Forest Depletion and Food Security of Poor Rural Populations in Africa: Evidence from Cameroon

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Forests play an important role in contributing to the food security of a large portion of Africa’s food insecure. However, under current practices, this contribution is not sustainable because forests are experiencing a high rate of depletion in this continent. This paper investigates the immediate factors of deforestation in Cameroon in relation to food security of poor populations. Quantitative estimates show that 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. Finally, food security has a negative relationship with forest depletion. Therefore, in order to protect the remaining forest areas and render the contribution of forests to food security sustainable, attention to non-forest policies should be a first-order priority in the future.

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1. Introduction

Forests are valuable environmental and economic resources, which support natural systems and play an important role in the economic

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welfare of human societies. The benefits they provide in the form of food, income and watershed protection have an important and often critical role in enabling people around the world to secure a stable and adequate food supply. Forests are important to the food insecurity because they are one of the most accessible productive resources available to them. The World Bank’s recent estimates show that one quarter of the world’s poor depend directly or indirectly on forests for their livelihood (World Bank, 2000).

In Sub-Saharan Africa, where the depth and severity of poverty is at its worst (Dorward et al., 2004), people have historically had relatively unrestricted access to forests. Poorer people have thus been able to exploit the forests for food, fuel and marketable products. Where forest product-gathering activities are not restricted to the poor, they depend on these activities to a greater extent. The poor, and especially poorer women, often dominate forest product gathering and processing activities, both for household products and income. According to Sène (2000), almost one-third of the population in Africa is chronically undernourished, and rural population in many areas are compelled by socioeconomic stresses to use all the natural resources available. Foods from forests in Africa constitute an important component of household food supply. They include a wide variety of plant and animal products found in markets in both rural and urban areas. In many villages and small towns, the contribution of forests to food supply is essential for food security, as they provide a number of important dietary elements that the normal agricultural produce does not provide adequately.

Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (FAO, 1996). Embodied in this concept is the recognition that people’s ability to consume food may be dependent on their own production as well as their ability to purchase food, and that sufficiency, stability and continuity of supply are necessary to achieve food security. This definition also implies that food security entails meeting food requirements not only for current populations but also for future generations. For this reason, information should be collected on factors that play a role in limiting food availability and the options that households have for food access. However, few information systems are presently in place that adequately
incorporate both food supply (production data) and access (entitlement data) in the same indicator of food security. A food supply orientation focusing on production data persists primarily because these data are easiest to obtain and are well suited to aggregated analysis. It is this orientation that is used in this paper in the empirical analysis to assess the relationship between food security and forest depletion.

With regard to poverty, it is commonly determined on the basis of thresholds of income or consumption. These criteria, although useful for national and international statistics, fail to capture the local complexity and dynamism of poverty. They also fail to take account of current and potential resources. This is why the concept has been extended to cover the lack of food security (Krishna, 2004). Poor people lack access to sufficient amounts of food and are therefore not consuming the food required for normal growth and development. This may be because of lack of access to food, because of unavailability, insufficient purchasing power, inappropriate distribution or inadequate utilisation at the household level.

Forest products, including food and household items, and the income generated by them are quite significant to the food security of local communities in Cameroon, many of which are food insecure. There are many different kinds of food gathered from forests, ranging from termite larvae, roots, tubers, rhizomes, nuts to mushrooms and leaves. Well-known examples of leaves consumed include the Cameroonian ndole (bitter leaf), baobab (Adansonia) and many types of tree leaves used for making beverages. In the northwest, and southeast provinces, women spend several hours a day collecting mushrooms during the early rainy season. Forests also provide the habitat for many commonly consumed wild animals and fish. In many regions, trapped and hunted wild animals provide supplementary income. Sometime, forest food is smoked, dried or fermented, making it available over extended periods of time. Thus, it becomes particularly important for poorer groups of rural people especially in times of crop failure. Women are often more reliant than men on forest products, obtaining from them income needed to feed and clothe the family, as well as fuel for cooking. In cultures where women and girls suffer from intrahousehold discrimination in food distribution, the contribution of forest foods can be very important.
Generally, the poorest households have the highest degree of reliance on forest products for income and food. Forests also influence food security through their impact on supplies of fuelwood, which is a major source of income to many poor households (Townson, 1995). In some villages (Foumban, Koutaba) in the west province in Cameroon, for example, poor farmers rely on year-round fuelwood gathering as a major source of supplementary income. Two in five people worldwide, or approximately 3,000 million people, rely on fuelwood or charcoal for heating or cooking, and approximately 100 million people are already facing a ‘fuelwood famine’ (FAO, 1995). A decreased fuel supply creates constraints on food preparation, which can lower nutritional values and increases risk of food-borne diseases (FAO, 1989). In many parts of the world, women are responsible for collecting fuelwood, and the increased time required for the collection of scarcer resources can impede women’s ability to participate in household and agricultural labour and thus jeopardise the household’s food security (FAO, 1987). The contribution of forest resources to household energy supply is essential in Africa and will remain so for the foreseeable future. Africa has the highest per capita annual fuelwood consumption in the world (0.89 m³ per year) (FAO, 2005). An estimated 623 million cubic metres are taken annually from forest. Most of this is used for cooking food, thus availability of fuelwood is important for household food security and nutrition (Sène, 2000). In Cameroon, the supply of fuelwood from forests accounts for over 60% of the energy consumed and has been increasing at a rate of 2.5% per year since 1974–6 (Cleaver, 1992, p. 65). Forests also contribute to the food supply, indirectly providing fodder for livestock, thereby helping maintain a supply of milk and meat.

Forest depletion however is impairing the capacity of forests to contribute to food security and other needs. This paper focuses on tropical forests, because they are located in the areas of the world with the highest concentration of the food insecure, and they are home to approximately 300 million people who depend on hunting and gathering to survive (FAO, 1996). Many are at risk of not consuming enough food to meet their daily energy requirement on a chronic, transitory or seasonal basis. Tropical forests are currently experiencing the highest rates of clearing and degradation. In the last 8,000 years, world forest cover declined...
more than 40%, from 6,200 to 3,300 million ha (Bryant et al., 1997). From 1980 to 1990, an estimated 146 million ha of natural forests in the tropics were cleared, with an additional loss of 65 million ha between 1990 and 1995 and 7.3 million ha per year between 2000 and 2005 (FAO, 1997, 2005). In Africa, between 3 and 5 million ha of tropical forests disappear each year, an area greater in size than the country of Togo and larger than several European countries (FAO, 1996). Compared with other regions, Africa has been the most affected, with an annual deforestation rate of 0.7% (Marcoux, 2000; FAO, 2005). In Cameroon, the high speed of actual forest exploitation accelerates degradation of forestry resources and the environment. In a total surface area of $475 \times 10^5$ ha, forest covered an area of $280.25 \times 10^5$ ha in 1965. This forest area dropped to $233 \times 10^5$ ha in 1980 (World Bank, 1992). Meanwhile in 1995, the extent of Cameroon forestland came down to $195.98 \times 10^5$ ha, which is a disappearance of $37.02 \times 10^5$ ha (16%) of forest compared with 1980. This forest-clearing process was at different rates from one period to another. Thus, between 1980 and 1985, the World Bank (1992) estimated an annual forest disappearance rate of $110 \times 10^3$ ha. This rate rose to $122 \times 10^3$ ha during 1980–90, to $190 \times 10^3$ ha from 1990 to 1995 and finally to $205 \times 10^3$ ha between 1990 and 2000 (World Bank, 1995; FAO, 2001). Generally, deforestation rate estimates in Cameroon range from 80,000 to 200,000 ha per year (Ndoye and Kaimowitz, 2000). However, Laporte et al. (1999) 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.

This accelerated rate of deforestation is facing a rather mediocre regeneration effort estimated at 1,000 ha per year (World Bank, 1995). The result is that an ever-expanding rural population must rely on decreasing forest resources. In terms of household food security, this trend implies diminishing availability and the use of forest food resources, fewer income-earning opportunities for the rural poor and increased burdens on households in their efforts to meet their basic needs. Deforestation is therefore a threat to sustainable food security of poor rural populations in Cameroon. 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 alleviate poverty in this country. A step towards 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 also been significantly modified with the creation of the National Forestry Action Program (NFAP) in 1995. 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 preoccupation and intends to put elements of economic policies that attempt to render the contribution of forests to food security of poor more sustainable 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 stands on two motivations. First, as deforestation and vulnerability to food insecurity are location-specific problems 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 determine empirically the extent and the degree to which the 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 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.
These motivations raise the following questions: What are the immediate causes of forest depletion in Cameroon? 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 food security and deforestation? Our paper shall be oriented towards these horizons.

The remaining part of our analysis will be built 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 Section 5 covers the conclusion.

2. Literature Review

2.1. Theoretical Framework

When forests are cut down to provide land for shifting agriculture, pasture or for other uses, it is not conducive to sustainable development neither for agricultural practices nor for natural resource conservation. With the forests gone, foods that normally supplement diets or add valuable nutrients during times of need vanish and the available fuelwood is reduced. This leads to a number of possible consequences that negatively impact on food security of poor. Therefore, reducing or halting the process of forest clearing has a linkage with food supply and food entitlement of poorer populations.

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-maximising) 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 minimise the labour

¹ However, other approaches such as the Chayanovian or the general equilibrium approach can yield hypotheses, which are consistent with both approaches mentioned earlier.
inputs given a subsistence target, implying that consumption beyond that level has no value. Agricultural production is determined by:

\[ X = A(f(L, H, F)), \]

where \( X \) is production in physical units, \( A \) is the technological level, \( L \) is the (on the field) labour input, \( H \) is the total land area of homogeneous quality and \( F \) is the fertiliser input. The production function (1) is concave, with positive but decreasing marginal productivity of all inputs \((f_i > 0; f_{ij} < 0)\). All inputs are normal and any pair of inputs is complementary \((f_{ij} > 0; i \neq j)\). 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’ (Angelsen et al., 1999). However, there are costs related to the 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 optimisation problem is to minimise \( L + h(H) \) subject to the constraint \( sxN = pxX - qxF \). The Lagrangian function for this minimisation problem is therefore:

\[ G = L + h(H) - \lambda x[pxAx(f(L, H, F)) - qxF - sxN], \]

where \( \lambda \) is the Lagrangian parameter, and \( p \) and \( q \) are output and fertiliser 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 with 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-maximising problem. However, this does mean that the household’s overall objective is to maximise 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 production problem is now to maximise total profit or land rent.

\[ X = pA(f(L, H, F)) - qF - w[L + h(H)], \]  

where \( X, A, L, H \) and \( F \) are defined as in equation (1). As in the PA, 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, is represented by a convex function \( h(H) \); \( p \) and \( q \) are output and fertiliser prices, respectively.

The first-order condition is summarised as follows:

\[ pA = \frac{w}{f_l} = \frac{wh_H}{f_H} = \frac{q}{f_F}. \]  

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 these make 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:

\[ D = f(p, A, q, w), \]  

where \( D \) is the area of agricultural land expansion, and the other parameters are as previously specified.
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. On the basis of the market theoretical approach, Angelsen et al.’s (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 precipitate 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 (Pimentel et al., 1991; World Bank, 1994). These results were confirmed in Malawi (Cromwell and Winpenny, 1991), in Botswana (Perrings et al., 1988) and in Amazonia (Laurence et al., 2004).

2.2.1. 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 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 (SAP) 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., 1999). 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 SAP 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 SAP. 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 (Besong, 1992; Cleaver, 1992; Toornstra et al., 1994).

Compared with the studies reviewed earlier, our paper has three special novelties. First, 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 to 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). Finally, our paper examines the connection between forest depletion and food security of poor populations, which is a first quantitative attempt in the economic literature.

2.2.2. Structural Shifts in Cameroon over the Period under Consideration

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 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 metres in 1977 to 2.1 million cubic metres in 1985 (Ndoye and Kaimowitz, 2000). Timber exports grew as well, but stagnated as companies sold more timber domestically (World Bank, 1988; Foteu, 1995). The oil boom stimulated construction, and this generated greater domestic demand for timber. However, food crop production apparently grew slowly during the oil boom owing to the 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 (Toornsta et al., 1994). With respect to food crop sector, its
growing importance severely affected deforestation compared with 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 1994–6 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 fertiliser 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 in the previous section, we draw a linear model for empirical analysis of the form:

\[ \text{FOR} = \alpha_0 + \alpha_1 \text{coffeep} + \alpha_2 \text{cocoap} + \alpha_3 \text{timberp} + \alpha_4 \text{vaah} + \alpha_5 \text{credit} \\
+ \alpha_6 \text{foodp} + \alpha_7 \text{fertp} + \alpha_8 \text{oilb} + \alpha_9 \text{sap} \\
+ \alpha_{10} \text{dev} + \alpha_{11} \text{rainf} + \mu_i, \]

(6)
where $\alpha_i$ represents the respective coefficients of the independent variables, and $\mu$ is the error term associated with 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. The variable timberp is the export price index of timber. The higher these prices, the more the forest area diminishes because of conversion of new forest portions and export of timber. A negative relationship is therefore expected between these variables and FOR ($\alpha_1 < 0$, $\alpha_2 < 0$, $\alpha_3 < 0$, $\alpha_6 < 0$).

The variable fertp is the fertiliser 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 fertilisers (Angelsen and Kaimowitz, 1999). On the one hand, higher fertiliser prices lead farmers to adopt more extensive production systems that use more land and less fertiliser. On the other hand, the higher costs associated with increased fertilisers 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 ($\alpha_7 > 0$ or $\alpha_7 < 0$).

The variable 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 ($\alpha_4 > 0$). The variable 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 ($\alpha_5 > 0$).

The dummy variables oilb, sap and dev are 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 ($\alpha_8 < 0$, $\alpha_9 < 0$, $\alpha_{10} < 0$).

The variable rainf stands for rainfall and is a proxy for food security. Throughout the Sahel and the Horn of Africa, agricultural production is strongly influenced by climatic factors, especially rainfall. Rainfall is an appropriate indicator in the case of Cameroon, as acute food shortages often result from
drought. The use of this variable reflects the conventional emphasis on supply determinants of food security. A negative relationship is expected ($\alpha_{11} < 0$).

The preceding 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 rainf. 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. The second variable is the rainfall (rainf), which is a proxy for food security (Table 1).

### 3.2. Sources of Data

As mentioned earlier, this paper aims at estimating the immediate causes of deforestation in Cameroon from 1970 to 2002 and at examining the nature of the relationship between food security and forest depletion. The data used in the analysis came from various sources. The main data source was the Department of Statistics and National Accounts. Information was obtained from the following documents: *Cameroon in Figures, Annual Statistical Reports* and *National Accounts*.
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. Producer prices of cocoa and coffee, timber price index and rainfall are from various issues of *Cameroon in Figures* and *Annual Statistical Reports*. The average producer prices for food crops in CFA franc per kilogram 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 fertiliser prices in CFA franc per tonne 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 subsection, we examine the time-series characteristics of the variables, testing for stationarity and co-integration 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 auto-correlation 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:

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

(7)

A unit root test implies testing the significance of \( \rho \) against the null that \( \rho = 0 \). The 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 \textit{ex post}. The PP test is formulated as follows:

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

(8)

To test for a unit root, equation (8) is estimated by OLS, and the \( t \)-statistic of \( \rho \) 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 co-integration analysis.

### 3.3.2. Co-integration 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 the co-integration of the series used in the model (Perman, 1989; Adam, 1993).

### 4. Empirical Results

#### 4.1. Unit Root Tests Results

Table 2 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 2 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 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 co-integration test.

4.2. Co-integration Test Results

As described earlier, we ran our regressions and tested the residuals for the presence of unit roots. The results as presented in Table 3 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 (DW) already indicate that the hypothesis of the absence of co-integration between the variables can be rejected (Pindyck and Rubinfeld, 1998).

Table 2: Unit Root Tests Statistics

<table>
<thead>
<tr>
<th></th>
<th>Levels</th>
<th></th>
<th>First difference</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ADF</td>
<td>PP</td>
<td>ADF</td>
</tr>
<tr>
<td>Ln(timberp)</td>
<td>–2.01</td>
<td>–2.01</td>
<td>–4.65</td>
<td>–5.25</td>
</tr>
<tr>
<td>Ln(cocoa)</td>
<td>–0.78</td>
<td>–0.69</td>
<td>–4.09</td>
<td>–4.51</td>
</tr>
<tr>
<td>Ln(coffee)</td>
<td>–1.85</td>
<td>–1.71</td>
<td>–3.63</td>
<td>–4.08</td>
</tr>
<tr>
<td>Ln(credit)</td>
<td>–6.9</td>
<td>–4.25</td>
<td>–3.31</td>
<td>–4.85</td>
</tr>
<tr>
<td>Ln(FOR)</td>
<td>–0.55</td>
<td>–0.73</td>
<td>–3.17</td>
<td>–4.57</td>
</tr>
<tr>
<td>Ln(vaah)</td>
<td>–1.97</td>
<td>–1.877</td>
<td>–3.953</td>
<td>–4.04</td>
</tr>
<tr>
<td>Ln(foodp)</td>
<td>–0.5</td>
<td>–0.172</td>
<td>–3.09</td>
<td>–3.855</td>
</tr>
<tr>
<td>Ln(fertp)</td>
<td>–2.02</td>
<td>–1.674</td>
<td>–4.04</td>
<td>–7.18</td>
</tr>
</tbody>
</table>

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 ($3.7343, 2.9907, 2.6348$).
4.3. Empirical Results

We have used the ordinary least squares estimation procedure to obtain the results in Table 3. These results meet our expectations in terms of their signs except credit, which presents a contrary sign.

The estimated coefficients of the variables cocoap, foodp and timberp are statistically significant at 10, 10 and 5%, respectively, with the expected negative signs. This indicates that the prices paid to farmers of 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 to price increases. This is

Table 3: Results of the Estimation of the Function of Determinants of Deforestation [Dependent Variable log(FOR)]

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln(coffeep)</td>
<td>-0.02015</td>
<td>-1.08</td>
</tr>
<tr>
<td>Ln(cocoap)</td>
<td>-0.0833</td>
<td>-1.967***</td>
</tr>
<tr>
<td>Ln(timberp)</td>
<td>-0.0374</td>
<td>-2.045**</td>
</tr>
<tr>
<td>Ln(vaah)</td>
<td>0.02489</td>
<td>2.17**</td>
</tr>
<tr>
<td>Ln(credit)</td>
<td>-0.004202</td>
<td>-0.8189</td>
</tr>
<tr>
<td>Ln(foodp)</td>
<td>-0.05998</td>
<td>-1843***</td>
</tr>
<tr>
<td>Ln(fertp)</td>
<td>-0.01743</td>
<td>-1.117</td>
</tr>
<tr>
<td>Ln(rainf)</td>
<td>-0.03934</td>
<td>-2.372**</td>
</tr>
<tr>
<td>oilb</td>
<td>-0.0332</td>
<td>-3.178*</td>
</tr>
<tr>
<td>sap</td>
<td>-0.0272</td>
<td>-2.372**</td>
</tr>
<tr>
<td>dev</td>
<td>-0.0567</td>
<td>-3.179*</td>
</tr>
<tr>
<td>C</td>
<td>9.353</td>
<td>37.65*</td>
</tr>
</tbody>
</table>

ADF = -4.544
PP = -6.328
$R^2 = 0.8836$
$R^2 = 0.8597$

DW statistics: 2.44  F-stat: 141.215
F-stat: 0.0000
Standard deviation-independent variable: 0.00753
Standard error of regression: 0.09513

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

2 The results with cocoap and coffeep lagged for three years, and those with foodp lagged for one year, which are not reported in this paper. These lagged variables were not significant and deteriorated the performance of the whole model.
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; Lewis, 2006). 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., 1999).

The fertiliser price index has a negative sign and 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 fertiliser or by the difficulties to obtain reliable data on the variable. Angelsen et al. (1999) found this variable insignificant for Tanzania.

Food security proxied by rainfall has the expected negative relationship with forest depletion and is statistically significant at 5% level. This indicates that forest depletion negatively impacts on the rural poor household’s basic food needs in Cameroon.

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 utility per hectare. The higher this utility, the less the attack of the farmer of parcels of forests. This variable can therefore be at the centre of a governmental policy aimed at discouraging deforestation.

Credit to farmers does not 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.

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. As a whole, our model has performed well because all the coefficients except one have the expected signs. The adjusted coefficient of determination ($R^2$) shows that the variables included in our model have succeeded to explain at 88% 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 DW statistic. As appeared in Table 3, 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

The contribution of forests to food security in Africa is significant and will remain so for the foreseeable future. This factor must be taken into consideration in decisions regarding forest management objectives as well as food security interventions. This contribution is diversified and valuable. It ranges from direct production of food to provision of jobs and income. Also, most African households, both rural and urban, depend on fuelwood for domestic energy supply for cooking food. However, under current practices, these contributions are not sustainable because forests in Africa are experiencing the highest rates of depletion and degradation. This paper aimed at addressing the factors of forest clearing in Cameroon and their magnitudes in the long run and at examining the relationship between food security and deforestation. The empirical evidence suggests that the producer prices of 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 fertiliser price index and the credit to farmers have no effect on the activities of deforestation. The oil boom, the structural adjustment policies and the devaluation of the CFA franc increase the speed of deforestation in Cameroon. Finally the relationship between food security and deforestation is negative.
The implications of these results are such that all attempts to slow down the speed of forest depletion in order to increase the contribution of forests to food security 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 characterised by the liberalisation of economies, which put an end to the stabilisation 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 centre of governmental policies aimed at discouraging forest depletion. This is possible through the promotion of intensive farming system by increasing the amount of labour 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 (i.e., how much to intensify and how much to expand an area) in response to perceived opportunities. In addition, adequate funding of programmes designed to enforce environmental legislation, support for economic alternatives to extensive forest clearing and building institutional capacity in remote forest regions can reduce deforestation (Santilli et al., 2005).

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 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 (Mertens et al., 1999). In order to protect the remaining forest areas and render
the contribution of forests to food security sustainable, 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 for growth and also as a safety net. With this knowledge, better informed choices of trade-offs involved in forest management can be made.

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**References**


