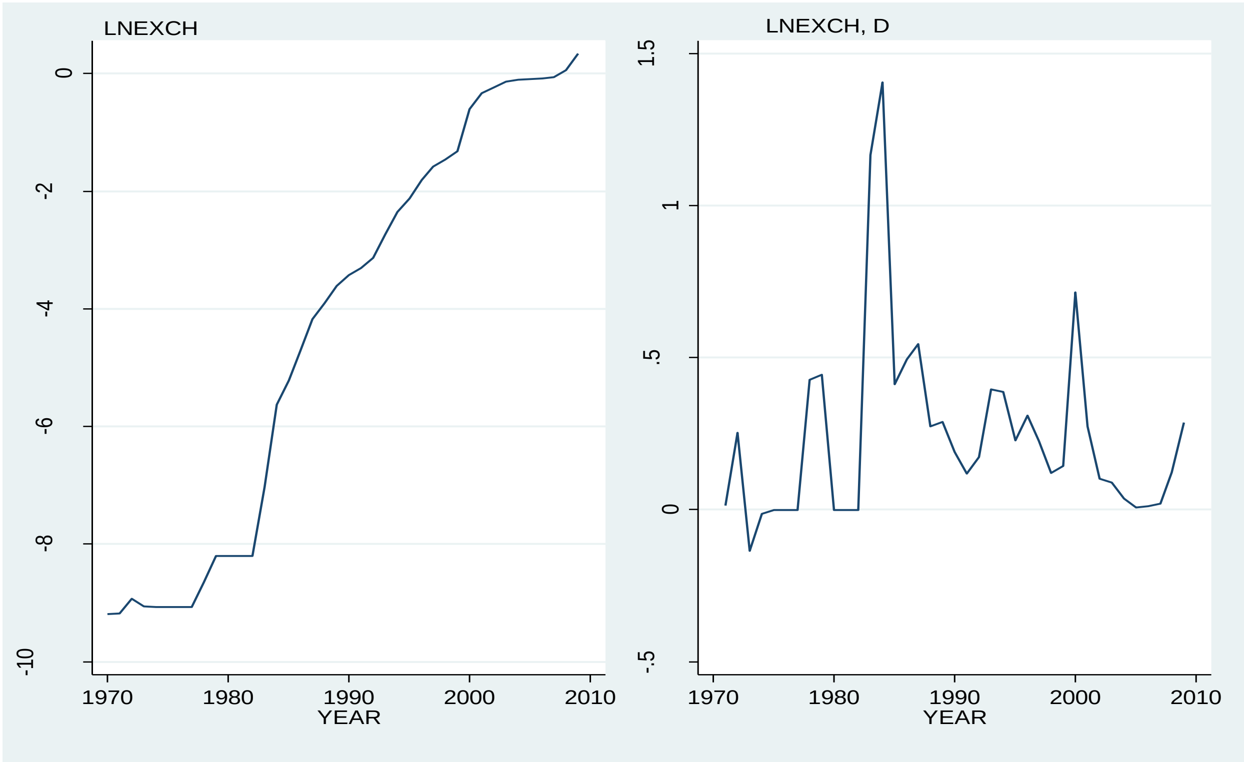
APPENDIX 3

GRAPHS OF REGRESSION VARIABLES IN LEVEL AND FIRST DIFFERENCE




LNURB
LNRUPRESS
LNAPI
LNURB, D
LNRUPRESS, D
LNAPI, D
YEAR
1970
1980
1990
2000
2010
.8
1
1.2
1.4
1.6
2.5
3
3.5
4
4.5
5
-.2
-.1
0
.1
.2
.4

LNDEBT
LNTRADE
LNFOREST
LNDEBT. D
LNTRADE, D
LNFOREST, D
YEAR
1970 1980 1990 2000 2010



DEFINITIONS

LNDEF,D =First difference of LNDEF

LNGDP,D =First difference of LNGDP

LNGDP,D = First difference of LNGDP2

LRUPRESS,D =First difference of LNRUPRESS

LNFOREST,D =First difference of LNFOREST

LNAPI,D =First difference of LNAPI

LNURB,D = First difference of LNURB

LNTRADE,D =First difference of LNTRADE

LNDEBT,D =First difference of LNDEBT

LNEXCH,D **=**First difference of LNEXCH

APPENDIX 4

VARIABLE DELETION TEST

Variable Deletion Test (OLS case)

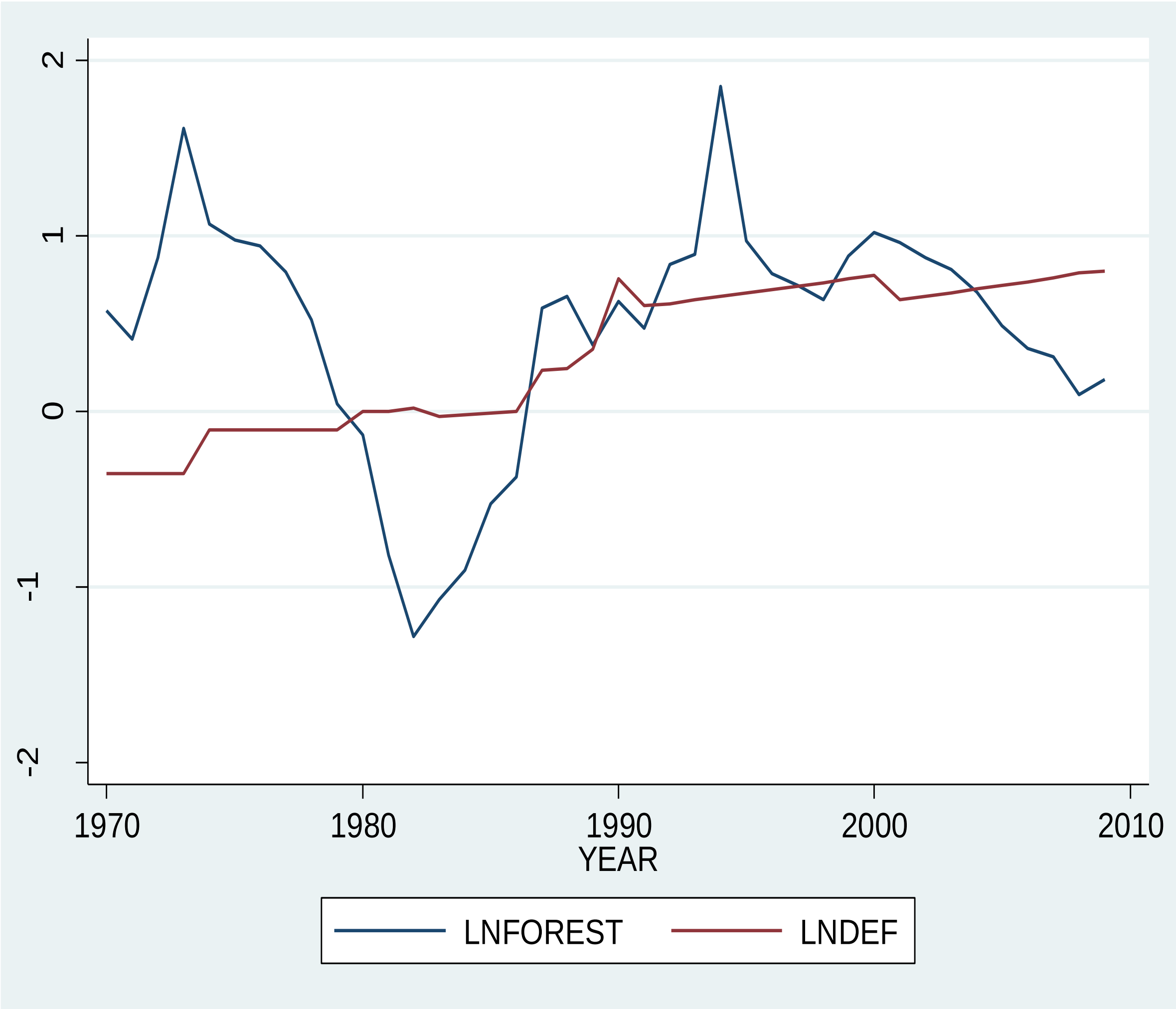
```
*******************************************************************************
 Dependent variable is DLNDEF
 List of the variables deleted from the regression:
 LNDEF(-1)       LNGDP(-1)       LNGDP2(-1)      LNURB(-1)       LNRUPRESS(-1)
 LNAPI(-1)       LNTRADE(-1)     LNFOREST(-1)    LNEXCH(-1)      LNDEBT(-1)
 38 observations used for estimation from 1972 to 2009
*******************************************************************************
```

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
INPT	.25401	.075609	3.3595[.004]
DLNDEF(-1)	-.18976	.19948	-.95123[.357]
DLNGDP	17.2450	29.0584	.59346[.562]
DLNGDP(-1)	-9.7800	29.2999	-.33379[.743]
DLNGDP2	-1.4649	2.6158	-.56003[.584]
DLNGDP2(-1)	.94225	2.6336	.35778[.725]
DLNURB	-.47779	.31111	-1.5357[.145]
DLNURB(-1)	.74188	.29912	2.4802[.025]
DLNRUPRESS	.57501	.42703	1.3465[.198]
DLNRUPRESS(-1	.28259	.48503	.58264[.569]
DLNAPI	-.87682	.22424	-3.9103[.001]
DLNAPI(-1)	-.40996	.25106	-1.6329[.123]
DLNTRADE	.20092	.12647	1.5887[.133]
DLNTRADE(-1)	.13606	.15831	.85944[.404]
DLNFOREST	-.11228	.050175	-2.2378[.041]
DLNFOREST(-1)	-.064811	.053881	-1.2029[.248]
DLNEXCH	-.090319	.13984	-.64585[.528]
DLNEXCH(-1)	-.18961	.098632	-1.9224[.074]
DLNDEBT	-.059358	.10604	-.55978[.584]
DLNDEBT(-1)	-.057664	.095516	-.60372[.555]
TREND	-.014409	.0081780	-1.7620[.098]
SAP	.30915	.15492	1.9956[.064]
PROPRIGHT	.3554E-4	.067363	.5275E-3[1.00]

```
*****************************************************************************
 Joint test of zero restrictions on the coefficients of deleted variables:

 Lagrange Multiplier Statistic     CHSQ(10)=  36.1550[.000]

 Likelihood Ratio Statistic        CHSQ(10)= 114.9546[.000]

 F Statistic                    F( 10,   5)=   9.7982[.011]
*****************************************************************************
```

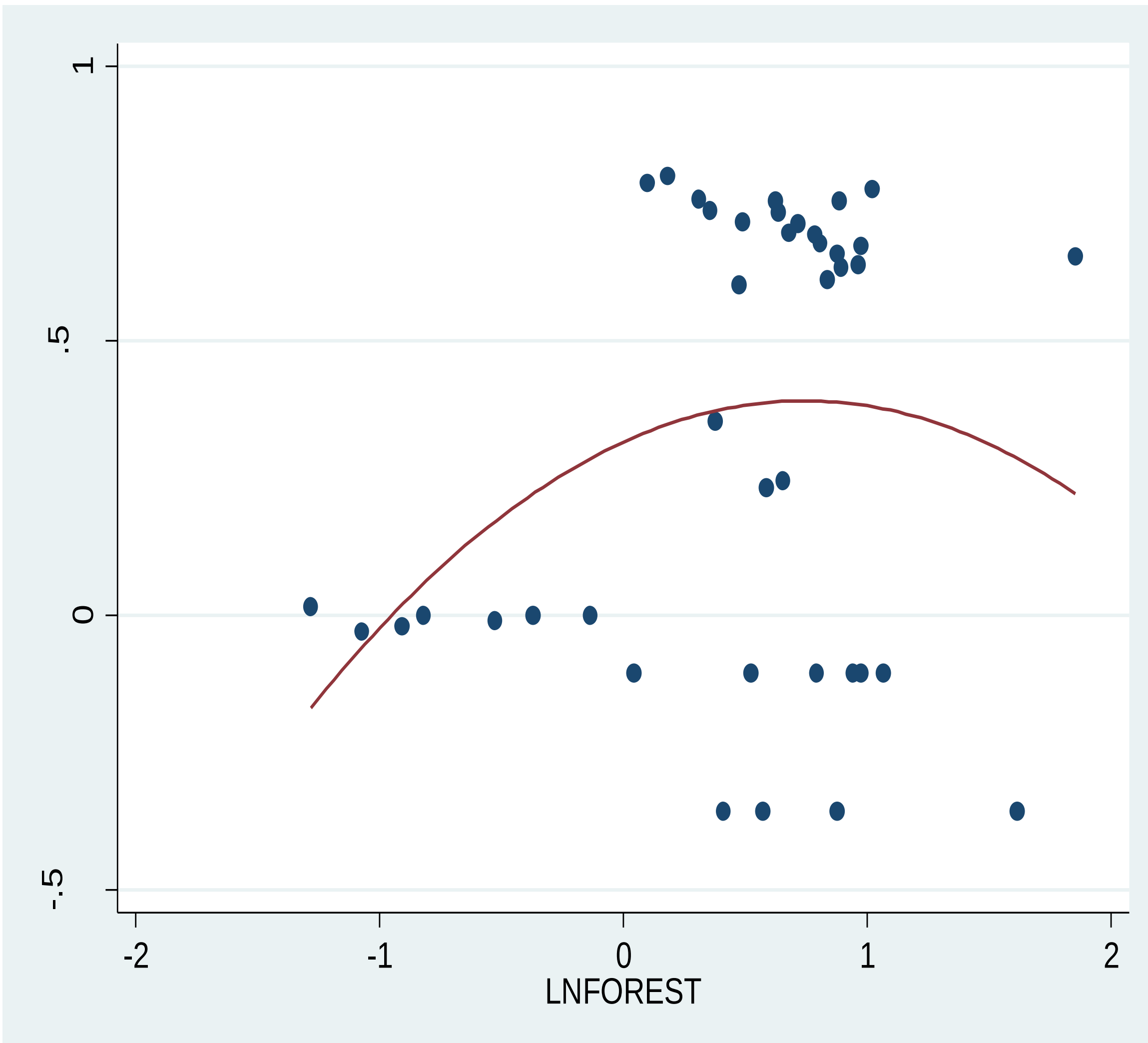
APPENDIX 5A

TIME SERIES PLOT OF LNFOREST AND LNDEF



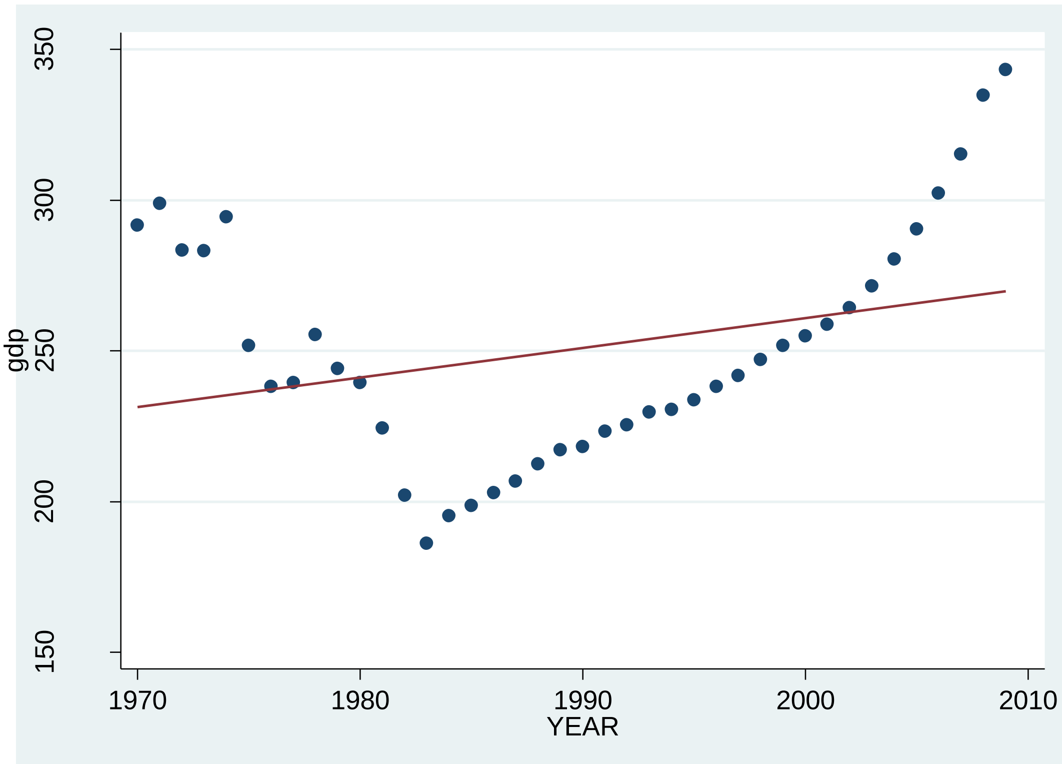
APPENDIX 5B

QUADRATIC PREDICTION OF THE RELATIONSHIP BETWEEN DEFORESTATION AND FOREST EXPORT VALUE AS A PERCENTAGE OF GDP IN GHANA



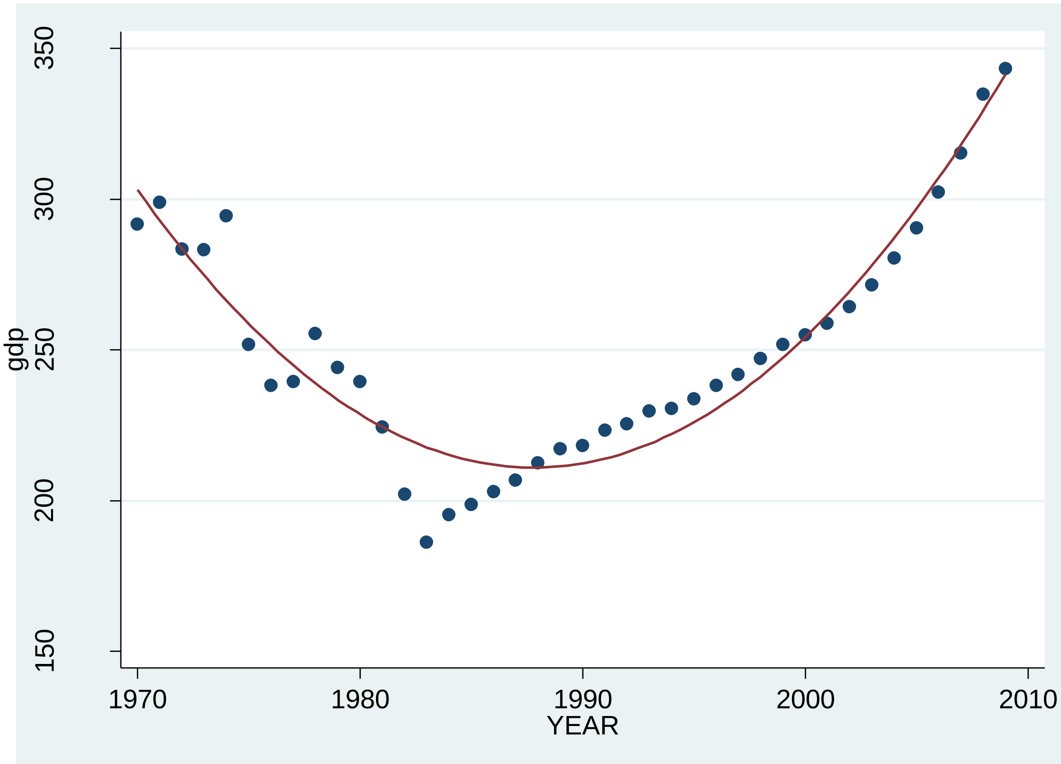
APPENDIX 5C

LINEAR AND QUADRATIC TRENDS IN GDP



Time series plot of GDP with linear prediction

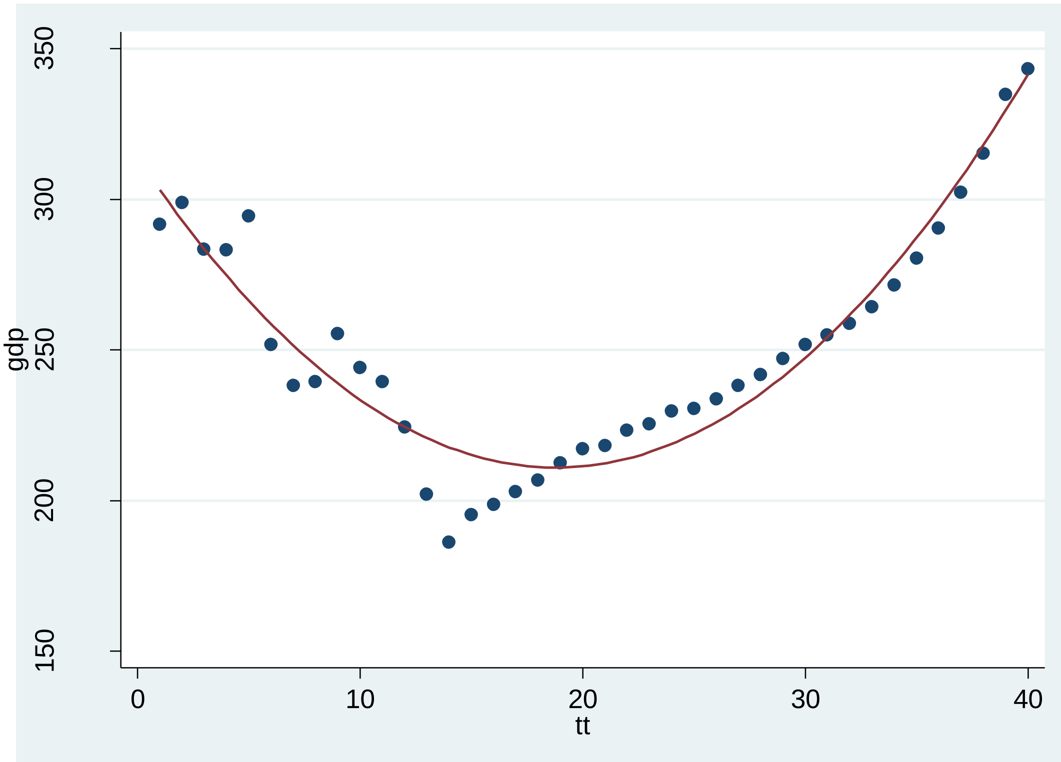
APPENDIX 5C (CONT'D)



Time series plot of GDP with quadratic prediction

From the linear and quadratic predictions of the time series plots of GDP, it is clear that GDP follows a quadratic rather than a linear trend. Generating a trend variable tt for tt=1,2,3……40 for 1970, 1980, 1981……..2009 respectively, the time series plot of GDP can be redrawn with year replaced with the trend term ,tt. The graph is estimated below:

APPENDIX 5C (CONT'D)



Time series plot of GDP with quadratic prediction (year is replaced with tt)

As can be seen, there is no loss of information. The GDP plot can be estimated using a quadratic model expressed as:

$GDP_t = \alpha + \beta tt + \chi tt^2 + \varepsilon_t$. Using STATA 11, the equation is estimated as:

$$GDP_t = 313.6909 - 10.92982tt + 0.2906652tt^2$$

Given the income turning point of the simple EKC as $364.99, tt can be solved quadratically to obtain tt =42. tt =42 corresponds to the year 2011.