DEFORESTATION IN CAMEROON, AND POVERTY IN THE RURAL ZONE.

BY

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ABSTRACT

The effects of deforestation in Cameroon such as the erosion of agricultural lands, drying up water bodies during dry seasons, desertification, disappearance of plant and animal species, modifications of both local and regional climatic conditions and global warming through its effect on the global carbon cycle are likely to affect agricultural activities and economic growth and therefore aggravate poverty in the rural zone. This paper investigates the immediate causes and consequences of deforestation in Cameroon between 1970 and 2000. Quantitative estimates show that coffee, and cocoa producer prices, food crop prices, and timber export price index on one hand, and the oil boom, the structural adjustment policies and the devaluation of the CFA franc on the other hand are quite important in stimulating the clearing of forests. Equally, the agricultural value added per hectare increases the profitability of maintaining forests. The implication of these results is that the importance of nonforest policies is underappreciated in Cameroon.

1.Introduction.

The progressive disappearance of tropical forests constitutes one of the major environmental problems in both industrialized and developing countries. World Bank estimates show that about 11,4 million hectares of tropical forests disappeared annually in the 1980s, and that this rate lies within the bracket of 17 – 20 million hectares per year in the 1990s (World Bank, 1992; P. 58). Whereas forests play a very important role in the genesis and maintenance of the production potential of soils and watershed protection, harbour large proportions of the world's plant and animal species, serve as a reservoir of resources in the form of food, medicinal plants and wood. Over one half of the world's living species are found in tropical forests that only occupy seven percent of the total land surface (Edward, 1988). Unfortunately, most of these species are not found in any other type of ecosystem. It has been estimated that 25 percent of the species which existed in the mid-1980s may be extinct by 2015 (Peter,1988)). If tropical forest conversion continues unabated, the world may lose between 5 and 15% of its total plant and animal species between 1990 and 2020 (Reid and Miller, 1989). These figures have significant economic and social implications. More than three quarters of the world's population depend directly on plants for medicines, many of which are extracted from tropical forests (Serageldin, 1992).

In Cameroon, the supply of fuel wood from forests accounts for over 60% of the energy consumed and has been increasing at a rate of 2.5% per year since 1974-1976 (Cleaver, 1992, P.65). The forestry sector occupies the first place in export tonnage and third place in foreign earnings. It accounts for about 4% of the Gross Domestic Product (GDP) and offer about 40,000 jobs (Besong, 1992). Cameroon's forests contain an estimated 300 different tree species and the country can be said to have a forest based-economy (Idem). With her potential, Cameroon is at the second position amongst forestry African countries after the Democratic Republic of Congo. Furthermore, forests serve as a habitat for primitive populations (Pygmy). They live in and near tropical forests and are for the most part very poor. It is then clear that the immediate survival of these people is threatened and their poverty trend is aggravated when and where forests are damaged through inappropriate development. The survival and sustainability of forests is crucial and perhaps obligatory for the interests of both the present and future generations of pygmy. Clearly, forest conservation goes hand in hand with the well-being and empowerment of the populations concerned.

Cameroon has some of the greatest biodiversity in Africa, and also has the highest percentage of logged forest of any African nation with substantial rain forest (Ndoye and Kaimowitz, 2000). In addition, Cameroon is one of the Sudano-Sahelian countries in Africa that show signs of some desertification (Cleaver, 1992). The northern part of the country was previously under forest, and due to the extreme degradation of vegetative cover, it's now under savannah grasslands. It appears therefore that deforestation in Cameroon should be the preoccupation of environmental and human resource economists, ecologists as well as policy makers because of its threat to ecological sustainability and socio-economic development in the long run.

Many of the world's tropical forests are however, being decimated as the immediate needs of the developing world overshadow the often uncertain future benefits from these forests. New studies demonstrate a rate of forest loss considerably worse than previously known (UNESCO, 1990; Houghton.R.A,1990; Serageldin. I, 1992; FAO, 2001). These studies indicate an annual tropical forest loss of over 20 million hectares, a staggering 55,000 hectares per day (Serageldin, 1992, P.337). This figure is nearly 80% above the FAO's 1980 estimate of tropical deforestation rates. Thus, within the last decade, despite the growing global concern about forest destruction, the rate of loss has continued to increase without abatement.

Applying the definition of the FAO that deforestation occurs when tree cover is reduced with at least 10% during the modification of a forest, between three and five million hectares of tropical forests disappear each year in Africa, an area greater in size than the country of Togo and larger than several European countries (UNESCO, 1990). The FAO (2001) estimated the rates of deforestation of about 18,947.8 ha and 11,903.1 ha per year in Africa respectively in the 1980s and between 1990 and 2000. With respect to the rates of tropical deforestation mentioned above, UNESCO (1990) concluded that tropical forests in Africa will be gone within 60 years.

In Cameroon, the high speed of actual forest exploitation accelerates degradation of forestry resources and the environment. It's very crucial to intensify the programmes of regeneration in zones of dense forest to compensate for trees felled for woodwork. In a total surface area of 475, 10^5 ha, forest covered an area of 280.25, 10^5 ha in 1965. This forest area dropped to 233, 10^5 ha in 1980, of which about 165 10^5 ha of exploitable dense forest was for woodwork (World Bank, 1992). Meanwhile in 1995, the extent of Cameroon forestland came down to 195.98 10^5 ha, that is a disappearance of 37.02 10^5 ha of forest compared to 1980. This forest clearing process was at different rates from one period to another. Thus, between 1980 – 1985, the World Bank (1992) estimated an annual forest disappearance rate of 110, 10^3 ha. This rate rose to 122, 10^3 during 1980 – 1990, to 190, 10^3 from 1990 to 1995 and finally to 205, 10^3 ha between 1990 - 2000 (World Bank, 1995; FAO, 2001). Generally, deforestation rate estimates in Cameroon range from 80,000 to 200,000 hectares per year (Ndoye and Kaimowitz, 2000). However, Laporte et al (1995) made the most serious effort to measure deforestation and found that an average of 130,000 ha of forest was cleared each year from the mid-1970s. One additional paper on deforestation in the area around Ndélélé in East Province confirms a marked increase in deforestation after the economic crisis in the mid-1980s (Mertens et al, 1999). According to these authors, average annual net deforestation was twice as high in the area around Yaoundé between 1987 and 1995 as it had been between 1973 and 1988. In the Ndélélé area, average annual net deforestation was four times higher between 1986 and 1996 than it had been between 1973 and 1986.

This accelerated rate of deforestation is facing a rather mediocre regeneration effort estimated at 1000 ha per year (World Bank, 1995). This is why the identification of factors leading to the halting of forest disappearance has become a priority. A step toward this aspiration is 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 causes of deforestation. Our paper falls in line with this preoccupation and intends to put elements of economic policies at the disposal of policy makers.

To better apprehend the negative externalities of deforestation, it is important to diagnose very well the causes. That is the factors that shape agents’ actions, and in particular their decision to deforest. These causes can be grouped under three categories:

- The direct sources of deforestation. Possible variables to be included here are expansion of agricultural area, fuel wood collection, and timber production.
- The immediate causes of deforestation, which are the variables that influence the decisions by the deforestation agents.
- The underlying causes, which are macro-level variables that determine deforestation behaviour through their influence on the decision parameters, but do not enter the agents’ decision problem directly.

However, the immediate and the underlying causes as well as the sources of deforestation are often mixed up when modeling the determinants of forest clearing. For the purpose of clarity and logic, it is important to distinguish the different types of factors of forest destruction (Angelsen and Kaimowitz, 1999; Kooten et al, 1998). It is therefore fundamental to note that the underlying causes of deforestation which by nature are macroeconomic variables determine the immediate causes, which in turn influences the agents of deforestation (Farmers, animal husbandry, loggers) who are in principle the sources of deforestation. The immediate causes influence the decisions by the deforestation agents. Possible variables include output and input prices, wages, access costs. The underlying causes determine deforestation behaviour through their influence on the decision parameters. Examples include GDP per capita, economic growth, foreign debt, and population growth/density (Angelsen et al, 1999). 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 stands on two motivations. Firstly, 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 immediate factors identified influence the progressive disappearance of forests 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. Secondly, given that a mixing up of the various levels of factors causing deforestation 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 the immediate causes have a direct effect on the disappearance of forests compared to the underlying causes. They determine the major decisions that farmers and loggers make (that is area to be cleared for agriculture and logging). Furthermore, 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 will be introduced. These motivations bring us to the following questions: What are the immediate causes of deforestation in Cameroon? What are the effects of these immediate factors of deforestation and what are the magnitudes of these effects? Our paper shall be oriented towards these horizons.

The remaining part of our analysis will be centered around five points. Sections 2 and 3 present the literature review and the methodological approach respectively; section 4 deals with the empirical results; and finally sections 5 and 6 cover the conclusion and the references respectively.

2. Literature review

2.1 Theoretical framework.

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). In the population approach (PA), no labour market exists, whereas a perfect labour market is assumed in the market approach (MA) 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.

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

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 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 (Angelsen et al, 1999). Thus, the production decisions of a utility-maximising household can be analysed as a profit-maximising problem. The open economy approach does not need to introduce any particular behavioural assumption for the farm household. The production problem is now to maximize total profit or land rent.

$$X = pAf(L,H,F) - qF - w[L + h(H)] \qquad (1)$$

Where X is production, A represents the technological level, L is labour input, H is total land area (assumed to be of homogeneous quality), and F is fertilizer input. The labour 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 fertiliser prices respectively.

The first order condition is summarized as follows:

$$pA = \frac{w}{f_l} = \frac{wh_H}{f_H} = \frac{q}{f_F} \qquad (2)$$

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.

2.2 Empirical review.

The causes of deforestation have been attributed to several factors. The most important categories are the immediate and the underlying causes. Barbier and Burgess (1996) analyzing the main factors affecting forest land conversion in Mexico between 1970-1985 found that maize and fertiliser prices appeared to be the main influences on the expansion of planted area. 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. In this country, 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. On the same score, 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, 1992). These results were confirmed in Malawi (Cromwell and Winpenny, 1991), and in Botswana (Perrings et al, 1988).

Previous studies on Cameroon.

Although Cameroon is the central African country that has attracted most attention from researchers and environmentalists, very few econometric studies on the causes of deforestation 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 cocoa, coffee and food production have a strong impact on forests and that pressure on forest areas increased after the oil boom, the Structural Adjustment Program (S.A.P) and the devaluation of the CFA franc in 1994. 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, 1999). This paper uses the same proxy to capture forest clearing as in Ndoye and Kaimowitz (2000). In justifying the importance of their proxies for deforestation, the paper explores the correlation between estimates of the area deforested in each village between 1991 and 1996 based on remote sensing analysis, and figures provided by farmers in household surveys about the area of agricultural plots they created or increased in 1997. This correlation was very high (r = 0.884) (P.991). These authors investigated the role of the main driving forces of deforestation at the village-level through bivariate regression analyses. They also used a linear multiple regression to identify the combination of variables driving deforestation at the village-level. However, this paper 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. Kamleu 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; Toornstra et al, 1994).

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).

2.3 Immediate factors of deforestation in Cameroon.

Cash and food crop prices, timber prices, agricultural input prices, agricultural wages and credit availability to farmers have been identified as immediate causes of deforestation in Cameroon that determine the profitability of farming and logging activities. To be in a position to mitigate or halt the effects of forest clearing with relevant counter-policies, one needs to appreciate the extent to which the immediate factors propel deforestation agents to deforest.

However, one aspect often overlooked is the environmental consequences of misguided government policies on deforestation. The effects of such policies are often indirect and unintended. With respect to social and economic costs of forest destruction, it is fundamental for tropical forestry countries to establish policies that counteract the opportunities of deforestation in situations where forest clearing is inappropriate. These policies have as goal, to make forest conversion less profitable, or other alternatives (either based on retaining forests or completely outside forest areas) be made more profitable. They can be grouped into six categories. Deforestation can be made less profitable by:

- Reducing the demand or prices for products produced from newly cleared land,
- Increasing the unit costs and riskness of activities associated with deforestation,
- Eliminating speculative gains in land markets.

Alternatives to deforestation can be made more profitable by:

- Increasing the income stream to be obtained from maintaining forests,
- Reducing the costs of maintaining forests.
- Increasing the opportunity costs of labor and capital that might otherwise be used in activities associated with deforestation.

We shall examine three of these policies.

2.3.1 Reduction of prices and demand for tropical Agricultural and forestry products.

Demand for tropical products is a function of the size and incomes of the consuming population, relative prices, quantitative trade restrictions, and consumer preferences. Policies that affect any of these variables can also affect demand.

High prices and demand for tropical agricultural commodities can stimulate the clearing of forests to produce these commodities. Therefore, policies that reduce the demand for tropical agricultural products can limit the conversion of forests to croplands and pastures. This approach has certain advantages. The policies involved are mostly national in scope, and governments can implement some of them easily and cheaply (at least with regard to their direct costs). However, these policies rely entirely on the market to distinguish where and how supply should be reduced, and this is unlikely to meet environmental objectives efficiently. In addition, it is difficult to win political support for policies that restrict the demand for or production of tropical products, particularly export products, and which restrict the incomes of primary producers in tropical developing countries.

Meanwhile, if high agricultural prices result from direct or indirect government subsidies, as is often the case, the argument for reducing demand by eliminating those subsidies is somewhat stronger. The stabilization of agricultural and forestry export product prices by the government also increases the expected profitability of deforestation both by increasing the expected sale price of outputs and by reducing the commercial risks associated with such ventures. Market promotion and marketing boards have similar effects. They both reduce market risk and volatility and increase long-run average returns to producers. Under these circumstances, eliminating subsidies or marketing assistance for products from newly cleared forestlands may be effective, and low cost.

Ceteris paribus, higher population implies more demand for agricultural products. Depending on the scope of the markets, the level of local, national, or international population may be relevant. However, income level and distribution, consumer preferences, and other factors that affect relative prices generally influence demand even more, at least in the short or medium term. After a considerable lag, policies that lead to lower population growth could potentially limit deforestation by lowering the demand for agricultural products, but the magnitude of that effect is unlikely to be large. Because population also affects many other important policy variables, governments are unlikely to design population policies principally with regard to their impact on deforestation.

Per capita income greatly influences the demand for tropical products. Some authors have speculated the existence of an “environmental Kuznets curve”, whereby at lower levels of per capita income, economic growth leads to greater deforestation as a result of increased demand for tropical products, but after income levels reach a certain threshold, deforestation declines because the economies become less dependent on agricultural and forest products, primary production becomes more intensive, new employment opportunities arise, and demand for forest preservation grows (Capistrano, 1990). The empirical evidence of this relationship is relatively weak and has been mostly based on the few “tiger economies of East Asia” which may not reflect how the majority of tropical countries are likely to evolve in the future. Nevertheless, given existing levels of per capita income in most tropical countries, without a change in the pattern of development, economic growth is likely to lead to greater forest clearing in the medium term (Stern et al, 1996). This implies that one way to avoid a tradeoff between economic growth and deforestation is for countries to promote patterns of economic development that are less dependent on primary agricultural and forestry commodities.

Exchange rate policies such as currency devaluations, designed to increase the relative price of tradable goods and services compared with non-tradables, generally increase real producer prices of tropical agricultural products, making it more profitable to convert forestland to agriculture (Capistrano, 1990; Wiebelt, 1994). This problem is most likely to arise where export producers are important agents of deforestation, such as in certain countries of South America and west and central Africa (cocoa, coffee) [Kaimowitz et al, 1996; Kaimowitz, 1997].

Because exchange rate policies are broad and far-reaching, under most circumstances concerns over inappropriate deforestation cannot be expected to be a major factor in their design. However, in situations where a large portion of anticipated export growth generated by devaluations comes from the expansion of agricultural production to areas currently under forests, the issue cannot be avoided. Policymakers should explicitly consider the tradeoffs between the possible benefits of short-term increases in exports and the costs associated with forest conversion. Alternatively, they might try to devise simultaneous parallel measures to minimize the predictable adverse impacts (Kaimowitz, Bryron, and Sunderlin, 1998).

2.3.2 Increase the costs and risks of production associated with deforestation.

Government actions that encourage intensive farming tend to reduce forest conversion, whereas interventions favouring extensive agriculture are likely to span the destruction of forests. Intensive farming means increasing the amount of labor, capital, and information applied per hectare of land (Lutz et al, 1998). Whether the expansion of market demands and higher product prices lead to more or less pressure on the forest-agriculture frontier will depend on the farmers' choice of technology (that is how much to intensify and how much to expand an area) in response to perceived opportunities.

Substantial increase in taxes and charges set by governments for the exploitation of natural forests might reduce logging in inappropriate areas and marginalize some of the least efficient operators from the industry, who may also be amongst the most destructive.

Road construction also plays a crucial role in deforestation. The general idea is that new road construction presents the greatest threat to remaining forests by providing access to forested areas (Bryant et al, 1997; Dudley et al, 1995). Roads are often essential both to market farm outputs and to deliver inputs to the farm and can greatly increase the profitability of agriculture and wood production in frontier areas. In many countries, one of the common forms of assistance requested by farmers is the extension and upgrading of road transport systems. However, the road construction and transport policy reforms that might be required to reduce deforestation activities do not necessarily involve less road building, but rather a change in the nature, type, and location of roads built.

2.3.3 Increasing the opportunity costs of labor and capital.

After examining factors that can reduce the gain related to destruction of tropical forests, we will actually be concerned with the analysis of the possibilities of intervention that can increase the profit attached to maintenance and management of forests. We have said that any policies that reduce the gain of forest destruction compared to their maintenance tend to slow the rate of deforestation. Given that labour and capital are the principal factors of clearing forest and contribute less to their maintenance, increasing their opportunity costs can reduce the speed of deforestation. Policies that increase the opportunity costs of labour and capital include general policies that promote growth as well as specific policies that promote employment. To illustrate this, in Korea and Malaysia where the opportunity costs of labour and capital are high, deforestation has considerably slowed and even been reversed. In other places where alternative returns to labor and capital remain low (Cambodia and Laos), deforestation rates remain high. This suggests possible connections between these costs and the extent of inappropriate deforestation (World Bank, 1994).

Although rapid growth in agriculture, timber industries, and plantation estates may contribute to deforestation, employment growth in sectors like tourism, textiles, and manufacturing has increased labour opportunity costs to such an extent that it has reduced deforestation. Where deforesters have been left out of that growth, and no more attractive livelihoods have emerged, deforestation has continued. This implies that the sustainable promotion of non-rural employment reduces the type of forest conversion carried out by the poor with the aim of earning a living.

As a whole, it is important to say that there is no perfect or generalise policy for the reduction of inappropriate deforestation. Each country has to choose from the set of factors examined above, a mix of variables, which can be specifically crafted to local conditions of its environment.

Finally, it is worth mentioning the structural shifts that occurred in the Cameroon economy during the period under consideration. Between 1970 and 2000, 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 (Ndoye and Kaimowitz , 2000). 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). Consequently, about 45% of cocoa farmers in the East province abandoned their cocoa area in 1993 (Toornsta et al, 1994). 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. As concerns cocoa and coffee, producer prices for these two crops rose, and farmers responded to the increases by expanding their productions. Sunderlin and Pokam (1998) found that a higher percentage of cocoa and coffee farmers increased their cultivated areas between 1993 and 1997 in the Centre and South provinces. On the same score, the same authors reported that 48% of plantain producers increased their cultivated areas between 1993 and 1997, as did 47% of producers of other food crops.

In general, it is obvious that perennial, food crop farmers, and timber exporters responded to changing economic conditions in Cameroon during the period under consideration by intensifying the pressure on forest areas through either the perennial crop sub-sector or the food crop sub-sector or both of the sub-sectors.

3. Methodology

3.1 Model specification

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

$$FOR = \alpha_0 + \alpha_1 coffeep + \alpha_2 cocoap + \alpha_3 timberp + \alpha_4 vaah + \alpha_5 GNPPC + \alpha_6 credit + \alpha_7 foodp + \alpha_8 fertp + \alpha_9 oilb + \alpha_{10} sap + \alpha_{11} dev + \mu_t \qquad [3]$$

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. Assuming complementarity between fertilizer and land area, increased fertilizer prices will reduce the area of cultivation. A positive relationship is expected ($\alpha_8 \succ 0$). **Vaah** is the agricultural value added per hectare. The higher this variable, the less the supplementary distruction of forest area. Thus the expected relationship is positive ($\alpha_4 \succ 0$). **GNPPC** represents the Gross National 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 ($\alpha_9 \prec 0, \alpha_{10} \prec 0, \alpha_{11} \prec 0$)

The above linear empirical model is a variant of the model of Osei Asare and Obeng-Asiedu (2000). However, it has originality for using two new variables, Vaah and GNPPC. The agricultural value added per hectar (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 better attached to our preoccupation than the approximate monthly revenue of farmers used by the authors mentioned above, which is even very difficult to evaluate. The second variable is the GNP per capita which influences deforestation as explained above.

3.2. Sources of data.

As mentioned above, this paper aims at estimating the immediate causes of deforestation in Cameroon from 1970 to 2000. The data used in the analysis came 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 GNPPC 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).

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 a 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 ADF 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:

$$\Delta y_t = \alpha + \rho\, y_{t-1} + \sum \gamma_j \Delta y_{t-j} + \varepsilon_t \quad . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ [4]$$

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:

$$\Delta y = \beta + \rho y_{t-1} + \mu_t \quad . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ . \ .[5]$$

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 roots test 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; and Perman, 1989).

4. Empirical Results.

4.1 Unit root tests results.

The table below reports the results of the ADF and the PP tests for the order of integration of our variables.

Table 1: Unit Root Tests Statistics

	Levels		First difference	
	ADF	PP	ADF	PP
Log (timberp)	- 2.01	- 2.01	-4.65	-5.25
Log (cocoap)	- 0.78	- 0.69	-4.09	- 4.51
Log (coffeep)	- 1.85	- 1.71	-3.63	- 4.08
Log (credit)	- 6.9	- 4.25	……	…...
Log (For)	- 0.55	- 0.73	-3.31	- 4.85
Log (GNPPC)	- 0.86	- 0.86	-3.05	- 3.05
Log (Vaah)	- 1.97	- 1.877	-3.17	- 4.57
Log (Foodp)	- 0.5	- 0.172	- 3.953	- 4.04
Log (fertp)	- 2.02	- 1.674	- 3.09	- 3.855

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).

After comparing the ADF and PP statistics in the table above with the Mackinnon critical values provided by the Eviews econometric package, we came out 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 one variable (credit) is stationary in its level. 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 the table below 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 the following table. These results meet our expectations in terms of their signs except the GNPPC, which presents a contrary sign. This is not the same situation with their levels of significance.

Tableau 2: Results of the estimation of the function of determinants of deforestation

Dependent Variable Log (FOR)

Variables	Coefficients	t-statistic
Log (Coffeep)	-0.02816	-1.7601***
Log (Cocoap)	-0.0676	-2,1**
Log (timberp)	-0.0314	-2.15**
Log (Vaah)	0.03457	3.14*
Log (Credit)	-0.00422	-0.8411
Log (GNPPC)	-0,009611	-0,2334
Log (foodp)	-0.05816	-2.9402*
Log (fertp)	-0.0143	-0.996
Oilb	-0.0326	-3.204*
Sap	-0.0275	-2.456**
Dev	-0.0519	-3.35*
C	9.465	60.24*
ADF = -4.43 PP = -6.493 R^2 = 0.9208 $\bar{R}^2$ = 0.9127	Durbin-Watson Stat = 2.19 S.D dependent Var = 0.00953	F-statistic = 162.35 Prob (F-stat) = 0.0000 S.E. of regression = 0,0253

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

The estimated coefficients of the variables coffeep, cocoap, foodp and timberp are statistically significant at 10%, 5%, 10% and 5% 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 al).

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 highly 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

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[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.

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.

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 GNPPC did not have the expected sign and is not significant. Its increase is assumed to influence the demand of agricultural and forestry products. Meanwhile, primary products in Cameroon are exported up to about 80% (Gbetnkom and Khan, 2000). This explains why the variation in GNPPC has a very little influence on deforestation.

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 91% 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 above, 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.

This paper aimed at addressing the immediate factors of deforestation in Cameroon and their magnitudes in the long-run. The empirical evidence suggest that the producer prices of coffee, and cocoa, timber prices, 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 GNP have no effect on the activities of deforestation. Finally, the oil boom, the structural adjustment policies and the devaluation of the cfa franc have seriously increased the speed of deforestation in Cameroon.

The implications of these results are such that all attempts to slow down the speed of deforestation in Cameroon must take into account the influences 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 globalization. It is worth mentioning that the liberalization of economies which put an end to the stabilization of the cash crops prices has contributed to slow down the conversion of forests to farmland, by rendering uncertain the prices paid to farmers. 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 deforestation. This is possible through the promotion of intensive farming system by increasing the amount of labor, capital, and information 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 respond 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 tropical deforestation in Cameroon, 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 (Merten et al, 1999). In order to protect the remaining forest areas, 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.

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