ISSN 2709-3409 (Online)

JOURNAL OF TERTIARY AND INDUSTRIAL SCIENCES

TERTIARY SCIENCES

ECONOMICS AND MANAGEMENT SCIENCES

A MULTIDISCIPLINARY JOURNAL OF THE HIGHER TECHNICAL TEACHERS' TRAINING COLLEGE, KUMBA

VOLUME 6, NUMBER 2
May, 2026

PUBLISHER:
HIGHER TECHNICAL TEACHERS' TRAINING COLLEGE (HTTTC)
UNIVERSITY OF BUEA
P.O Box: 249 Buea Road, Kumba
Tel: (+237) 33354691 – Fax: (+237) 33354692
Email: editor@jtis-htttcubuea.com
Website: https://www.jtis-htttcubuea.com

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

EDITORIAL BOARD

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

CONTENTS

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

Export Flows and Deforestation in Sub-Saharan Africa

Tchakounte Njoda Mathurin[1], Vangvaidi Albert[1] and Mbotta Ntjen Emmanuel Charberlain[2]
(1) FSEG, University of Maroua
(2) FSEGA, University of Douala – Cameroun
Corresponding Author: Phone: +237699374598 Email : vangvaidialbert@gmail.com

To Cite: Tchakounte et al. (2026), Export Flows and Deforestation in Sub-Saharan Africa. The Journal of Tertiary and Industrial Sciences, JTIS, 6(2), 19–34. https://doi.org/10.5281/zenodo.20588662

Submission Date: 28/02/2026 **Acceptance Date: 27/05/2026**

Abstract
This study focuses on economic information on the environmental sources of international business models. To do this, the study evaluates the impact of export flows on deforestation in Sub-Saharan Africa from 1990 to 2023. The sample consists of 43 countries with four regions. The mixed model version used is an unequal panel nested error component regression model. To test this hypothesis, we use a mixed model econometric approach that includes both fixed and random effects. The findings support the positive and significant effect of primary commodity exports on deforestation, thus confirming the theory that deforestation rates are higher in less developed countries where there are significant exports to many countries. This research contributes to the theory of ecologically unequal exchange, particularly by focusing on how globalization has allowed many developing countries to become part of the environmental costs of their production, which in turn makes knowledge ecologically unequal exchange. The positive results obtained using data from 43 Sub-Saharan African countries between 1990 and 2023 support the theory by confirming this hypothesis.
Keywords: Deforestation, unequal trade, weighted export flows, panel data, mixed model.

1. Introduction

In the context of faster than expected climate change, African forests are an important source and reservoir of biodiversity (fauna, flora and unknown molecules or species). In this respect, deforestation is a global problem, mostly concentrated in the tropics. It increases the world's wealth, causes land degradation, reduces forests to maintain the global climate and causes other hazards (e.g. Keller et al., 1991; Hecht, 1993; Solomon et al., 2009; FAO, 2010).

There has been progress in examining the economic context of how global trade leads to deforestation (Sheldon, 2006; Rice, 2007). Given recent advances in international trade (Copeland, 2018) and the increasing number of environmental disasters, particularly in underdeveloped countries, it is not surprising that the relationship between the global economy and the environment has received increased attention. The consequences of export and environmental degradation are a global issue facing African countries today (Tsurumi and Managi, 2014; Ordway, Asner and Lambin, 2017). Although difficult to measure, resource development by many developing countries has been identified as a major cause of environmental degradation in African countries (Jorgenson, Dick and Austin, 2010). This has become increasingly evident over time as commodity production in our underdeveloped countries, the production of monoculture products, and the extraction of natural resources for consumption by the rest of the world (especially new countries) have

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

increased. Countries with the lowest per capita resource consumption (poor countries) have the highest rates of deforestation and other environmental degradation.

This study contributes to the literature on exchange inequality theory by testing theoretical results in various models of the internationalization of deforestation in sub-Saharan African countries. To test this hypothesis, we construct a weighted index that measures the relative relationship of the vertical flow of primary export markets (e.g. agricultural products, forest products) to several countries close to the country's main export markets. Several additional economic and human ecological factors are included in the analysis to allow for a more accurate assessment. The results confirm and support the hypothesis tested. Other results are consistent with previous studies, particularly those focusing on the benefits of trade openness, economic development, or population growth.

This paper is divided into five sections. Section 1 presents literature review, section 2 the methodology focusing on general regression models, variables, and data construction. Section 3 presents and analyzes various results and constructs a hypothesis to test various hypotheses. Section 4 provides a detailed explanation of the performance of the initial business results. Section 5 Summary.

2. Literature Review

Researchs have drawn on the vast literature on economic dependency to further discuss its potential impact on other forms of dependency, particularly the relationship between economic and social dependency on the export of one or more products, but they have not addressed these issues empirically. The lack of such research hinders our understanding of the environmental impact of the entire structure of the global economy and the external performance of the environmental cost of logging. These important questions are addressed empirically by constructing measures that measure sample output and include them in the nested error panel.

In fact, many panels research have assessed the impact of export levels on deforestation (Abman and Lundberg, 2020; Carreira, Costa and Pessoa, 2024). These studies often include propositions on the relationship between exports and environmental degradation (Jorgenson, Dick and Austin, 2010). Ecologically unequal trade theory suggests that more developing and consuming countries re-transfer some of the environmental costs associated with consumption and production to less developed countries, thereby harming the environment (Jorgenson, 2006; Rice, 2007). It is argued that the process of ecologically unequal exchange occurs mainly through the vertical movement of exports from less developed countries to more developed countries (Jorgenson, 2006). Generally speaking, people living in different countries have established important positions in today's world economy and are therefore more likely to achieve and manage good economic conditions, which leads to their greater access to and absorption of natural resources. Especially African countries. This greater access makes it easier for them to transfer the environmental costs of consumption, extraction, and production to second countries, thus causing more damage and environmental damage at their borders. In other words, this system helps create the conditions that allow developed countries to overexploit the global "environment," which includes the natural resources and waste products of the ecosystems that support the organization of human life.

In many sub-Saharan African countries, most of the extracted materials, agricultural products and other important products are exported to and used in many developing

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

countries. For example, according to Forest News (2024), the direct cause of deforestation is the production and extraction of raw materials related to land use. The national economy of the sub-region is not diversified and is based on the export of agricultural products and mineral products; cocoa, coffee, rubber, cotton and wood are important activities that are heavily affected by deforestation. These countries tend to have low consumption and are vulnerable to environmental damage from consumption in many developed countries, while also imposing some environmental costs on poor countries. This will reduce consumption in the latter countries, while causing environmental degradation within their own borders.

Previous panel studies have confirmed these claims. First, developing and consuming countries tend to have the lowest levels of deforestation and other environmental degradation within their borders (Rice 2007; Jorgenson, Dick and Austin 2010). Although such explanations provide evidence for the negative relationship between consumption and environmental degradation, sometimes called the "use/degradation paradox," they do not provide direct evidence for the relationships that influence them, such as the equivalence of ecological exchange theory. However, some studies using panel regression analysis (Jorgenson 2006; Jorgenson, Dick, and Austin 2010) show that LDCs export more than developing countries, but have more deforestation at their borders. Specific studies of forest degradation in LDCs show that many developed countries use weighted measures of vertical distribution, leading directly to assessments of needs from ecological diversity theory. However, the index combines exports of all types of goods (manufacturing and services exports as well as primary industry), which questions the validity of the results. It is seen that the process of ecological imbalance directly leads to the degradation of forests in underdeveloped countries, which is mainly due to the vertical flow of exports from the primary sector to many countries.

3. Method and Data

Modelisation

In this section, we test a hypothesis from the theory of ecologically unequal exchange as follows: fewer countries exporting important goods to more countries are more affected by deforestation. To test this hypothesis, we use data for the analysis period from 1990 to 2023. The mixed model version used is an unequal panel nested error component regression model. It permet to have both fixed and random effects:

$$Deforestation_{ijt} = constant + Weighted'_{ijt}\beta + X'_{ijt}\alpha + u_{ijt} \quad (1)$$

The missing data panel for this model found nested natural groupings. Data for African countries are grouped by subregion. The parameters are β and α. The variable X_{ijt} is a vector of uncontrolled variables. The perturbation is derived from a vector of non-random control variables. The perturbation is given as follows:

$$u_{ijt} = \mu_i + v_{ij} + \varepsilon_{ijt} \quad (2),$$

with $i = 1,..., M$, $j = 1,..., N$i and $t = 1,..., T$i.

In formula (2), μ_i represents the specific unobservable effect that cannot be found in the ith sub-region, which is considered as IID(0, σ^2_μ), and v_{ij} represents the nested effect of the jth country. The ith sub-region, which is considered as IID(0, σ^2_v), ε_{ijt} represents the residual effect, which is also considered as IID(0, σ^2_ε). So μ_i, v_{ij} and ε_{ijt} are independent of

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

each other and are independent of each other. This is a nested classification in which each continuation of the error is embedded in the previous item (Graybill, 1961).

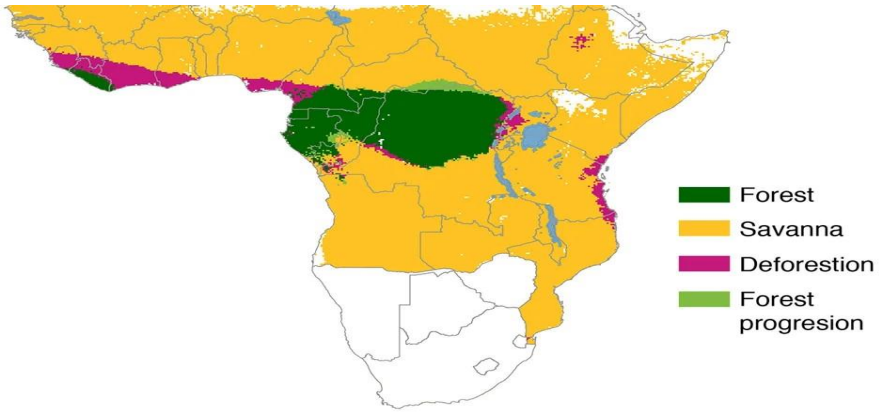
The model takes into account differences between countries within each subregion, as well as different observation periods. All prosperous and measure-neutral sub-Saharan African countries were considered. This resulted in a sample of 43 countries spread across four regions (CEMAC, COMESA, ECOWAS and SADC) (see Table A1 for a list). The following countries were excluded due to limited data: Djibouti, Mauritania, Sao Tome and Principe, Somalia, Sudan and South Sudan.

Dependant and independant variables

The measure of *deforestation* is the dependent variable, which expresses the change in land cover from forest to non-forest land. Deforestation is the conversion of intact or degraded forests to other land cover types, defined as a long-term effect in this approach. Data used are from the Global Forest Observation Database, which uses a 23-year time series (2001–2023) of countries in the database to create a new set of forest cover change data for the forest change map. For all data sources, please see Appendix A2. Statistics for 1990–2000 are from Our World in Data. Global Forest Watch data shows deforestation in unprecedented detail: (i) it covers decades of observation, (ii) it distinguishes direct clearing of intact forests from clearing of degraded forests, and more. Degraded forests are abundant. Direct deforestation is characterized by the fall of all trees within a few months. This information includes forest area and plantation areas used for other purposes.

As can be seen from Figure 1, deforestation (red in the figure) in sub-Saharan Africa has reached alarming levels in recent decades, contributing significantly, along with the Amazon situation, to global forest loss. Sub-Saharan Africa has lost around 99 million hectares of forest since 1990 (Wineman, Jayne and Stevens, 2021). This deforestation creates serious problems for the continent's forest ecosystems and the communities that depend on them, while the conversion of forests to other uses is intensifying.

Figure 1. Surface of deforestation in subsaharan africa in 2000



Source : See Aleman, J. C., Jarzyna, M. A. and Staver, A. C. (2018). Forest extent and deforestation in tropical Africa since 1900. *Nature ecology & evolution*, *2*(1), 26-33 ; see also https://news.yale.edu/2017/12/11/african-deforestation-not-great-feared-yale-research-shows

As principal independent variable, we calculate a weighted index measuring the relative size of exports from Sub-Saharan African countries to other countries since 1990. This index, called the *weighted log flow* (Weightedlog), is used to evaluate the hypothesis of

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

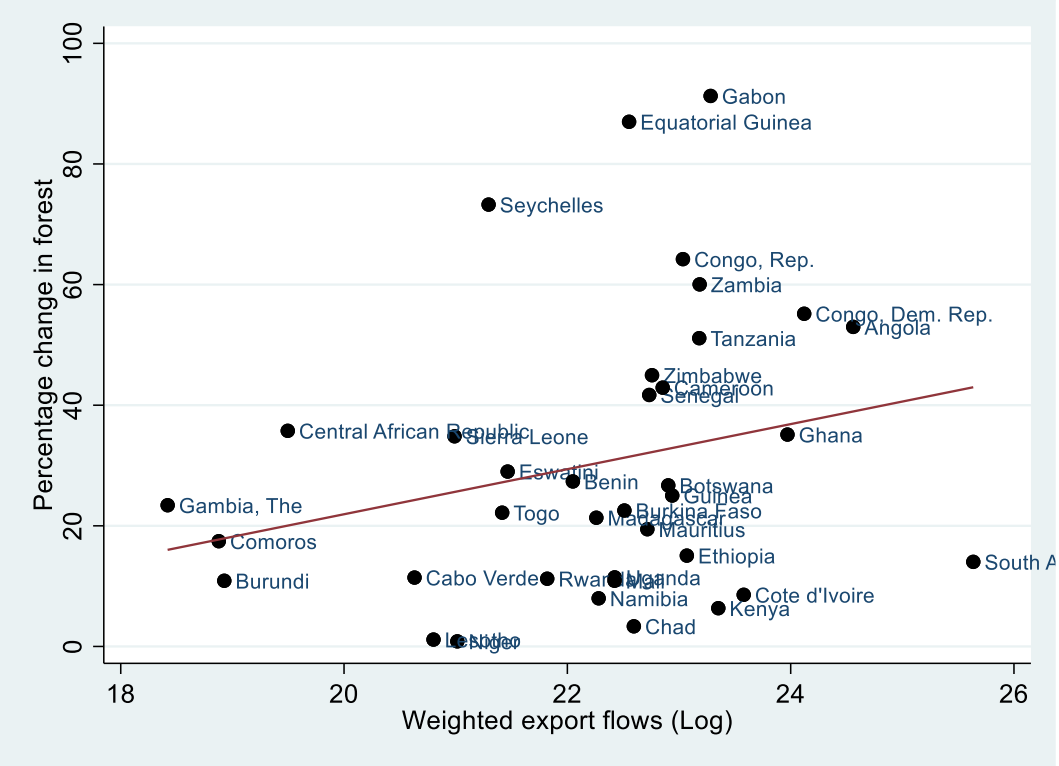
the study. The information required to construct the index includes a measure of the relationship in the form of primary exports of sending and receiving countries and a measure of the development of business or wealth in the country in the form of GDP per capita. Export data are taken from the United Nations Commodity Trade Statistics database and are expressed in US dollars. The primary data on the export market are the total volume of export flows.

The calculation formula of the weight index is as follows: $W_i = \sum_{i=j=1}^{N} p_{ij}\, \gamma_j$, where W_i is the flow weight of country i's primary export market and p_{ij} is the share of country i's primary export to country i. Recipient country j's remittances, γ_j is the per capita GDP of recipient country j. The index is calculated in three steps. The first step is to convert the primary sector export flow to the recipient country into a proportional share. More precisely, each person receives the country's exports as a proportion of the country's historical total primary economic exports. The second step is to multiply each proportion by the country's per capita GDP. The third step is to add the items in step 2. The value of these items includes the relative level of commercial exports from developing countries to other countries.

Figure 2 shows the percentage change in forests in terms of deforestation and weighted export flows for the countries in the sample in 2022. Clearly, small countries that export less, such as Burundi, Comoros or Gambia, suffer less loss in terms of deforestation, while economies with high export rates are areas where losses are enormous. However, even when exports are taken into account, there is enormous heterogeneity in deforestation. For example, while Gabon and Kenya have almost comparable export rates, the share of deforestation in the former is almost ten times higher than in the latter. The contrast between Benin and Namibia, two countries that also have similar export rates, is also striking. The share of forest loss in Benin lies almost exactly on the regression line. The share of the same losses in Namibia's economy is among the lowest in sub-Saharan Africa.

Figure 2. Export flux and deforestation in 2022

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)



Source: Authors

Control variables

In this study, *forest stock* volume (Forestlog) is the total forest or natural forest area calculated according to the world development indicators As. Data on these products are expressed in natural logarithms to correct various asymmetries. This makes it possible to control the scarcity or abundance of forest areas depending on the deforestation rates. Intuitively, the larger the forest stock, the less deforestation will occur. The higher the deforestation rate, the lower the forests.

Nearly all cross-country studies of deforestation include *gross domestic product per capita* (GDPlog) in terms of the natural logarithm. It measures a country's level of economic development. Data come from the International Monetary Fund and are presented in US dollars. The relationship between economic development and deforestation is widely discussed in the environmental economics literature. Many other studies, such as Jorgenson, Dick, and Austin (2010), find that the overall effect of the level of economic growth on deforestation is negative.

The *change in gross domestic product* (GDP) per capita looks at the percentage change in the economic development of the sample countries from 1990 to 2023. Jorgenson, Dick, and Austin (2010) found that in addition to the level of development, deforestation is also negatively associated with changes in the level of development. Therefore, we control for these two variables to allow for better hypothesis testing.

Population change (Total) is defined as the percentage of each country's population between 1990 and 2023. Data are converted to percentage change. Overall population growth is often theorized and identified as one of the main drivers of environmental degradation in less developed countries (Shaw, 1989). As ecologists suggest, human

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

population growth will have an impact on the environment, including forest areas (Cropper and Griffiths, 1994).

Exports and *imports* as a percentage of GDP measure the relative level of a country's exports and primary commercial exports. To calculate these changes, we use primary commercial exports and export prices, as well as estimated total GDP measured in US dollars. Using this information, it is possible to examine how the international business model, in the context of ecologically unequal trade, leads to forest degradation in underdeveloped countries, without considering the impact of all levels of the export industry.

The control of the difference in *CO2* emissions is expressed in tons of CO2 emitted per person in a given period. Carbon dioxide is one of the pollutants that causes global warming and local environmental damage (Solomon et al., 2009). The impact of forestry is often seen through the deforestation of large areas; trees are cut down to make way for agriculture and other land uses; these trees do not absorb more carbon dioxide if they are left to rot or burn to release carbon dioxide in the trunks and leaves. Forests are natural filters that absorb carbon dioxide from the air, but they also have a negative impact on emissions.

Openness (Trade) is used to balance the effect of trade (such as trade in agricultural and forest products) on deforestation. Globalization affects the environment. In fact, trade affects forest resources by affecting countries' production and consumption patterns (Sheldon, 2006). According to the Heckscher-Ohlin model, countries' participation in the economy depends on their profits. Rich countries with abundant resources tend to produce consumer goods. In contrast, poorer countries with more natural resources and labor will specialize in the production of natural resource-intensive products. There is an ongoing debate about the relationship between open markets and deforestation. Business can have positive or negative environmental impacts (Copeland, 2018). Theoretically, a country's international trade can have a positive or negative impact on deforestation rates.

In order to respond to the pressure from forest agriculture, we use the FAO definition of agriculture, the *value added by agriculture* (Agrilog) to the arable land area of a country (Agrilog). African countries have a comparative advantage in agricultural and forestry products, and deforestation has increased the demand for these products (Culas, 2007). Agriculture is the main cause of deforestation in developing countries, as it is beneficial in terms of income, employment and exports (FAO, 2010). This is evidenced by the fact that extensive agriculture has increased the share of cultivated land in these countries. This will cause a lot of damage, and this is the only way to increase agricultural production and income (Culas, 2007). However, as agriculture intensifies, this effect will reverse or diminish.

Population pressure exerted by *population density* (POP) affects the quality of the environment. As a result, population growth increases the demand for forest products and agricultural land, leading to deforestation. Population growth will also put pressure on the economy, increase unemployment and negatively affect forests (Culas, 2007). However, population growth can reduce deforestation through income and wealth (Cropper and Griffiths, 1994). In fact, increasing incomes can also change the demand for other energy sources such as gasoline. Advances in agricultural technology can reduce the height of forests through intensive farming practices.

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

The density of *international environmental non-governmental organizations* (EINGOs) represents the number of EINGOs reported as members of a country during the study period. Point estimates for the first year included in the analysis (1990) were used, based on previous studies on deforestation (Shandra, 2007). To provide a rough measure, a country's total EINGOs are divided by its million population. Information on EINGOs was first collected by Smith and Wiest (2005) in the Yearbook of International Associations for all EINGOs. The specific measures used here represent environmentally focused EINGOs. According to international political theory and related theories (Georgiev et al., 2024), EINGOs facilitate the transfer and promotion of international culture while influencing international political processes, helping to interpret the language of environmental agreements and policies, thus influencing the implementation of environmental policies.

Table 1. Descriptive statistics for variables included in the reported analyses

Variable	Obs	Mean	Std. Dev.	Min	Max
Deforestation	1373	34.396	24.858	.843	96.226
Weightedlog	1199	21.111	1.701	16.222	25.635
Forestlog	1373	10.502	2.212	5.036	14.225
GDPlog	1394	6.783	1.113	4.603	9.896
GDPchange	1394	1.409	6.978	-41.587	140.48
Total	1418	2.455	1.478	-16.881	16.626
Pop	1373	90.803	120.107	1.663	634.118
Exports	1199	29.556	18.666	4.429	111.52
Imports	1199	38.07	18.372	9.768	124.301
Trade	1232	67.352	33.405	19.684	235.82
CO2log	1330	7.644	1.606	4.182	13.013
Agrilog	1342	20.814	1.573	16.581	25.466
EINGO	1461	.012	.016	0	.089

Source: Authors.

Table 1 above and A3 in the Appendix present univariate statistics and correlation matrices for the test variables. The random statistics in Table 2 show that most countries in the sample have an average annual deforestation rate of around 34.39%. The export weight metric shows a rare variation in the sample when the mean is around 29.55 units, while the standard deviation of this measure is around 18.66 units. The correlation matrix in Table A3 shows that commodity exports are correlated with the average annual deforestation rate. This is not the case for most transformations.

3. Results and Discussion

The results of the regression analysis are shown in Table 2. We present five estimates using the maximum likelihood technique. The results can be expressed as a chi-square difference of 1% in general. Estimation (1) is assumed to be a simple baseline with weights of exports, forestry and agriculture. Due to the small sample size, it was not determined that a model should have more than three independent variables. Estimates (2) to (5) include the variables included in the result (Model 1) and additional estimates. Estimate (2) also includes the change in GDP per capita, and the additional estimate of the difference in estimate (3) is the change in total population. Estimate (4) includes the base estimate plus exports as the distribution of GDP, and the additional estimate variable added to estimate

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

(5) is CO2 emissions. Unstandardized regression coefficients are presented and statistical significance is schemed.

Overall, the results confirm the empirical hypothesis. Weighted export flows from sub-Saharan African countries have a positive effect on deforestation (Jorgenson, Dick and Austin, 2010), with the balance of effect being stable in most of the five models. This result confirms this hypothesis as well as supporting the importance of the theory of ecologically unequal exchange. Vertical flows of primary trade exports have caused deforestation in less developed countries (Jorgenson, 2006; Rice, 2007). Regarding other determinants, deforestation was negatively correlated with the level of development and positively correlated with changes in growth, consistent with recent comparisons of forest degradation. In fact, the growth of the economy can be associated with a negative deforestation rate because during the period of economic expansion, financial capital has the opportunity to invest in activities addressing forest loss (Rudel, 2023).

The results for overall population change are positive, a result that bears resemblance to long-standing discussions on the environmental impacts of population growth. The effect of the ratio of primary economic exports to GDP is more significant. In addition to allowing for a more rigorous evaluation of hypotheses, the main effects and accepted recommendations clarify the importance of examining the environmental impacts of international business models and the economy as a whole. Finally, the effect of CO2 emissions is negligible. In other words, there appears to be no relationship between deforestation and soil CO2 emissions (Keller et al., 1991).

The results of the second estimation are summarized in Table 3. Estimates (4), (5) and (6) control for the variables and measure openness to international trade. Estimate (7) gives results that take into account the effect of the primary economy, which replaces the insignificant CO2 change in the table 3.

Table 2. Coefficients (1) for panel regression analyses of deforestation in subsaharan countries, 1990–2023

Deforestation	(1)	(2)	(3)	(4)	(5)
Weightedlog	0.355***	0.359***	0.358***	1.471***	0.180
	(-3.39)	(-3.43)	(-3.42)	(-8.61)	(1.60)
Forestlog	13.50***	13.52***	13.50***	12.54***	12.15***
	(36.41)	(36.45)	(36.44)	(33.14)	(32.26)
GDPlog	-0.731***	-0.735***	-0.728***	0.752**	-0.599***
	(-4.18)	(-4.21)	(-4.17)	(3.01)	(-3.60)
GDPchange		0.00849*			
		(1.90)			
Total			0.0498*		
			(1.91)		
Exports				0.0515***	
				(8.12)	
CO2log					-1.364
					(-10.71)

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

_cons	-94.74***	-94.85***	-94.78***	-72.89***	-82.39***
	(-14.14)	(-14.15)	(-14.15)	(-10.76)	(-12.95)
Prob > chi2	0.000	0.000	0.000	0.000	0.000
N	1161	1161	1161	1161	1123

Source: Authors. *t* statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3. Coefficients (2) for panel regression analyses of deforestation in subsaharan countries, 1990–2023

Deforestation	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Weightedlog	0.355***	0.359***	0.358***	1.471***	0.545***	1.045***	0.249*
	(-3.39)	(-3.43)	(-3.42)	(-8.61)	(-4.31)	(-6.65)	(-2.33)
Forestlog	13.50***	13.52***	13.50***	12.54***	13.53***	13.21***	12.52***
	(36.41)	(36.45)	(36.44)	(33.14)	(36.58)	(35.82)	(31.96)
GDPlog	-0.731***	-0.735***	-0.728***	0.752**	-0.442*	0.244	0.136
	(-4.18)	(-4.21)	(-4.17)	(3.01)	(-2.15)	(1.01)	(0.62)
GDPchange		0.00849*					
Total			0.0498*				
Exports				0.0515***			
Imports					0.0117**		
Trade						0.0182***	
Agrilog							1.061***
_cons	-94.74***	-94.85***	-94.78***	-72.89***	-93.47***	-85.04***	-70.82***
	(-14.14)	(-14.15)	(-14.15)	(-10.76)	(-14.01)	(-12.75)	(-9.85)
Prob > chi2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	1161	1161	1161	1161	1161	1161	1134

Source: Authors. *t* statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The results of the control variables are different in terms of sign and degree of significance. The significance of the export variable is accepted. In fact, its coefficient is positive and significant at the 1% level. The increase in exports has led to the production of forest products in order to meet external demand. On the other hand, import activities are increasing in the domestic market. Both industries use raw materials or sell products to customers. On the other hand, high import prices provide producers with the opportunity to increase the value of forest products and engage in many activities at the same time. Imports have a positive effect on deforestation, but the effect is smaller compared to exports (Hech, 1993; Belloumi and Alshehry, 2020).

Another conclusion is that the open market and the agricultural revolution have achieved the desired results. This means that both the increase in trade in forest products and the expansion of agricultural land will lead to increased deforestation in African countries. More importantly, openness to trade is a major driver of deforestation in sub-Saharan Africa. This conclusion is consistent with the recent contribution of Tsurumi and Managi (2014) who reported that open markets for both primary and total products lead to deforestation. Clearance is what drives forest change. The main link is clearing caused by the processing of agroforestry products for export (Abman and Lundberg, 2020; Carreira, Costa and Pessoa, 2024). Increasing demand for agricultural and forest products is driving tropical countries to expand their agricultural activities through deforestation and logging.

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

Olive oil, soybeans, cocoa, coffee, rubber, and wood products are good examples of export commodities that drive deforestation in sub-Saharan Africa (Ordway, Asner and Lambin, 2017; Goldman et al., 2020).

4. Robustness Analysis

To verify the robustness of the results, the econometric analysis focuses on three systems. First, the control variable of population growth is removed and forest area is replaced by population density. Another management change is to include the work of international environmental non-governmental organizations (EINGOs). Many organizations focus on destroying forests and the environment in general. Second, another simple measure of deforestation, the deforestation rate, actually serves two purposes. The first goal is to find out what kind of results can be obtained from different measurements of different variables. The second goal is to ensure the stability of the results.

Compared to these main targets, the overall analysis shows that the importance of exports does not change, with population density and the differences in delivery under control on the one hand, and the differences on the other hand changing the importance of exports (Table 4). Population density and imports play a negative role in deforestation, although their effects are not very strong. The efforts of international environmental NGOs also yielded negative results, as expected; but not so significant. In this context, the results show that EINGO has a weak effect on deforestation in Sub-Saharan Africa. This can be confirmed by the results of other studies (Jorgenson, Dick and Austin, 2010).

Third, we also try to verify whether there is a relationship between average income and forestry, as discussed in the literature (Pablo-Romero, Sánchez-Braza and Gil-Pérez, 2023). In fact, as Joshi and Beck (2016) found in the case of African countries, while average income plays a negative role in deforestation, the square of money plays a positive role. Growth in GDP per capita does not necessarily lead to deforestation; however, after reaching a certain threshold, the forest will shrink. These results are consistent with Caravaggio (2020), Adila, Nuryartono and Oak (2021), and Ajanaku and Collins (2021).

Table 4. Coefficients (3) for panel regression analyses of deforestation in subsaharan countries, 1990–2023

Forestlog	(1)	(2)	(3)	(4)
Weightedlog	0.00744 (-0.72)	0.0121 (-1.17)	0.00132 (0.13)	0.000621 (0.06)
Pop	-0.000466*** (-3.91)	-0.000507*** (-4.24)	-0.000219 (-1.88)	-0.000217 (-1.87)
Imports	-0.000648 (-1.86)	-0.000508 (-1.46)	-0.00200*** (-5.73)	-0.00200*** (-5.73)
GDPlog	-0.215*** (-4.38)	-0.0452** (-2.79)		
GDPlog2	0.0120*** (3.66)			
Exports			0.00213*** (4.07)	0.00216*** (4.21)

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

Agrilog			0.0853***	-0.0849***
			(-6.90)	(-6.89)
Trade			0	
			(.)	
EINGO			0.185	
			(0.42)	
_cons	11.58***	11.09***	12.20***	12.21***
	(23.23)	(23.11)	(26.40)	(26.39)
Prob > chi2	0.000	0.000	0.000	0.000
N	1161	1161	1134	1134

Source: Authors. *t* statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5. Conclusion

The importance of forest conservation in the context of ecologically balanced trade between developed and developing countries has led to a reassessment of the relationship between exports and deforestation. The theory suggests that a layered international economy allows more developed countries to create their environmental costs through the vertical distribution of exports from less developed countries. It is also argued that the change in environmental cost exacerbates the situation of environmental degradation in less developed countries. Our view is therefore that sub-Saharan African countries have a high level of primary economic exports to the rest of the world and hence higher deforestation. To test this hypothesis, we use a mixed model econometric approach that includes both fixed and random effects. The positive results obtained using data from 43 Sub-Saharan African countries between 1990 and 2023 support the theory by confirming this hypothesis.

The findings support the positive and significant effect of primary commodity exports on deforestation, thus confirming the theory that deforestation rates are higher in less developed countries where there are significant exports to many countries. This research contributes to the theory of ecologically unequal exchange, particularly by focusing on how globalization has allowed many developing countries to become part of the environmental costs of their production, which in turn makes knowledge ecologically unequal exchange.

Several other factors also help explain the differences in deforestation across countries. Previous studies have shown that the level and change of economic development have a negative and positive effect on deforestation, respectively, while forest degradation affects overall population development. The importance of the variable has been recognized. Increased exports have also led to an increase in the number of forest products produced to meet external demand. Similarly, increased trade in forest products and the expansion of agricultural land have led to increased forest cover in African countries. However, the role played by carbon dioxide emissions is positive but not significant.

Overall, these results support human ecological theory as well as various economic theories. For example, the integration of economic measures, agricultural and economic development policies can reduce deforestation costs. Since the study is possible, we focus only on the impact of forest product exports on deforestation in African countries. However, other types of exports can affect forests. These include agricultural and mining exports from poor countries to rich countries.

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

6. References

Abman, R., & Lundberg, C. (2020). Does free trade increase deforestation? The effects of regional trade agreements. *Journal of the Association of Environmental and Resource Economists*, *7*(1), 35-72.

Adila, D., Nuryartono, N., & Oak, M. (2021). The Environmental Kuznets Curve for Deforestation in Indonesia. *Economics and Finance in Indonesia, 67*(2), 195.

Ajanaku, B. A., & Collins, A. R. (2021). Economic growth and deforestation in African countries: Is the environmental Kuznets curve hypothesis applicable? *Forest Policy and Economics, 129*, 102488

Belloumi, M., & Alshehry, A. (2020). The impact of international trade on sustainable development in Saudi Arabia. *Sustainability, 12*(13).

Caravaggio, N. (2020). A global empirical re-assessment of the Environmental Kuznets curve for deforestation. *Forest Policy and Economics, 119*, 102282.

Carreira, I., Costa, F., & Pessoa, J. P. (2024). The deforestation effects of trade and agricultural productivity in Brazil. *Journal of Development Economics*, *167*, 103217.

Copeland, B. R. (2018). *Trade and the environment: Recent evidence and policy implications*. ADBI Working Paper.

Cropper, M., & Griffiths, C. (1994). The interaction of population growth and environmental quality. *The American Economic Review*, *84*(2), 250-254.

Culas, R. J. (2007). Deforestation and the environmental Kuznets curve: An institutional perspective. *Ecological economics*, *61*(2-3), 429-437.

FAO (Food and Agriculture Organization) (2010) Global Forest Resources Assessment, Main report. FAO Forestry Paper 163, Rome, Italy.

Forests News (2024), Central Africa: Battling deforestation, balancing development, https://forestsnews.cifor.org/82512/central-africa-battling-deforestation-balancing-development?fnl=en

Georgiev, G., Alasaly, S., Fatima, S., & Sommer, J. M. (2024). Does Freedom of Domestic Movement Impact Forest Loss? A Cross-National Analysis. *Socius*, *10*, 23780231241238673.

Goldman, E., Weisse, M., Harris, N., & Schneider, M. (2020). Estimating the role of seven commodities in agriculture-linked deforestation: Oil palm, soy, cattle, wood fiber, cocoa, coffee, and rubber. *Technical Note, World Resources Institute*.

Graybill, F.A. (1961). *An introduction to linear statistical models*. New York: McGraw-Hill.

Hecht, S. B. (1993). The logic of livestock and deforestation in Amazonia. *BioScience*, *43*(10), 687-695.

Jorgenson, A. K. (2006). Unequal ecological exchange and environmental degradation: A theoretical proposition and cross-national study of deforestation, 1990–2000. *Rural Sociology*, *71*(4), 685-712.

Jorgenson, A. K., Dick, C., & Austin, K. (2010). The vertical flow of primary sector exports and deforestation in less-developed countries: A test of ecologically unequal exchange theory. *Society and Natural Resources*, *23*(9), 888-897.

Joshi, P., & Beck, K. (2016). Environmental Kuznets curve for deforestation: evidence using GMM estimation for OECD and non-OECD regions. *iForest-Biogeosciences and Forestry*, *10*(1), 196.

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

Keller, M., Jacob, D. J., Wofsy, S. C., & Harriss, R. C. (1991). Effects of tropical deforestation on global and regional atmospheric chemistry. *Climatic change*, *19*, 139-158.

Ordway, E. M., Asner, G. P., & Lambin, E. F. (2017). Deforestation risk due to commodity crop expansion in sub-Saharan Africa. *Environmental Research Letters*, *12*(4), 044015.

Pablo-Romero, M. P., Sánchez-Braza, A., & Gil-Pérez, J. (2023). Is deforestation needed for growth? Testing the EKC hypothesis for Latin America. *Forest Policy and Economics*, *148*, 102915

Rice, J. (2007). Ecological unequal exchange: Consumption, equity, and unsustainable structural relationships within the global economy. *International Journal of Comparative Sociology*, *48*(1), 43-72.

Rudel, T. (2023). Population, development and tropical deforestation: a cross-national study. In *The causes of tropical deforestation* (pp. 96-105). Routledge.

Shandra, J. M. (2007). Economic dependency, repression, and deforestation: a quantitative, cross-national analysis. *Sociological Inquiry*, *77*(4), 543-571.

Shaw, R. P. (1989). Rapid population growth and environmental degradation: Ultimate versus proximate factors. *Environmental Conservation*, *16*(3), 199-208.

Sheldon, I. (2006). Trade and environmental policy: A race to the bottom? *Journal of agricultural economics*, *57*(3), 365-392.

Smith, J., & Wiest, D. (2005). The uneven geography of global civil society: National and global influences on transnational association. *Social Forces*, *84*(2), 621-652.

Solomon, S., Plattner, G. K., Knutti, R., & Friedlingstein, P. (2009). Irreversible climate change due to carbon dioxide emissions. *Proceedings of the national academy of sciences*, *106*(6), 1704-1709.

Tsurumi, T., & Managi, S. (2014). The effect of trade openness on deforestation: empirical analysis for 142 countries. *Environmental Economics and Policy Studies*, *16*, 305-324.

Wineman, A., Jayne, T. S., & Stevens, C. (2021). The relationship between medium-scale farms and deforestation in Sub-Saharan Africa. *A United States Agency for International Development (USAID) Paper on the relationship between medium-scale farms and deforestation in Sub-Saharan Africa*.

APPENDIX

Table A1. List of countries in the sample

Cameroon	Burundi	Benin	Angola
Chad	Comoros	Burkina Faso	Botswana
Central African Republic	Congo, Dem. Rep.	Cabo Verde	Eswatini
Congo, Rep.	Eritrea	Cote d'Ivoire	Lesotho
Equatorial Guinea	Ethiopia	Gambia, The	Malawi
Gabon	Kenya	Ghana	Mozambique
	Madagascar	Guinea	Namibia
	Mauritius	Guinea-Bissau	Seychelles
	Rwanda	Liberia	South Africa
	Seychelles	Mali	Zambia

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

	Uganda	Niger	Zimbabwe
		Nigeria	
		Senegal	
		Sierra Leone	
		Togo	

Table A2. Source of variables

Variable	Description	Source
Deforestation	Percentage change in forest	https://www.globalforestwatch.org/ https://ourworldindata.org/deforestation
Weightedlog	Weighted export flows (Log)	https://comtradeplus.un.org/
Forestlog	Total size of total forest (Log)	https://data.worldbank.org/indicator/AG.LND.FRST.ZS
GDPlog	Gross domestic product per capita (Log)	https://www.imf.org/external/datamapper /NGDPDPC@WEO/OEMDC/ADVEC/WEOWORLD
GDPchange	Gross domestic product per capita change	https://databank.worldbank.org/metadataglossary/world-development-indicators/series/NY.GDP.PCAP.KD.ZG
Total	Total population change	https://www.unfpa.org/data
Pop	Population density	https://www.macrotrends.net/global-metrics/countries/WLD/world/population-density https://population.un.org/wpp/
Exports	Exports of goods and services (% of GDP)	https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?locations=DE.
Imports	Imports of goods and services (% of GDP)	https://data.worldbank.org/indicator/NE.IMP.GNFS.ZS
Trade	1.1 Trade openness	https://www.theglobaleconomy.com/rankings/trade_openness/
CO2log	1.2 Annual carbon dioxide emissions (Log)	https://www.statista.com/statistics/276629/global-co2-emissions/
Agrilog	Agriculture, forestry, value added	https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS
EINGO	Environmental international nongovernmental organization	https://uia.org/yearbook?qt-yb_intl_orgs=1 https://data.worldbank.org/indicator/SP.POP.TOTL

Table A3

Journal of Tertiary and Industrial Sciences *Vol. 6, No. 2, 2026*
ISSN 2709-3409 (Online)

	Deforestation	Exports	Forestlog	GDPlog	GDPchange	Total	Pop	Weighted log	Imports	Trade	CO2log	Agrilog	EINGO
Deforestation	1												
Weightedlog	0.395***	1											
Forestlog	0.336***	-0.0319	1										
GDPlog	0.269***	0.664***	-0.147***	1									
GDPchange	-0.0994***	0.0350	-0.0714*	0.0543	1								
Total	0.0706*	-0.128***	0.272***	-0.205***	-0.0618*	1							
Pop	-0.228***	-0.0407	-0.690***	0.106***	0.0780**	-0.220***	1						
Exports	0.122***	0.417***	0.544***	0.530***	0.0484	0.0478	-0.238***	1					
Imports	0.0442	0.664***	-0.409***	0.386***	0.0935**	-0.267***	0.106***	-0.0104	1				
Trade	0.242***	0.914***	-0.240***	0.577***	0.0702*	-0.216***	0.0351	0.225***	0.911***	1			
CO2log	0.0645*	0.210***	0.562***	0.395***	0.00718	0.0102	-0.265***	0.903***	-0.123***	0.0495	1		
Agrilog	-0.182***	-0.353***	0.621***	-0.203***	0.0364	0.226***	-0.204***	0.610***	-0.549***	-0.493***	0.628***	1	
EINGO	-0.0179	0.227***	0.190***	0.210***	-0.000439	-0.201***	-0.253***	0.262***	0.157***	0.211***	0.352***	-0.0428	1

Source: Authors. *t* statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$