DEFORESTATION IN GABON: DETERMINANTS OF FOREST ACTIVITIES AND ECONOMIC GROWTH AMIDST LANDSCAPE PROTECTION AND CLIMATE CHANGE CRISIS

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Abstract

Forestry is vital in the socio-progress of numerous societies and nations, especially those with abundant forest reserves, like Gabon. However, managing forests sustainably faces challenges due to factors such as population growth, expansion of agriculture, wood fuel, and round wood production at the expense of nature, habitats and tourism activities. Understanding the drivers of forest-related actions is crucial for developing policies supporting forest preservation and economic progress. This research explores the factors influencing forest-related actions and their implications for growth in Gabon, including population size, wood fuel production, round wood production, energy emissions, agriculture, and gross domestic product (GDP). Using time series methods, we analysed data from the United Nations Forest and Agriculture Organization covering the period from 1980 to 2019. We uncover significant connections through tests like Augmented Dickey Fuller (ADF) and Engle Granger cointegration test for assessing stationarity and long-term relationships among these variables as ordinary least squares (OLS) multiple regression analysis to understand their impact on economic growth. Our results highlight that population and wood fuel production affect growth while round wood production has a negative impact. Moreover, we find that wood fuel production and agriculture contribute to expanding wood production, while energy emissions also influence the economy, and yet are considered critical factors of deforestation. These insights could guide policymakers in Gabon aiming to craft strategies for forest management and economic advancement while forestering landscape protection, biodiversity and ecosystems services.

Keywords : Agriculture, Eco-toursism, deforestation and forest degradation, firewood and charcoal, landscape conservation, roundwood, Tourism activities

Introduction

Forests play a role in ecosystems by offering a range of benefits globally such habitats, soil regulation, recreation services, air regulation, climate mitigation among others. Moreover, forest ecosystem services are vital in eco-tourism given the biodiversity role they play. In nations like Gabon, where forests are abundant, they serve as a driver of economic progress and societal development (Asamoah et al., 2020, FAO, 2020, Bamwesigye et al., 2020a, Bamwesigye et al., 2020b, Bamwesigye et al., 2020c). However, managing forests sustainably faces obstacles due to social, economic, and environmental factors (Bamwesigye and Hlavackova, 2018, Bamwesigye et al., 2020a, Bamwesigye et al., 2020c). Understanding the factors influencing forest activities and their impact on growth is essential for creating policies that balance conservation with development goals (Bamwesigye et al., 2020a, Bamwesigye et al., 2020b, Bamwesigye et al., 2020c, Bamwesigye, 2023).

Gabon, situated in Central Africa, is renowned for its forest resources that cover around 88% of its land area, according to the World Bank (2019).

The country's forests protect biodiversity, support the livelihoods of many people, and contribute significantly to the national economy through activities like timber exports. However, challenges such as population growth, expanding agriculture, and rising energy emissions are hindering forest management and economic progress in Gabon (Niang et al., 2017; Nkoumou et al., 2018, Asamoah et al., 2020).

To tackle these issues effectively, Gabon's policymakers need evidence on what drives forest activities and how they impact growth. By understanding the factors influencing forest activities and their connection to indicators, policymakers can implement targeted measures to support

sustainable forest management and inclusive economic development (World Bank, 2020, Bamwesigye, 2023).
This study explores the factors influencing forest activities and their effects on growth in Gabon. Specifically, it examines the correlation between population size, wood fuel production, Roundwood production, energy emissions, agriculture, and Gross Domestic Product (GDP). Through the use of time series analysis methods and econometric models, the study aims to shed light on the relationships between these variables and how they influence economic growth as well as the impact on landscape conservation and protection which could save endangered biodiversity and forest ecosystems services. This study aims to enhance our knowledge of forest economics and sustainable development by focusing on Gabon.

Material and methods

Data collection

The study used a secondary data source from the Forest and Agriculture Organization of the United Nations (FAO) from 1980 to 2019. Although the sample size includes limited observations, there is a lack of data on the 1970 or earlier. Using FAO data is much more appropriate because it is a recognized organization under the United Nations and provides a credible report for public usage. A theoretical framework for a general model is if it takes interdependence among variables into account: GDP, energy emission, agriculture, population, Roundwood production, and wood fuel production. Research by (Hobbs, Dimitrios, & Mostafa, 2021, AboElsoud, 2018) transformed their time series into natural logarithm. However, the selected variables for the analysis of this paper were also transformed into their natural logs. Emissions are often measured in carbon dioxide (CO2) equivalent, the population in millions, gross domestic product in billions of US$, Roundwood production, and wood fuel in meters cube.
This study investigates some of the determinants of forest activities in Gabon. In achieving this objective, we consider some factors(variables) significant to the paper. It is well-known that time series analysts have a different approach to analyzing economic data (Granger, 1981). It encompasses an empirical assessment of total energy emission linkage with agriculture, population, wood fuel, and Roundwood production towards economic growth. We are observing the dynamics associated with different assessment levels and gaining much insight into the movement of torrents associated with these selected variables in Gabon. The study on the impact of GDP was conducted using quantitative analysis. The quantitative approach is analyzed to give empirical results to verify the hypothesis. The empirical outcome is utilized to make some important recommendations to policymakers in the country of study, allowing them to determine the relationship between the variables. The study used multiple regression through the ordinary least squares, the Augmented Dickey-Fuller test(ADF), and the Engle-Granger cointegration test.

Model specification

The study targeted model specification focusing on economic indicators such as (GDP and population), forest indicators (Round wood and wood fuel productions), and environmental pollution activity such as (energy emission and wood fuel usage). Round wood production can be considered part of GDP, but these activities directly affect the forest; hence it is essential to examine them individually. Investigating whether population, Round wood, and wood fuel production contribute to economic growth, an econometric model was designed to achieve the set goal as indicated in equation one (1) to answer whether these variables affect growth in Gabon since the country is endowed with large forestland.

$$lnGDP_t = \alpha + \beta_1 lnWFP_t + \beta_2 lnPop_t + \beta_3 lnRDW_t + \mu_t \quad (1)$$

$lnGDP_t$ represents the log of gross domestic product, $lnWFP_t$ indicates the log of wood fuel production $lnPop_t lnRDW_t$ and stands for the log of population and a log of Round wood production, respectively. GDP is used as the explained variable because it is often considered the most significant in assessing a country's economic growth and indicating the market size. To further expand the scope of this study, Round wood production was used as the dependent variable, as shown in model equation two (2), to investigate its relationship with population, wood fuel production, energy emission, and agriculture.

$$lnRDW_t = \alpha + \beta_1 WFP_t + \beta_2 Pop_t + \beta_3 Agric_t + \beta_4 EM_t + \mu_t \quad (2)$$

$lnRDW_t$ Indicates the log of round wood production Pop_t represents the population $Agric_t$ and EM_t stands for agriculture and energy emission, respectively. The expected sign of the selected coefficients is that wood fuel production is positive, the population is positive, agriculture is negative, and energy emission is negative An anticipated negative sign for agriculture is that activities such as farming lead to disforestation. Energy emission reduces Round wood production because of the countermeasures to stop disforestation; hence there is an expectation of a negative coefficient. Also $\beta_1, \beta_2, \beta_3, and\ \beta_4$ are the regression coefficients μ_t represents the error term α and represent the constant term of the obtained models.

Results

Augmented Dickey-Fuller test

The study used the Augmented and Dickey-Fuller to test for the assumption of the unit-root presence in the time series variables and verify the stationarity property of the times series (Dickey & Fuller, 1979). The method of testing whether a time series has a unit root or equal in Value is that the variable follows a random walk (Dickey & Fuller, 1979). Under the ADF unit root test, we exploit all three variants, including without constant, with constant, and with constant and time. Table 1 shows that the variables are non-stationary at levels.

Tab. 1: ADF Unit root test at levels and first difference

Variables	**Sample period**	**ADF T-Stat**	**p-value**	**Critical Value (5%)**	**ADF T-Stat**	**p-value**	**Critical Value (5%)**
Log of GDP	1981-2019	-2.412	0.372	-0.209	-5.443	8.39e-08	-0.881
Log of Wood Fuel Production	1981-2019	-2.074	0.559	-0.217	-6.005	4.502e-09	-0.987
Log of Population	1982-2019	-1.573	0.496	-0.001	-7.325	2.69e-10	-0.116
Log of Roundwoodm3	1981-2019	-1.368	0.599	-0.070	-5.470	7.326e-08	-0.877
Log of Agriculture	1981-2019	-3.017	0.127	-0.413	-8.592	1.261e-15	-1.332
Log of Energy Emission	1982-2019	-1.610	0.789	-0.162	-9.574	4.098e-18	-1.373

The null hypothesis of the ADF test states no unit root existence, and the alternative hypothesis of unit root presence. Table 1 above indicates a unit root presence in the time series based on the significance level of 5%. However, the first difference of variables displayed stationarity. Therefore, the series were integrated in the first order I (1). Consequently, Table 2 shows the cointegration test relationship of the residuals using the Engle-Granger test.

Tab. 2: Engle-Granger cointegration test

Unit-root $H0$: a = 1 model: (1-L) y = (a-1) *y (-1) + e	estimated Value of (a - 1): -0.508 test statistic: tau_ct (4) = -3.835 P-value= 0.036

The cointegration investigates the long-run relationship between the variables. It assesses the movement from each relative to a shock or any deviation. However, the rule of cointegration states that variables must have a unit root and no unit root in the error term. Table 2 shows that the variables meet the cointegration since the p-value of the error term is less than the 5%

significance level. Conversely, Tables 3 and 4 show the collinearity test using the variance inflation factor under the Belsley-Kuh-Welsch collinearity diagnostics.

Tab. 3: Collinearity test of model 1

Variables	Variance Inflation Factor
Log of Wood Fuel Production	6.271
Log of Population	5.821
Log of Roundwood	2.629

According to the Belsley-Kuh-Welsch collinearity diagnostics, Cond greater or equal to 30 represents strong near-linear dependence between the variables, and Cond between 10 and 30 is moderately strong. The outcomes from Tables 3 show no excessive collinearity in both models estimated using the variance inflation factor. The significance of the multicollinearity test is that its existence in a model violates the classical assumption, which states that the variables should not be a combination (none of the variables should be a perfect explanation of the other).

Regression results

Table 4 indicates the regression coefficients of the model with a log of GDP as the dependent variable. The constant of the model is not statistically significant. All variables of interest were significant for interpretation. The variable's coefficient indicates that Round wood production negatively impacts economic growth in Gabon, whereas population and wood fuel production affect growth positively.

Tab. 4: Model 1 estimation

Indicators	Coefficient	Std. Error	t-ratio	p-value
Constant	−0.406	1.357	−0.299	0.7663
Log of Wood fuel	0.841	0.153	5.494	3.30e-06***
Log of Population	0.874	0.194	4.505	6.75e-05***
Log of Round wood	−0.550	0.132	−4.166	0.0002***

Note: significance code: *** 1%

The log wood fuel production coefficient means an increase of 0.84% will lead to a percentage change in GDP. However, if the population changes by 0.87%, the GDP of Gabon is increased by a percentage difference, whereas a change in the log of Round wood production by 0.55% decreases growth. The evidence that population increases GDP is because as the number of people expands, it leads to a large labour force, which expands the country's output. On the contrary, wood fuel production increases the GDP since most of the population depends on it as a source of energy for cooking and other housing activities. The implication is that as the production of wood fuel increases, demand will expand, which leads to an expansion of the country's aggregate production. However, the model variant shows that the regressors explain 91% of the variation in GDP.

The coefficients of the variables wood fuel production, agriculture, and energy emission are statistically significant. However, the coefficient sign of energy emission shows that an increase will reduce Round wood production. On the other hand, agriculture and wood fuel production positively impact Round wood production. It means that an increase in agriculture and wood fuel expands production. Agriculture and wood fuel production directly affect round wood because agricultural activities such as clearing land for farming lead to an expansion in the dependent variable. Wood fuel production positively affects Round wood production because of their direct linkage. It is because of people's demand for wood fuel for household activities like cooking.

Discussion and Conclusion

The results of this study are in line with research that has identified population growth, wood fuel production and Roundwood production as factors influencing development in countries rich in forests. Forests ecosystems offer a range of benefits globally such habitats, soil regulation, recreation services, air regulation, climate mitigation, recreation services (tourism and eco-tourism services) among others. Moreover, forest ecosystem services are vital in eco-tourism given the biodiversity role they play. However, this study brings perspectives by examining how

energy emissions, agriculture and their consequences impact forest operations and economic progress in Gabon. The positive relationship between population growth and economic advancement underscores the importance of implementing policies to manage population growth for long-term stability. Similarly, the findings on wood fuel production and Roundwood production underscore the need for forest management strategies that balance expansion with environmental conservation objectives (Niang et al., 2017; Nkoumou et al., 2018, Asamoah et al., 2020, World Bank, 2020, Bamwesigye, 2023).

This study provides insights into the factors affecting forest-related activities and their effects on growth in Gabon. The results highlight the significance of adopting approaches to forest management that consider not only factors but also social, environmental, and cultural aspects related to forest resources. By integrating forest management practices with strategies, decision makers can promote both forest preservation and economic development in Gabon, ensuring prosperity for future generations in modern forest services such as biodiversity conservation and eco-tourism services.

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Souhrn
Lesní ekosystémy nabízejí v celosvětovém měřítku řadu přínosů, jako jsou mimo jiné stanoviště, regulace půdy, rekreační služby, regulace ovzduší, zmírňování klimatických změn, rekreační služby (turistika a ekoturistika). Pochopení hnacích sil činností souvisejících s lesy má zásadní význam pro rozvoj politik podporujících zachování lesů a hospodářský pokrok. Tento výzkum zkoumá faktory ovlivňující činnosti související s lesy a jejich důsledky pro růst v Gabonu; velikost populace, produkci dřevních paliv, produkci kulatiny, emise energie, zemědělství a hrubý domácí produkt (HDP). Odhalujeme významné souvislosti pomocí testů, jako je rozšířený Dickey Fullerův (ADF) a Engleho Grangerův kointegrační test pro posouzení stacionarity a dlouhodobých vztahů mezi těmito proměnnými, jakož i vícenásobné regresní analýzy metodou obyčejných nejmenších čtverců (OLS), abychom pochopili jejich dopad na hospodářský růst. Naše výsledky zdůrazňují, že počet obyvatel a produkce dřevních paliv ovlivňují růst, zatímco produkce kulatiny má negativní dopad. Navíc zjišťujeme, že výroba dřevních paliv a zemědělství přispívají k rozšiřování produkce kulatiny, zatímco emise energie rovněž ovlivňují ekonomiku, a přesto jsou považovány za rozhodující faktory odlesňování. Tyto poznatky by mohly být vodítkem pro tvůrce politik v Gabonu, jejichž cílem je vypracovat strategie pro hospodaření v lesích a ochranu krajiny mezi ekonomickými ambicemi a zároveň zajistit moderní lesnické služby, jako je ochrana biologické rozmanitosti a ekoturistické služby.

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