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Forest Depletion in Ghana: An Analysis of Determinants

Joseph Kwadwo Tuffour (PhD)

Research Centre, University of Professional Studies, Accra, jktuffour@yahoo.co.uk

Abstract. Forest resources support livelihood of people in jurisdictions in which forest is located. However, the forest size is gradually depleting continuously. The lack of information about the specific agents and forces of forest depletion is worrying. This is due to the inter-generational and intra-generational equity notions that affect mankind. As such, there is the need to maintain such resources on a non-declining value basis so as to maintain human welfare over time. Thus, the objective of this study is to empirically examine the determinants of forest depletion in Ghana over the 1970-2012 period in Ghana. This study employs multiple regression concepts to examine the effects of the determinants on forest depletion. The findings of the study indicate that gold extraction for export, population growth and logging increase the rate of forest depletion for the study period. More significantly, population growth reflected in settlement expansion, agriculture purposes, increased use of fuel wood, etc have greater effect on forest loss in Ghana. This suggests that, protection of the forest is necessary and sufficient condition for economic growth. As a result of these, both government and policy-makers need to safeguard the forest estate, by increasing afforestation schemes and also using part of the returns from gold exports to regenerate the forest.

Keywords: Econometric Analysis, Forest Depletion, Ghana

JEL Classification: C22, L73, N57

1.0 Introduction

Ghana is well endowed with rich natural resources, both renewable and non-renewable such as gold, manganese, diamond, bauxite, clay, timber among others. Some of these have contributed to the development of the country for decades in the forms of employment, Gross Domestic Product (GDP), revenue and foreign exchange. The total value of tropical forest can be expressed as being the sum of direct and indirect use values (both forming the use value) and, option and existence values-non use value (Pearce, 1991; Ehrlich & Ehrlich, 1992; Tutu, 1992; Smith, 1997).

It is pertinent that economic development and the environment are interdependent which raises sustainability issues. Sustainable development, that is, maximizing the net benefit of economic development subject to maintaining the quality of the natural resources over time is the ideal situation but it appears that much attention is not given to this, rather the benefit overrides the care for the environment. The issues of environment and development have taken an increasingly important place on the international agenda since the Stockholm Conference in 1972. In the past, environmental degradation was viewed as a problem of industrialised nations alone, but now it has been recognised to be a vital issue in developing countries as well, in view of the new, intensive growth and development agenda. As of now, there is a general agreement on the importance of safeguarding the natural environment and the necessity of achieving sustainable development as we pursue our survival and development goals.

In an attempt to maximize the net benefit of economic development today, we must ensure that the quality of the natural resources are not underestimated so as to leave the resources in a better condition to support future generations. This is usually done by maintaining a mix of man-made, human and natural capital. The protection of the environment is an essential part of development. Without adequate environmental protection, development will be undermined. In this case, it can be said that development can take place if and only if there is environmental protection. This presents trade-offs and choices which policy–makers have to make, since there are many development objectives and strategies pursued by countries, so are there many legitimate debates within the environmental circles about ways to value and manage the forest and environment (Brandon & Brandon, 1992). In pursuing this development, there could be many channels through which the forest can be depleted. The problem is what are the key specific causes of forest depletion? To what extent do the agents interact with the forces of development to cause forest depletion in Ghana? The objective of the study is to examine the determinants of forest depletion in Ghana.

This study has been organised into five sections. Section one entails the introduction. Section two contains a brief literature review on the determinants of forest depletion. The methodology is contained in section three and empirical data analyses and results are contained in Section four. Section five contains the conclusion with policy implication and recommendations.

2.0 Literature Review

It is argued that, "the struggle to save the world's rainforest and other forests continues and there is a growing worldwide concern about the issue" (Chakravarty et al., 2012, pp. 6). This concern translates into knowing the causes of forest lost, reflected in the way forest cover is been reduced. Literature focuses on three aspects. One part tries to differentiate between the agents and causes of deforestation. The agents are the human instruments such as loggers, firewood collectors, infrastructure developers, commercial and subsistence farmers, charcoal burners, etc. Thus, the causes in respect of the agents are the specific forces which encourage the said agents to destroy the natural forest for their gain.

In the second breath, literature has categorised the forest depletion determining factors into direct and indirect causes. For the direct causes, they are usually the sources of deforestation (Caviglia, 1999). The indirect causes reflect the external, trans-boundary factors which are usually difficult to measure as raised by Sands (2005) and Humphreys (2006). The third category of causes have been tagged as emanating from competition for forest land use on one hand and lack of economic systems to accurately value forest resources (Pearce & Brown, 1994). Here other competing land use options such as agriculture, urban and industrial infrastructure development, etc. compete for forest land. On the other hand, the inability to quantify and market some of the forest resources does not reflect the actual value of the forest. On a general note, the effectiveness of the causes of forest depletion is enforced by fiscal and other macroeconomic policies.

It is estimated that, more than half of any tropical forest destroyed is as a result of agriculture and related resettlement of subsistence farming settlers (Amor, 2008; Amor & Pfaff, 2008). Related to this is overgrazing. Although on a minor scale, overgrazing can initiate deforestation as well as reinforcing degraded land. Forest can be cleared so that pasture can be made available for grazing while at the same time, agriculture land can be degraded more by grazing. In the face of changing and alternating seasons, bush fires contribute to forest depletion. It is estimated that, about 1% of forest cover is destroyed each year by bush fires (FAO, 2010).

In most parts of the forest area in Ghana and other parts of African countries, major mining activities take place in the forest zones. Mining, both surface and underground mining with their attendant land requirement for resettlement of displaced communities, for machines, cyanide dams, etc is very destructive (Carvalho et al., 2004; Sands, 2005). Mining is estimated to be the main cause of deforestation in Philippines (Docena, 2010) and in Jharkhand, India (FAO, 2011). The requirement of cities and villages to support growing population is usually achieved by expanding to hitherto forest areas (Wilkie et al., 2000; Sands, 2005; Amor, 2008; Amor & Pfaff, 2008).

External causes of forest depletion have also been raised. It is argued that deforestation is caused by industrialised nations' demand for wood products; colonialism-exploitation of forest resources; debt burden-the urge of poor countries to massively exploit their forest resources so as to obtain more foreign exchange to service external debt (Colchester & Lohmann, 1993). Also, indirect cause of forest depletion can also be identified domestically. These include poverty (Chomitz et al., 2007); population growth (Purnamasari, 2010); fiscal policies and market issues (Barbier & Cox, 2004; Angelsen, 2004); corruption and political issues (FAO, 2001) and undervaluing of forest resources (Sands, 2005).

Oteng-Yeboah (1997), argues that since surface mining activities temper with the forest region, it is quite appropriate to examine ways in which the effects can be mitigated. He, like Tufuor (1998) identifies the major causes of deforestation in Ghana to be agriculture, logging, mining and urbanization. The spread of deforestation is positively related to development option of the land use especially near communities (Anderson, 1987; Perez-Garcia & Lippke, 1993). According to FAO (1982), shifting cultivation and subsistence farming were the leading cause of deforestation in both tropical West Africa and Semi-arid Africa, accounting for 70% of the woodland. The growth of towns and cities according to Anderson (1987) leads to the observed decline in tree stock in the surrounding countryside in Ghana. Also population growth has been raised (Pearce et el., 1991; and Rowe & Sharma, 1992).

3.0 Methodology

In this section, following the literature review on forest depletion in Ghana (Tufuor, 1997; Oteng-Yeboah, 1997; Anderson, 1987; Tutu, 1992; Dzigbodi-Adjuma, 1996 and Asamoah, 1998), the explanatory variables of forest depletion (F) have always been urbanization (U), population growth (P), lumbering (T), mining (G), bush fires (B), charcoal burning (C), chain saw operations (O), and agricultural clearance (A). Thus, forest depletion is said to be determined by the above factors. In reference to the above, the functional form of forest depletion can be stated as:

$$F = f(U, P, T, G, B, C, O, A) \quad (1)$$

Yet it is common knowledge that in economic life, other more factors may effect forest depletion. In econometrics, the influences of these 'other' factors are taken into consideration by the introduction into the economic relationship of a random variable (error term – ε[1]). One of the limitations of the study has been the lack of adequate data on bush fires, chain saw operations, urbanization, rate of charcoal burning and agricultural clearance.

[1] Examples of factors that contribute to forest depletion but are not included in the model, which are catered for by the error term include soil profile and composition, afforestation rate, and topography of the area

Due to certain considerations, the explanatory variables that have been used are gold exports, timber and timber products exports and population growth to explain forest depletion in this study. It is assumed that, all these factors combine to cause forest depletion, which can be specified in Cobb-Douglas form as:

$$F = \beta_1 G^{\beta_2} T^{\beta_3} P^{\beta_4} \quad (2)$$

After linearising the above specification by applying natural logarithm to it and incorporating an error term gives:

$$\ln F_t = \beta_1 + \beta_2 \ln G_t + \beta_3 \ln T_t + \beta_4 \ln P_t + \varepsilon_t \quad (3)$$

Where F is annual forest depletion, G is total volume of gold exports, T is total volume of timber and timber products export, P is total Ghanaian population, ln is natural logarithm, t is time, β_1 is the intercept term, β_2, β_3 and β_4 are coefficients and ε is stochastic error term.

The last equation is an example of a linear regression model. In this linear regression analysis, our concern is to explain the behaviour of a dependent variable in relation to the behaviour of other independent variables allowing for the fact that the relationship between the two sides is not exact. Since the equation is in log form, the coefficients may be interpreted as elasticities. It is expected that gold, timber exports and population growth will have a positive effect on the forest depletion in Ghana.

Thus, $\frac{\partial F}{\partial G} > 0$, $\frac{\partial F}{\partial T} > 0$; and $\frac{\partial F}{\partial P} > 0$

The difference between levels of total forest estate in current and previous years was used as forest depletion in the country. On the part of gold exports and its effects on forest depletion, the total volume of fine ounces exported was used instead

of the earnings from export or the total production level. This is due to the fact that, the unit price of gold keeps changing as demand and supply conditions in the world market change.

The reason for using gold to represent all other major minerals export in Ghana – manganese, diamond and bauxite is that (apart from gold) each has only one major mining company in the country[2]. Moreover, gold is the most widely mined mineral, has seen massive investment and expansion so far and contribute about 95% of mineral exports. Another reason for the use of export volume of the products is that, an exhaustible and non-renewable natural resource such as gold is found and exploited in the forest regions of Ghana under Open Cast method. As such, to increase gold production and export volume means using and devastating more land and these deplete more of Ghana's forest estate. The total volume of timber and timber products exported were used rather than the log exports or the earnings. The use of the volume of export products of timber is advantageous because the price per cubic metre keeps changing due to the market conditions on the world market as pertains to gold.

In Ghana, forest depletion is also caused by increases in human activities apart from the extraction of gold and timber. Charcoal burning, bush fires, urbanization[3] and agricultural clearance are other contributors to forest depletion. As stated, there is virtually a lack of time series data on urbanization, bush fires and agricultural clearance. It is certain however, that these activities are done by residents of a nation for survival and thus the growth in population increases the need to undertake these activities. Hence population has been used as a proxy for these in the estimation because, the increase in these activities is dependent on human goal of survival. The survival calls for road construction, building of houses,

[2] At the time of the study
[3] Represents increases in settlement sizes and wood materials needed for such settlements

cultivation of food crops, hunting, etc. Thus, having identified the determinants of forest depletion in Ghana, the data is analysed.

4.0 Data Analyses

The study utilizes annual time series data for the period 1970-2012. These secondary data were obtained from Ghana Statistical Service and Forestry Commission of Ghana. Recent developments in econometrics require that, time series data first have to be checked for their stationary properties before regression analyses are applied on them. The unit root tests for the variables in the equation are given in Table 1 below.

Table 1: Unit Root Test Results for the Model Variables

Variables	DG-GLS TEST		KPSS TEST	
	Test Statistic	Stationarity Comment	Test Statistic	Stationarity Comment
lnF	-1.95	I (0)	0.158	I (0)
lnG	-1.83	I (0)	0.119	I (0)
lnT	-1.66	I (0)	0.154	I (0)
lnP	-1.91	I (0)	0.152	I (0)

For the KPSS unit root test, under constant and linear trend assumptions, the asymptotic critical values for 1%, 5% and 10% are 0.216, 0.146 and 0.119 respectively. For the DG-GLS unit root test, the test critical values for 1%, 5% and 10% are -2.660, -1.955 and -1.609 respectively for an intercept assumption.

From Table 1, all the variables are stationary at levels using both DF-GLS and KPSS unit root tests, which mean the variables can be estimated. However, the state of cointegration must be checked. Cointegration represents the tendency of a group of variables to drift together over time, in order words, they have a long run relationship. When it is known that the variables are cointegrated, the relationship

between them can be referred to as long-run. As such, any deviation from the long run cannot be permanent but will return to the equilibrium path after some time.

Two main cointegration tests are performed: the Johansen Cointegration and Engle-Granger tests. The Johansen test results are presented in Table 2 below. Given various test types, both the trace and maximum Eigen values tests show that, there is at least one cointegration among the dependent and the independent variables.

Table 2: Johansen Cointegration Test Summary

Data Trend	**None**	**None**	**Linear**	**Linear**	**Quadratic**
Test Type	**No Intercept**	**Intercept**	**Intercept**	**Intercept**	**Intercept**
	No Trend	**No Trend**	**No Trend**	**Trend**	**Trend**
Trace	2	2	1	3	2
Max-Eig	1	0	1	1	1

Selected (0.05 level*) Number of Cointegrating Relations by Model, * Critical values based on MacKinnon-Haug-Michelis (1999), and a lag interval of 1 to 2

In addition, the Engle-Granger two step cointegration test was also performed using Augmented Dickey-Fuller (ADF). But here the test is applied to the residuals of the cointegrating regression. Using the Augmented Dickey-Fuller unit root test, (based on Schwarz Information Criteria and Maximum lag length of 6), the test statistic for the error term obtained from the long run model on the exogenous assumption of constant, constant and linear trend, and none shows -3.27, -3.24 and -3.35 respectively which indicates stationarity at 5%, 10% and 1% respectively. Thus, the two cointegration tests collaborate each other. In this case, the rate of forest lost and the explanatory variables move together. Having established stationary and cointegration, the model was estimated.

Table 3: Regression Results of the Model

Variable	Coefficient	t-Statistic	Prob. Value
Constant	6.3351	5.0737	0.000
lnG	0.1439	2.2842	0.031
lnT	0.2036	2.8561	0.008
lnP	2.068	4.0579	0.0005

Note: Adjusted R-squared = 0.699; F-statistic = 18.6747; Prob (F-statistic) = 0.000002

The results show that, the explanatory variables (gold exports, timber and timber products exports and population) explain about 70% of the cause of forest depletion in Ghana for the sample period. This reveals a high explanatory power of the model. The gold export variable has the expected sign (as been positively related to forest depletion). Its coefficient value of 0.1439 shows that for every one 1% increase in the volume of gold exports, there will be about 0.14% increase in forest depletion for the sample period.

Timber (and timber products) exports also has the expected sign; the increased export of these products will lead to a loss of forest estate, its coefficient seems to be higher. A 1% increase in total volume of timber and timber products exports will lead to about 0.20% increase in forest depletion for the sample period.

The coefficient of population means when there is a 1% increase in population of Ghana, there will be about 2% increase in forest depletion for the study period. This result from influences such as increased demand for fuel wood, wood materials for housing purposes, agricultural land purposes, chain saw operations and charcoal burning.

The coefficients of the explanatory variables are noteworthy. In the context of elasticity, it is realised that, forest depletion is highly responsive to population growth. A small increase in population growth will lead to a greater effect on

deforestation in Ghana. On the other hand, growth of mineral and timber exports also affect the forest size in Ghana. But relatively, the effect of these on forest is smaller than population. The independent variables are all significant at the 5% level as revealed by the prob-value from the above table.

Diagnostic tests performed on the model indicate that there is no autocorrelation in the error terms even at the 1% significant level. Again, the RESET test shows stability of the coefficients. The Wald Coefficient Test was performed for gold exports, timber and timber products exports and population, and the null hypotheses were rejected at 5% significant level. This implies that these variables are significant in causing forest depletion in Ghana for the study period, and thus, the model specification was correct.

Our estimated results indicate that, population has a negative effect on forest of Ghana like other studies. For instance, in Hainen Island in China, Zhang, Uusivuori and Kuuluvainen (2000) estimated that population growth is a significant driving force behind the loss of natural forests. This suggests that growing population generally causes some rainforests to be converted into agricultural, industrial and residential land. In the same way, higher timber prices have accelerated rainforest exploitation. Barbier and Burgess (2001) estimated that, agriculture development is significant factor in determining land expansion. Another study by Pandy and Wheeler (2001) found that Structural Adjustment has had strong impact on exports, consumption and production in many forest products sectors.

5.0 Economic Implications, Policy Recommendations and Conclusion

These results show that, as we exploit our gold deposits, although we obtain returns in the forms of foreign exchange, income for employees and revenue to government, there is a direct effect on forest depletion. This forest depletion results in various indirect economic implications for the nation. One of the economic implications is the subsequence cost of treating water related health problems. If the watersheds of

the people who dwell in the hinterlands are destroyed, then they will depend on stagnant water and other water bodies that are not wholesome because most of these areas do not have access to treated water. There will be an additional cost of maintaining the health of these people.

Again, since grassland sometimes replaces lost forest and degraded soil, there is the likelihood of climatic change, which will affect food production. The fall in food output as a result will have to be replaced with importation from other countries thereby reducing the amount of foreign exchange available for other developmental projects and importation of vital equipment. Apart from these effects, the increase in importation of food will worsen the balance of payments position of the nation.

Moreover, siltation of river courses, flooding and loss of wind breaks cause havoc to both human beings and property. The cost of refitting the forest also impacts on the economy. The cost of afforestation through tree seedlings acquisition, tree planting and maintenance will siphon resources from other productive sectors of the economy.

In light of the above findings from the study, the granting of mineral rights should be tied to both afforestation and reafforestation schemes presented in the license seekers' environmental action plans, renewal of such licenses should be based on past record of adherence. It is recommended that mining institutions and authorities begin to move from forest areas to non-forest areas in terms of granting mining leases. Also, since gold could be mined underground as was done in the past, it is recommended that emphases should be placed on the need to return to the underground mining to maintain our forests. Family planning in respect of population reduction should be encouraged. Finally, the government should make tree seedlings available to those who are ready to go into tree planting for livelihood.

In conclusion, the study was based on time series data over the 1970 -2012 period. Using least square estimation methodology, the results show that while mineral

mining, timber extraction and population growth all have devastating effect on forest depletion, the rate of destruction is severe with population growth than with other causes of forest depletion in Ghana.

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