FOREST MANAGEMENT AND CLIMATE CHANGE IN AFRICA: EVIDENCE FROM CAMEROON

By

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Abstract.

Sustainable forest management to mitigate the climate change in Africa involves introducing policies and technologies that minimize the conversion of forest areas into farmland. However, under current practices, forests are experiencing the highest rates of depletion and degradation in this continent. This paper addresses the factors of forest clearing in Cameroon taken as a picture of Africa. The empirical evidence suggests that the producer prices of coffee and cocoa, timber prices and food crop prices influence the decision to cut down wood and to convert forests into farmland. The agricultural value added per hectare positively affects forest cover. The fertilizer price index, the credit to farmers and the per capita GDP have no effect on deforestation. Climate change has a significant negative relationship with forest depletion. Finally, the oil boom, the structural adjustment policies and the devaluation of the CFA franc have increased the speed of deforestation. A critical lesson from this paper is that policy measures outside of the formal forest sector are key part of the problem of tropical deforestation, and therefore potentially a key part of the solution. This paper also lends support to the inclusion of forest conservation in the next commitment period of the Kyoto Protocol.

***JEL*: Q5, Q23, Q54, C32**

Key words*: *Forest management, Climate change, Africa, Cameroon

1. Introduction.

There is a global consensus today that our world is getting warmer and warmer. The global mean temperature has increased by 0.6 degree Celsius during the twentieth century and modern temperature records go back to about 1860 (Bolin, 2004). These changes in temperature are the expression of the climate change, which mainly refers to the long-term variation in the weather as a consequence of the atmosphere being altered by humankind's activity. This variation also includes other weather-associated features such as wind pattern, and precipitation.

The consensus in the scientific community is that the rise in the global temperature is caused by the accumulation of the so-called "greenhouse gases" composed of carbon dioxide and nitrous oxide mostly produced by deforestation and forest fires. Forest fires release large quantities of CO2 to the atmosphere and are estimated to contribute 10-20% of annual global emissions of methane and nitrogen oxide, both potent greenhouse gases.

Deforestation is therefore a threat to climate stability in Africa in general and in Cameroon particularly. This is why the identification of factors leading to the halting of forest disappearance has become a priority, and one of the main components of the overall strategy to fight against climate change in this country considered as an accurate picture of Africa. A step toward this aspiration was recently made by revising the forest policy in order to promote a sustainable use of forest resources. This has resulted in the creation of the "Office National de Développement des Forêts (ONADEF)" in 1990 and the Ministry of Environment and Forest (MINEF) in 1992. Regulations governing the entire forestry sector have been also significantly modified with the creation in 1995 of the "National Forestry Action Program (NFAP)". However, the pressure on forest areas is not yet reduced, indicating the need for further investigation of the factors of forest clearing. Our paper falls in line with this concern and intends to put elements of economic policies that attempt to reduce the contribution of forests destruction to climate change at the disposal of policy makers.

The factors that shape agents' decision to deforest can be grouped under three categories, namely the direct sources, the immediate and the underlying causes. The underlying causes, which are macroeconomic variables, determine the immediate causes, which in turn influence the agents of deforestation (Farmers, animal husbandry, loggers) who are the sources of deforestation. The immediate causes influence the decisions by the deforestation agents. According to Angelsen and Kaimowitz (1999), the mixing up of these three levels of deforestation distorts the causal relationship and often leads to serious misspecification in regression models. Furthermore, potential statistical problems of multicollinearity and biased estimates may be encountered.

This paper argues that, as deforestation is a location specific problem with the effect and magnitude of each identified factor differing from country to country and from one region to another, it is absolutely necessary to empirically determine the extent and the degree to which the factors identified influence the progressive disappearance of forests that release greenhouse gases in the atmosphere in Cameroon. This would help in the formulation of appropriate economic and environmental policies to mitigate, if not halt the effects of unsustainable conversion of forests. In addition, given that a mixing up of the various levels of factors causing forest clearing leads to a wrong specification of causal relationship between variables, this paper avoids this type of mistake by concentrating on immediate causes of conversion of forests. This is because we expect to find a much stronger correlation between deforestation and the micro-level decision parameters, than between deforestation and macro-level variables. In addition to the immediate causes, GDP per capita is introduced. These motivations bring us to the following questions: What are the immediate causes of forest depletion in Cameroon taken as a picture of Africa? What are the effects of these immediate factors of deforestation and what are the magnitudes of these effects? What is the nature of the relationship between climate change captured by temperature and forest destruction? Our paper is oriented towards these horizons.

The remaining part of our analysis is articulated around four points. Sections 2 and 3 present the literature review and the methodological approach respectively; section 4 deals with the empirical results; and finally section 5 covers the conclusion.

2. Literature Review

2.1 Theoretical Framework

Forests not only have a significant impact on climate change, but they also influence it. They influence the local and global climates. They moderate the diurnal range of air temperatures and maintain atmospheric humidity levels. Forests absorb atmospheric carbon and replenish the oxygen in the air we breathe. Through their destruction, forests can be serious sources of greenhouse gases and through their sustainable management they can be important sinks of the same gases. They act as important buffers that cushion the impact of ongoing climate change. Therefore, measures to protect, restore, and sustainably manage forests offer significant climate change mitigation potential.

Agricultural expansion is the major direct cause of forest depletion compared to other direct causes such as pasture, logging, harvesting of forest products, and development of infrastructures. Some evidences show that cropland expansion alone is responsible for about 50-60% of total deforestation (Culas, 2004). The environmental effects of this agricultural expansion depend on the changes in profitability of different crops. Assuming that the profitability of agriculture in general increases, the literature on the causes of accelerated clearance of tropical forests for agricultural activities relies principally on two different approaches, namely the population (subsistence) approach and the open economy (market or profit-maximizing) approach[1]. These two approaches are useful to explore the range of hypotheses for the effect on deforestation of changes in economic variables.

The population and open economy approaches refer to different assumptions made about household behaviour and the labour market, the latter being the most important (Angelsen et al, 1999). The population approach (PA) assumes that a person's objective is to satisfy his subsistence requirement by producing agricultural commodities. The economic problem is to minimize the labor inputs given a subsistence target, implying that consumption beyond that level has no value. Agricultural production is determined by:

$$X = Af(L, H, F) \qquad (1)$$

Where X is production in physical units, A is the technological level, L is (on the field) labor input, H is total land area of homogenous quality, and F is fertilizer input. The production function **(**1**)** is concave, with positive but decreasing marginal productivity of all inputs ($f_i \succ 0; f_{ij} \prec 0$). All inputs are normal and any pair of inputs is complementary

[1] However, other approaches such as the Chayanovian or the general equilibrium approach can yield hypotheses, which are consistent with both approaches mentioned above.

($f_{ij} \succ 0; i \neq j$). It is assumed that no market exists for land and uncultivated land (forest) can be brought into cultivation on “a first come first served basis” (Idem). However, there are costs related to clearing of new land (L) and also costs from having a large area to cultivate in terms of walking, transport of inputs and outputs. These costs are represented by a convex function $h(H)$. Hence, the optimization problem is to minimize $L + h(H)$ subject to the constraint $sxN = pxX - qxF$. The Lagrangian function for this minimization problem is therefore:

$$G = L + h(H) - \lambda x\left[pxAxf(L, H, F) - qxF - sxN\right] \quad (2)$$

Where λ is the Lagrangian parameter, p and q are output and fertilizer prices, the subsistence requirement is given by subsistence consumption (equal to income) per capita (s), multiplied by total population (N)

In the market approach (MA) a perfect labour market is assumed where any amount of labour can be sold and hired at a fixed wage. In our paper, the MA seems to be more appropriate because of the long-term effects of the study and also because migration became very important in Cameroon after the oil-boom in 1978 (Ndoye and Kaimowitz 2000). In addition the population in Cameroon no longer relies on subsistence farming activities.

Compared to the subsistence approach, the open economy approach has a different way of reasoning although the key change in the underlying model assumptions is only the introduction of a labour market where labour can be sold at a fixed wage (w). This wage rate gives the opportunity costs of labour used in agriculture (Angelsen et al, 1999). The forest clearing decisions can then be examined as a profit-maximizing problem. However, this does not mean that the household’s overall objective is to maximize profit. The perfect labour market assumption implies that production decisions can be separated from the consumption and labour supply of the household (Idem). Thus, the production decisions of a utility-maximising household can be analysed as a profit-maximising problem. The production problem is now to maximize total profit or land rent.

$$P = pAf(L, H, F) - qF - w\left[L + h(H)\right] \quad (3)$$

Where P is profit and, A, L, H and F as defined in (1). As in the population approach, the labor used to cultivate the land, in addition to the costs related to the clearing of new land

and also costs from having a large area to cultivate are represented by a convex function h(H). p and q are output and fertilizer prices respectively.

The first order condition is summarized as follows:

$$pA = \frac{w}{f_l} = \frac{wh_H}{f_H} = \frac{q}{f_F} \qquad (4)$$

The main difference between the two versions of the model (PA and MA) is that whereas the wage rate (w) is exogenous in the MA, the shadow wage is endogenous in the PA. Population on the other hand is endogenous in this model whereas it is exogenous in the subsistence model. All this makes a fundamental difference to the response of exogenous changes. Within the MA agricultural production and land use are determined by the relative profitability of agriculture, and not by any population requirement.

In general the demand function for agricultural land expansion in terms of the immediate causes discussed under both approaches is specified as:

$$D = f(p, A, q, w) \qquad (5)$$

Where D is area of agricultural land expansion and the other parameters are as previously specified. This equation can be extended to cover many other variables.

2.2 Empirical review.

The causes of forest depletion have been attributed to several factors. The most important categories are the immediate and the underlying causes.

In Sudan, Stryker et al (1989) found that increased producer prices of export crops encouraged woodland clearing for crop cultivation and this resulted in significant deforestation. Based on the market theoretical approach, Angelsen. et al (1999) statistical analysis in Tanzania showed that the increase of agricultural output prices, in particular annual crops is a major factor behind deforestation. The results of these authors were confirmed in Ivory Cost where the effects of price increase of export goods contributed to deforestation but to a lesser extent than the lack of a consistent and secure land tenure system (Reed,1992). Osei Asare and Obeng Asiedu (2000) found in Ghana a long-run equilibrium relationship between the producer prices of cocoa and coffee, fertiliser prices, food crop prices, agricultural wages, timber prices and agricultural credit on the one hand and deforestation on the other hand. According to the findings of these authors, higher levels of fertiliser prices, food crop prices and coffee producer prices stimulate in the long-run higher levels of deforestation whereas higher levels of agricultural wages precipitates lower levels of deforestation. Other empirical works reveal that devaluations undertaken in Ghana at the beginning of 1980s motivated forestry exploiters to intensify tree felling for more exploitation of timber and woodwork. This ended up accelerating deforestation (World Bank ,1994; Pimentel et al, 1991). These results were confirmed in Malawi (Cromwell and Winpenny, 1991), and in Botswana (Perrings et al, 1988).

In Cameroon, very few econometric studies on the causes of forest clearing are available. Ndoye and Kaimowitz (2000) look at the influence of macroeconomic and agricultural policies, market fluctuations and demographic changes on the humid forest zone of Cameroon between 1967 and 1997. To capture deforestation, they use increases in perennial crop area and in the combined area of annual crops. The results indicate that after the oil boom, the Structural Adjustment Program (S.A.P) and the devaluation of the CFA franc in 1994, the net effect of cocoa, coffee and food production increased the pressure on forest areas. This paper is basically descriptive.

A study of deforestation in the area around Ndélélé in the East Province based on remote-sensing analysis points to a marked increase in deforestation after the economic crisis in the mid-1980s (Mertens et al, 2000). This paper uses the same proxy to capture forest clearing as in Ndoye and Kaimowitz (2000). It investigated the role of the main driving forces of deforestation at the village-level through bivariate regression analyses. However, it concentrated on the underlying factors of deforestation and covered a very small part of the country territory.

The impact of S.A.P on forests is also addressed by Kaimowitz et al (1998) using a comparative analysis between Cameroon, Bolivia and Indonesia. The results indicate that forest clearing for food crops increased under S.A.P. Nkamleu et al (2002) examined fuelwood consumption in households of forest zones in Cameroon. The results confirmed the importance of fuelwood as a source of energy, and the econometric analysis showed a negative correlation between income levels and fuelwood consumption. Finally, a series of papers focusing on the underlying, and social causes of deforestation confirmed the high rate of forest clearing in Cameroon and concluded to the necessity of some well-elaborated protection policies (Cleaver, 1992; Besong, 1992; Foteu, 1995).

Compared to the studies reviewed above, our paper has three special novelties. Firstly, it explores the linkages between socio-economic variables and deforestation using long-run statistical analysis, which is the first attempt in Cameroon. The need for quantitative analysis of the immediate factors behind deforestation in Cameroon became necessary in order to determine the net effects of policies and provide more concrete policy guidelines. Secondly, data on annual forest cover is used as a proxy for deforestation. This proxy seems to craft better to the deforestation process in Cameroon than the increases in perennial crop area combined with area of annual crops used in previous papers. Although agricultural land expansion is a major source of deforestation, the proxy is not good at the national level for two main reasons:

1. It does not cover all sources of deforestation.
2. Some agricultural expansion may not be into forest, but, for example, grasslands and Savannah.

Thirdly our study uses the agricultural value added per hectare instead of the approximate monthly revenue of farmers used in various papers (Osei Asare and Obeng- Asiedu, 2000).

2.2.1 Structural breaks in Cameroon.

It is worth mentioning the structural shifts that occurred in the Cameroon economy during the period under consideration. Between 1970 and 2002, three main structural shifts can be underlined in Cameroon, namely the oil boom, the Structural Adjustment program (SAP) and the devaluation of the CFA franc.

During the oil boom, high international coffee and cocoa prices and more favourable producer price policies encouraged forest clearing to plant coffee and cocoa. Furthermore, government investment of oil revenues in parastatal oil palm (SOCAPALM) and rubber plantations (HEVECAM) fuelled deforestation. Wood harvest rose from 1.2 million cubic meters in 1977 to 2.1 million cubic meters in 1985 (Angelsen et al, 1999). Timber exports grew as well, but stagnated as companies sold more timber domestically (Foteu, 1995; World Bank, 1988). The oil boom stimulated construction, and this generated greater domestic demand for timber. However, food crop production apparently grew slowly during the oil boom due to promotion of rapid rural to urban migration (Ndoye and Kaimowitz 2000)

Contrary to the oil boom, the Structural Adjustment policies induced a reduction of cocoa and coffee producer prices by 40% and 60% respectively in Cameroon (Blanford. et al, 1994; Gbetnkom and Khan, 2002). Consequently, about 45% of cocoa farmers in the East province abandoned their cocoa area in 1993 (Besong, 1992). With respect to food crop sector, its growing importance severely affected deforestation compared to cocoa and coffee. As rural households found their incomes from cocoa and coffee collapsing, many compensated for those losses by increasing food production.

In January 1994, the CFA franc was finally devalued by 50%. The new exchange rate greatly stimulated timber production, and this negatively affected large areas of forest. The devaluation doubled the prices timber companies received for their logs, but only increased their production costs by 34% (Ndoye and Kaimowitz 2000). This induced logging companies to increase their production. On average, log exports from Douala were almost twice as high in 1994-1996 as between 1987 and 1993. Concerning cocoa and coffee, producer prices for these two crops rose, and farmers responded to the increases by expanding their productions. With respect to food crops, Sunderlin and Pokam (1998). reported that 48% of plantain producers increased their cultivated areas between 1993 and 1997, as did 47% of producers of other food crops. This is because urban dwellers consumed fewer imported foodstuffs, since the devaluation greatly raised their price. Meanwhile, the total number of urban consumers continued to grow.

In general, it is obvious from the reviewed studies that prices paid to the producers of coffee, cocoa, and food crops, the export price index of timber, the fertilizer price index, the monthly average revenue of farmers, the gross National Product per capita, the credit to agriculture, and the changing economic conditions (oil boom, structural adjustment policies, and the devaluation of the CFA franc) are important immediate causes of deforestation in Cameroon.

3. Methodology

3.1 Model specification

From the theoretical framework presented above, we draw a linear model for empirical analysis of the form:

$$FOR = \alpha_0 + \alpha_1 coffeep + \alpha_2 cocoap + \alpha_3 timberp + \alpha_4 vaah + \alpha_5 GDPPC + \alpha_6 credit + \alpha_7 foodp + \alpha_8 fertp$$
$$+ \alpha_9 oilb + \alpha_{10} sap + \alpha_{11} dev + \alpha_{12} temp + \mu_t \ldots\ldots [6]$$

α_i represents the respective coefficients of the independent variables, and μ is the error term associated to the regression of the equation. **FOR** stands for annual data on the forest area used to capture deforestation. The variables **coffeep**, **cocoap,** and **foodp,** are the prices paid to the producers of coffee, cocoa, and food crops respectively. **timberp** is the export price index of timber. The higher these prices, the more the forest area diminish because of conversion of new forest portions and export of timber. A negative relationship is therefore expected between these variables and FOR ($\alpha_1 \prec 0, \alpha_2 \prec 0, \alpha_3 \prec 0, \alpha_7 \prec 0$). **fertp** is the fertilizer price index. The theory of how changes in agricultural input prices affect forest clearing leads to indeterminate conclusions, and the empirical evidence is mixed, particularly for fertilizers (Angelsen and Kaimowitz, 1999). On the one hand, higher fertilizer prices lead farmers to adopt more extensive production systems that use more land and less fertilizer. On the other hand, the higher costs associated with increased fertilizers make agriculture in general less profitable and can lead to a reduction in the amount of land devoted to crops. Therefore the relationship can go either way ($\alpha_7 \succ\prec 0$). **Vaah** is the agricultural value added per hectare. The higher this variable, the less the supplementary destruction of forest area. Thus the expected relationship is positive ($\alpha_4 \succ 0$). **GDPPC** represents the Gross Domestic Product per capita, which can be interpreted as a proxy for alternative employment opportunities. The higher it is, the less the dependency of the populations on the export of cash crops and forestry products. Thus a positive relationship is expected ($\alpha_5 \succ 0$). **Credit** is the volume of credit destined for agriculture. It is one of the critical inputs necessary for small and large-scale production. The inadequacy of formal credit to farmers or the lack of it in farming operations may hinder farmers from undertaking investments in land improvements and better farm management practices to intensify production. An increase of this variable favours forest protection. The expected relationship is positive **(**$\alpha_6 \succ 0$**)**. **Oilb**, **Sap** and **Dev** are dummy variables designed to capture the effects of the oil boom, the structural adjustment policies and the devaluation of the CFA franc on deforestation respectively. Each of these dummies takes 0 before the corresponding structural shift and 1 after. The expected relationship for the three is negative ($\alpha_9 \prec 0, \alpha_{10} \prec 0, \alpha_{11} \prec 0$). **Temp** stands for temperature and is a proxy for climate change. The expected relationship is negative ($\alpha_{12} \prec 0$).

The above linear empirical model is a variant of the model of Osei Asare and Obeng-Asiedu (2000). However, it has originality for using three new variables, Vaah, Temp and GDPPC. The agricultural value added per hectare (Vaah) has a direct influence on deforestation. Its increase indicates an intensive agriculture; therefore the populations have no more interest in the extension of farmland and thus deforestation. This variable seems more accurate than the approximate monthly revenue of farmers used by the authors mentioned above. The other variables are temp and GDP per capita explained above.

3.2. Sources of data.

As mentioned above, this paper estimates the immediate causes of deforestation, their effects and magnitudes in Cameroon taken as an accurate figure of Africa from 1970 to 2002. The data used in the analysis come from various sources. The main data source was the Department of Statistics and National Accounts. Information was gotten from the following documents: Cameroon in Figures, Annual Statistical Reports, and National Accounts documents. Other consulted sources include various reports from the World Bank, the Bank of Central African States and the FAO. All prices are deflated by the GDP deflator for 1993. Annual data on forest cover are collected from various FAO and World Bank Reports, and are measured in hectare (ha). Producer prices of cocoa and coffee, timber price index, and GDPPC expressed in CFA franc are from various issues of Cameroon in Figures, and Annual Statistical Reports. The average producer prices for food crops in CFA franc per kg are calculated from the prices of four main food crops in Cameroon (Maize, Millet, Cassava and Plantains) that come from various issues of African Developments Indicators. The fertilizer prices in CFA franc per tone are obtained from some issues of “Fertilizer’s Statistic Yearbook” of the FAO. Credit to agriculture is used as a proxy for credit availability to farmers. It comes from various reports of the Bank of Central African States (BEAC). The agricultural value added per hectare is obtained from the World Bank’s Economic and Social database (BESD). Finally data on temperature is from Cameroon in Figures and African Development indicators.

3.3 Estimation technique.

In this sub-section, we examine the time-series characteristics of the variables, testing for stationarity and cointegration of the variables in the equation under consideration.

3.3.1 Unit Root Tests

We need to know the underlying process that generates our time-series variables. That is, whether the variables are stationary or non-stationary. Non-stationary variables might lead to spurious regressions. In this case the results may suggest statistically significant relationships between the variables in the model, when in fact this is just evidence of contemporaneous correlation. We have used the Augmented Dickey Fuller (ADF) and the Phillips Perron (PP) tests to examine our variables for the presence of a unit root. The Dickey Fuller Test assumes that the data generating process is autoregressive to the first order. This is done so that the autocorrelation in the error term does not bias the test. The ADF includes first-difference lags in such a way that the error term is distributed as a white noise. The test is formulated as follows:

$$\Delta y_t = \alpha + \rho\, y_{t-1} + \sum \gamma_j \Delta y_{t-j} + \varepsilon_t \quad . . . . [7]$$

A unit root test implies testing the significance of ρ against the null that $\rho = 0$.
The Phillips Perron (PP) Test on its part addresses the problem of the unknown structure of the data generating process under the null hypothesis by adjusting the t-statistic for the potential omitted variable bias *ex post.* The PP test is formulated as follows:

$$\Delta y = \beta + \rho y_{t-1} + \mu_t \quad . . . .[8]$$

To test for a unit root, the above equation is estimated by OLS and the t-statistic of ρ is corrected for serial correlation. If the results of the unit root tests show that the variables are not stationary in their levels, we proceed with a cointegration analysis.

3.3.2 Cointegration Analysis

In a regression involving non-stationary variables, spuriousness can only be avoided if a stationary co- integrating relationship is established between the variables. Therefore, if two or more variables can be linked together to form an equilibrium relationship spanning the long run, then even though the variables themselves may contain stochastic trends they will nevertheless move closer over time and the difference between them will be stable. To test for co-integration in this paper, we run our regressions and use the ADF and the PP unit root tests to test for the stationarity of the residuals. If the residuals are stationary, then we conclude for co-integration of series used in the model (Adam,1993; Perman, 1989).

4. Empirical Results.

4.1 Unit root tests results.

Table 1 in the appendix reports the results of the ADF and the PP tests for the order of integration of our variables. After comparing the ADF and PP statistics in table 1 with the Mackinnon critical values provided by the Eviews econometric package, we came up with the following conclusions concerning the unit root tests. Most of the variables are not stationary in their levels, implying the non-rejection of the null hypothesis of non-stationarity. But they all become stationary in their first differences. The examination of the correlograms leads to the same conclusions. This means that they all have a single unit root. Only two variables (credit and temp) are stationary in their levels. We cannot therefore specify our model in its level without the risk of obtaining spurious regressions except they are co-integrated. It is therefore necessary to carry out a cointegration test.

4.2 Co-integration Test Results

As described above, we ran our regressions and tested the residuals for the presence of unit roots. The results as presented in table 2 in the appendix reject the null hypothesis of no co-integration. The ADF and PP statistics presented in the table are significant at 1%. In addition, the statistics of Durbin-Watson already indicate that the hypothesis of the absence of cointegration between the variables can be rejected (Pindyck and Rubinfeld, 1998).

4.3 Empirical Results

We have used the ordinary least squares estimation procedure to obtain the results in table 2. These results meet our expectations in terms of their signs except GDPPC and credit, which present contrary signs. This is not the same situation with their levels of significance.

The estimated coefficients of the variables coffeep, cocoap, foodp and timberp are statistically significant at 10%, 5%, 5% and 10% respectively with the expected negative signs. This indicates that the prices paid to farmers of coffee, cocoa, and food crop, and to exporters of timber effectively influence the speed of forest clearing in Cameroon. However, there is a difference in the response for annuals and perennials crops. The results show weak evidence of cocoa and coffee farmers responding in the short run[2] to price increases. This is because very often, farmers of perennials crops respond to price incentives in the short run by intensifying care and improving husbandry for their existing crops. Furthermore, since perennial export crops are less soil erosive, and productivity can be improved from rehabilitating existing plantations, it is obvious that forest clearing would be slower than for annual crops (Angelsen et al, 1999). Food crop farmers can easily respond to price incentives in the short run by expanding the land area. In addition, because most annual crops deplete soil fertility faster than cash crops, they require more new fertile land (Angelsen et, 1999).

The fertilizer price index has the expected sign but is statistically insignificant. The behaviour of this variable can be explained either by the fact that farmers of perennial crops consume very negligible quantity of fertilizer or by the difficulties to obtain reliable data on the variable. Angelsen et al (1999) found this variable insignificant in Tanzania.

The agricultural value added per hectare (Vaah) is significant (1%) with the expected positive sign. This variable measures what a farmer derives from his agricultural activities as profit per hectare. The higher this profit, the less the attack of the farmer of parcels of forests. This variable can therefore be at the center of a governmental policy aimed at discouraging deforestation.

Credit to farmers doesn’t have the expected sign, and is not significant. This can be linked to the fact that in Cameroon, access to banking credits by small-scale farmers of rural zones who make up about 90% of farmers is very difficult. Only a minority of farmers possessing modern agricultural tools can obtain credit. To reduce the weight of this problem, the government had established state structures to give small-scale subventions to peasant farmers (FONADER, CREDIT AGRICOLE DU CAMEROON), unfortunately, all these structures disappeared during the economic reforms. The very negligible effect of bank loans on deforestation can also be the consequence of the absence of reliable data on this variable.

[2] The results with cocoap and coffeep lagged for three years, and foodp lagged for one year are not reported in the paper. These lagged variables were not significant and deteriorated the performance of the whole model

The three dummy variables oilb, sap, and dev designed to capture the three structural breaks that occurred in the Cameroon economy during the period under consideration in this paper have the expected signs, and are significant at 1%, 5% and 1% respectively.

The GDPPC doesn't have the expected sign and is not significant. Its increase is assumed to reduce the demand of agricultural and forestry products.

Climate change (temp) has the expected negative relationship with deforestation, and is significant at 10% level. This result confirms that forest depletion is the hidden cause of global warming.

As a whole, our model has performed well, because all the coefficients except two have the expected signs. However, in terms of their significance, some of our expectations were not met. The adjusted coefficient of determination ($\overline{R^2}$) shows that the variables included in our model have succeeded to explain at 86% deforestation in Cameroon. Osei Asare and Obeng Aseidu (2000) had 97% in the case of Ghana. The Fisher Statistics (F-Stat) for the general performance of the model is significant. To test for serial correlation, we have used the Durbin-Watson statistic (DW). As appeared in table 2, the DW shows that the null hypothesis indicating the presence of a serial correlation has been rejected. All the probabilities of these two statistics are not significantly different from zero.

5. Conclusion.

Managing the remaining forest resource for climate stability in Cameroon taken as an accurate picture of Africa involves introducing improved forest management and harvesting policies and technologies to stimulate the existing forests' capacity for carbon sequestration and storage. This can be accomplished by making investments that minimize the loss of forest area to deforestation, improve tree growth, minimize soil disturbance and that ensure quick and satisfactory regeneration of new forests. It could also include ensuring satisfactory natural regeneration of harvested forests and forests damaged by fire, improving forest fire suppression and management capabilities; adopting reduced-impact logging practices; and minimizing the negative environmental impact of road construction and maintenance. In short, it means practicing sustainable forest management. However, under current practices, the overwhelming majority of tropical forests are not sustainably managed. In Africa, forests are experiencing the highest rates of depletion and degradation. The empirical statistics in this paper suggest that the producer prices of coffee and cocoa, timber and food crop prices influence at various degrees the decision to cut down more wood for export and to convert forests into farmland. The agricultural value added per hectare positively affects forest cover. This means that its increase rather motivates the conservation of forests. The fertilizer price index, the credit to farmers and the per capita GDP have no effect on forest depletion. The oil boom, the structural adjustment policies and the devaluation of the CFA franc have seriously increased the speed of deforestation in Cameroon. Finally, climate change captured by the variation of temperature is negatively correlated to deforestation in Cameroon and is significant at 10% level.

The implications of these results are such that all attempts to slow down the speed of forest depletion in Cameroon must take into account the influence of the significant variables in our model on this phenomenon. Meanwhile, the policies aimed at reducing the prices of agricultural products shall hardly get the support of the populations, given that about 75% of them depend on agriculture. In addition, it would be difficult to implement them in the actual context characterized by the liberalization of economies, which put an end to the stabilization of the cash crops prices. The agricultural value added per hectare, which measures what a farmer derives from his agricultural activities as profit per hectare increases the profitability of maintaining forests. This variable can therefore be at the center of governmental policies aimed at discouraging forest depletion. This is possible through the promotion of intensive farming system by increasing the amount of labor, and capital applied per hectare of land. Whether the expansion of markets demands and higher product prices lead to more or less pressure on the forest-agriculture frontier depends on the farmers' choice of technology (that is how much to intensify and how much to expand an area) in response to perceived opportunities.

Another implication of this study is that the new institutional tools for forest management and land-use planning in Cameroon (ONADEF, MINEF) have not yet provided a sustainable response to the problems of the progressive disappearance of forests.

Finally, a critical lesson from this paper is that policy measures outside of the formal forest sector are key part of the problem of forest depletion in Africa, and therefore potentially a key part of the solution. This means that, prior to the crisis, and also during the crisis, governmental authorities did not pay sufficient attention to the unintended and the undesirable consequences of, inter alia, structural adjustment policies, urban and public sector employment policies, infrastructure policies, agricultural pricing and import policies, and exchange rate policies (Perrings et al, 1988). In order to protect the remaining forest areas, and render sustainable the contribution of forests to climate stability, attention to these policies should be a first-order priority in the future. It is obvious that governmental authorities will not alter exchange rates to protect forests, but environmental preoccupation should be taken into consideration when determining what macroeconomic policies to implement. It appears therefore that an important challenge is likely to be learning how to manage forests both for growth, and also as a safety net. With this knowledge, better-informed choices of trade-offs involved in forest management can be made.

This paper also lends support to a proposal for inclusion of forest conservation in the next commitment period (after 2012) of the Kyoto Protocol, which could encourage tropical countries to make meaningful contributions to reducing global emissions. It is proposed that, taking as the baseline the average annual deforestation for the 1990s, developing countries that elect to reduce their emissions from deforestation during the five years of the first commitment period would receive financial compensation for the emissions avoided, based on the average market value of carbon in 2012 (Santilli et al, 2005). Conversely, if these countries increase their deforestation rates during the first commitment period in relation to the average of the 1990s, the incremental increase would have to be compensated by a compulsory reduction during the second commitment period. Only after thus offsetting increased emissions during the first commitment period would they again be eligible for financial compensation for additional reductions. If their deforestation rates continue to increase they would be subject to international sanctions established in the Kyoto Protocol (Santilli et al, 2005).

References.

Adam, C.S (1993).``Time Series Econometrics in Africa``. Lecture Notes for a Technical Workshop run by AERC, Nairobi, Kenya.

Angelsen, A. and D. Kaimowitz (1999). “Rethinking the causes of deforestation: lessons from economic models”. The World Bank Research Observer, vol. 14, No 1.

Angelsen, A, E.C.K Shitindi, and J. Aarrestad (1999). « Why do farmers expand their land into forests? Theories and evidence from Tanzania". Environment and Development Economics 4: 313-331.

Arnold, J.E.M (1998). Forestry and sustainable rural livelihoods. In Carney.D, ed. Sustainable rural livelihoods: What contribution can we make? London, UK, Department for International Development.

Besong.B.J (1992). "New directions in National Forestry policies – Cameroon" in Cleaver, K et al, eds. Conservation of West and Central African Rainforests. World Bank Environment Paper N° 1. October.

Blanford. D, D. Friedman, S.Lynch, N.Mukherjee, and D.E.Sahn (1994). « Oil boom and bust : the harsh realities of adjustment in Cameroon" in D.E. Sahn, ed., Adjusting to Policy Failure in African Economies. Ithaca, NY, Cornell University Press, 131-163.

Bolin, B. (2004): Responding to Climate Change Knowledge and Insight Required to Act under Uncertainty: *Focusing on Robust Findings* SEI Climate and Energy Programme Report 2004-01.

Bryant. D, D.Nielsen, and L.Tingley (1997). The last frontier Forests: Ecosystems and economies on the Edge. Washington D.c; World Resources Institute.

Cleaver, K (1992). "Deforestation in the western and central African forest: the agricultural and demographic causes, and some solutions" in Cleaver, K et al, eds. Conservation of West and Central African Rainforests. World Bank Environment Paper N° 1. October.

Cromwell, C.et J.T Winpenny (1991). Has Economic Reform Harmed the environment? A review of Structural Adjustment in Malawi. Londres: Institut de développement outré-mer.

Dorward, Andrew; Jonathan Kydd, Jamie Morrison and Ian Urey (2004). A policy agenda for pro-poor agricultural growth. World Development, Vol. 32, N° 1, pp. 73-89.

Epstein, Paul,R and Evan Mills (eds) (2005). Climate change futures: Health, Ecological and Economic Dimensions. The Center for Health and the Global Environment. Harvard Medical School.

FAO (1987). Small-scale forest-based processing enterprises. FAO Forestry Paper N0 79. Rome.

……(1989) Forestry and food security. FAO Forestry paper N0 90. Rome, 1989.

…….(1995) Forests, fuels and the future. Forestry Topics Report N0 5, 1995.

…….(1996) Forest Resources Assessment 1990 : Survey of tropical Forest cover and study of change processes. FAO forestry Paper 130. Rome.

…….(1997) State of the World`s forests. Rome.

…….(2001) State of the World's Forests., Rome.

Foteu, R (1995). "Impact de la dévaluation sur le secteur forestier du Cameroun », Yaoundé, Ministère de l'Environnement et des Forêts.

Gbetnkom, D and S. Khan (2002). Determinants of agricultural exports: the case of Cameroon. *AERC Research Paper 120*. Nairobi- Kenya.

Hulme, M., Doherty, R.M., Ngara, T., New, M.G., and D. Lister (2001): 'African Climate Change: 1900-2100'. *Climate Research*, 17:145-168.

Harmon, M.E., W.K. Ferrell and J.K. Franklin (1990). Effects on carbon storage of conversion of old-growth forests to young forests. *Science* 247: 699-702.

Houghton, R., Skole, D. & Nobre, C**. (**2000). Annual fluxes of carbon from deforestation and regrowth in the Brazilian Amazon. *Nature*, 403: 301–304.

IPCC. (2001). Technical Summary. In *Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press: Cambridge, United Kingdom and New York, NY, USA.

IPCC.(2000). *Land use, Land-use change, and Forestry - Intergovernmental Panel on Climate Change Special Report* (eds. Watson R.T., Noble I.R., Bolin B., Ravindranath N.H., Verardo D.J., Dokken D.J.) Cambridge University Press, Cambridge.

Kaimowitz. D, Erwidodo, O.Ndoye, P. Pacheco and W. Sunderlin (1998). « Considering the impact of structural adjustment policies on forests in Bolivia, Cameroon and Indonesia ». Unasylva 194, Vol.49, Rome.

Krishna, Anirudh (2004). Escaping poverty and becoming poor: who gains, who loses, and why? World Development Vol. 32, N° 1, pp 121-136.

Laporte. N, Sunderlin.W.D and O. Ndoye (1999). Assessing land cover change in the dense humid forest of Cameroon: comparison of satellite image maps and household surveys. CIFOR. Cameroon.

Mason, S. J., and A. M. Joubert, 1997: Simulated changes in extreme rainfall over southern Africa. *International Journal of Climatology*, **17**, 291-301.

Marcoux, Alain (2000). Population and deforestation. FAO, June.

Mertens. B, W.D. Sunderlin, O.Ndoye and E.F.Lambin (1999). « Impact of macro-economic change on deforestation in South Cameroon: integration of household survey and remotely sensed data.

Ndoye, O and D. Kaimowitz (2000). "Macro-economics, markets and the humid forets of Cameroon, 1967-1997". The Journal of Modern African Studies, 38, 2 PP 225-253, UK .

NKamleu, D. Endamana, J.Gockowski, O.Ndoye, and W. Sunderlin (2002). « Analyse économique de la consommation du bois de feu en régions forestières : leçons des zones urbaines. Science et Changements Planétaires, Secheresse, Vol 13 N°2 Avril-Mai-Juin.

Nyong, A. (2005): The Economic, Development and Livelihood Implications of Climate Induced Depletion of Ecosystems and Biodiversity. Paper presented at the Scientific symposium on Stabilisation of Greenhouse gases Met office, Exeter, UK. 1-3 February.

Osei Asare and Obeng- Asiedu (2000). The immediate cause of deforestation: the case of Ghana. Beijer Research Seminar, 13-15 March.

Perman, R (1989). "Cointegration: an introduction to the literature". Strathclyde Papers in Economics 89/7.

Perrings. C, H.Opschoor, J.Arntzen, A.Gilbert, and D.W.Pearce (1988). Economics for sustainable development – Botswana : Acase study. Gaborone: Ministère des finances et de la Planification du développement.

Pimentel. D, B.Floyd, W.Teel, and J.Bourns (1991). « Deforestation, Biomass depletion, and Land degradation : Linkages to policy Reform in Sub-saharan Africa ». Document à un séminaire. Université Cornell, Department of Natural Resources, Ithaca, N.Y.

Pindyck, R.S, and Rubinfeld, D.L (1998). Econometric models Economic forecasts. Irwin McGraw-Hill. New York.

Reed, D (1992). " Structural Adjustment and the environment", in Munasingh, M (ed) Environmental impacts of Macroeconomics and sectoral policies. The International Society for Ecological Economics (ISEE). The World Bank and the United Nations Environmental Programme (UNEP).

Santilli, Roberto, A et al. (2005): «Tropical deforestation and the Kyoto Protocol". *Climatic Change 71* PP 267-276.

Sène, El Hadji (2000). "Forests and food security in Africa: the place of forestry in FAO's Special Programme for Food Security" in FAO/GIEWS Africa Report, N° 1, April.

Serageldin, I (1992). Saving Africa's Rainforests. Environmentally Sustainable Development, The World Bank (Second Edition).

Stryker, J. Dirck, R.L.West, J.C.Metzel, B.Lynn Salinger, P.M.Haymond, A.T.Slack and B.Aylward (1989). « Linkages between policy reforms and natural resource management in sub-saharan African" in Munasingh, M (ed) (1996) op cit.

Sunderlin, W.D,and J.Pokam (1998). “Economic crisis and forest cover change in Cameroon: the roles of migration, crop diversification and gender division of labour”. CIFOR.

Toornstra, F.H, G.A. Persoon, and A. Youmbi (1994) . “Deforestation in context: the southern forest region in Cameroon: case study report of the project local actors and global tree cover policies”. Leiden: Centre of Environmental Science.

Townson, I.M (1995). Forest products and household incomes: a review and annotated bibliography. Tropical Forestry Papers N0 31. Oxford, UK, CIFOR and Oxford Forestry Institute.

World Bank (1994). L’Ajustement en Afrique: Réformes, Résultats et chemin à parcourir. Rapport sur les Politiques de Développement.

World Bank (1998, 1992, 1995). World Development Report. Washington D.C.

World Bank (2000). World Bank Reviews global forest strategy. News release N0 2000/193/S.

Appendix.

Table 1: Unit Root Tests Statistics

	Levels		*First difference*	
	ADF	*PP*	*ADF*	*PP*
Ln (timberp)	*- 2.01*	*- 2.01*	*-4.65*	*-5.25*
Ln (cocoap)	*- 0.78*	*- 0.69*	*-4.09*	*- 4.51*
Ln (coffeep)	*- 1.85*	*- 1.71*	*-3.63*	*- 4.08*
Ln (credit)	*- 6.9*	*- 4.25*	……	…...
Ln (For)	*- 0.55*	*- 0.73*	*-3.31*	*- 4.85*
Ln (GDPPC)	*- 1.71*	*- 1.57*	*-2.68*	*- 2.66*
Ln (Vaah)	*- 1.97*	*- 1.877*	*-3.17*	*- 4.57*
Ln (Foodp)	*- 0.5*	*- 0.172*	*- 3.953*	*- 4.04*
Ln (fertp)	*- 2.02*	*- 1.674*	*- 3.09*	*- 3.855*
Ln(Temp)	*-2.73*	*-2.27*	……	*-4.38*

The critical values of Mackinon for rejecting the hypothesis of the presence of a unit root at the 1%, 5% and 10% levels are: ADF (-3.7497, -2.9969, -2.6381) and PP (-3.7343, -2.9907, -2.6348).

Table 2: Results of the estimation of the function of determinants of forest depletion

Dependent Variable Log (FOR)

Variables	*Coefficients*	*t-statistic*
Ln (Coffeep)	*-0.02816*	*-1.83****
Ln (Cocoap)	*-0.0856*	*-2,36***
Ln (timberp)	*-0.0284*	*-1.89****
Ln (Vaah)	*0.0294*	*2.67**
Ln (Credit)	*-0.00362*	*-0.717*
Ln (GDPPC)	*-0,009611*	*-0,2334*
Ln (foodp)	*-0.0504*	*-2.41***
Ln (fertp)	*-0.0175*	*-1.199*
Ln(Temp)	*-0.0602*	*-1.79****
Oilb	*-0.0368*	*-3.388**
Sap	*-0.0266*	*-2.302***
Dev	*-0.0513*	*-3.326**
C	*9.691*	*36.97**
ADF = -4.538 *PP = -6.327* $R^2 = 0.8808$ $\bar{R}^2 = 0.8647$	*Durbin-Watson Stat = 2.65* *S.D dependent Var =0.0075*	*F-statistic = 149.116* *Prob (F-stat) = 0.0000* *S.E. of regression = 0,0263*

*, ** and *** imply significance at 1%, 5% and 10% respectively.