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Deforestation and Welfare: Evidence from Africa

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Deforestation and Welfare: Evidence from Africa

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Abstract

This paper examines the effects of deforestation on the welfare of rural communities in the Congo Basin. Using moment conditions of agricultural and forest exploitations, findings indicate deforestation significantly improves welfare both at overall-rural and agricultural household per capita income levels. As a policy implication, in the process of forest exploitation a balanced approach is needed to take account of the interests of both rural communities, timber companies and international forest-sustainability standards. This should require among other things, the development and implementation of sustainable forest management plans by timber companies, exclusion from harvesting species that are important to local communities, compensation of timber companies for compliance with management plans as well as involvement of rural communities in monitoring the activities of timber companies.

JEL Classification: J10; L73; N50; O13; Q23

Keywords: Demography; Forestry; Agriculture; Welfare; Africa

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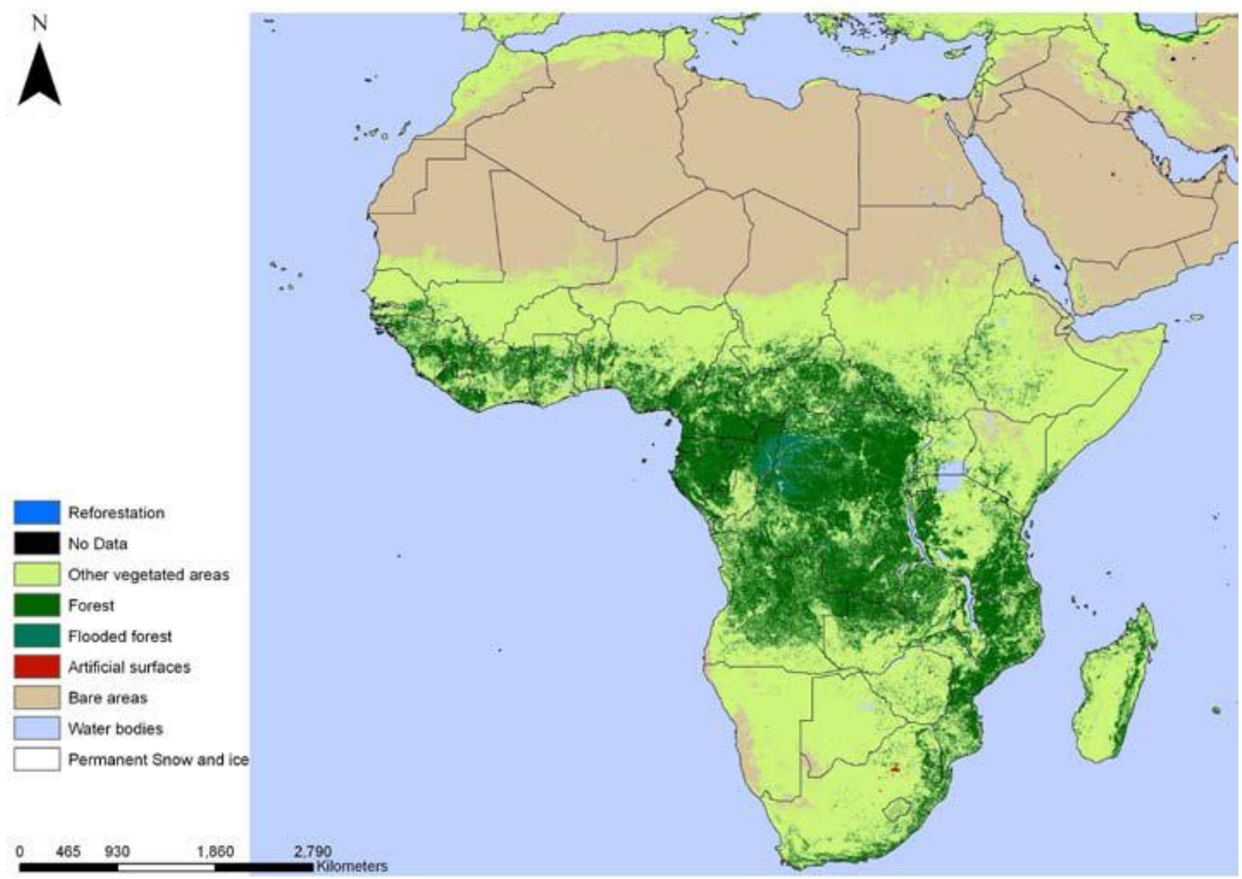
1. Introduction

From time immemorial the destiny of humans and trees has remained tightly bound. Forests have exerted a tremendous influence on living conditions and economic development in many societies. In spite of the benefits to different stakeholders derived from forest resources, the activities of deforestation have been identified as the most significant threat to the integrity of tropical rainforest ecosystems and the livelihoods of forest dwellers in the Congo Basin (Asongu & Jingwa, 2012a,b).

The growing importance of timber production and the continued use of forest damaging logging practices, the multiple-use value of most timber species, the ongoing structural adjustment programs have all contributed to the currents distressing trends of climate change and calls for sustainable forest management. One of the most pressing concerns facing forestry in Africa is that of reconciling the needs of timber companies with those of forest dependent people. When timber companies have exhausted commercial species in one region, they simply move to another. This has already happened in Ivory Coast, where-in some of the companies responsible for the devastation of the natural forest of that country in recent years are currently operating in Cameroon and other countries in the Congo Basin. Local forest-dependent indigenes however lack such mobility and will consequently remain in poverty. The need to re-examine the social, economic and environmental effects of industrial timber logging on local communities and biodiversity conservations has been widely recognized by the international community (FSC, 2000; Ahadome, 2002). If stringent measures are not put in place, the near future will be characterized by the liquidation of timber stocks and degradation of forests along with rural livelihood opportunities (Noye & Tieguhong, 2004).

This study aims to examine the current situation in the Congo Basin forest region and from the findings, discuss improvements in conversation and sustainable forest management in order to maintain ecosystem integrity and sustain the livelihoods of forest-dependent people. The findings will be interesting to global policy makers, national governments and local communities, given current distressing features of climate change and the endangerment of animal, bird and plant species. The remainder of the paper is organized in the following manner. The introductory part is completed with a picture-presentation of the story. Section 2 reviews existing literature. The data and methodology are presented and outlined respectively in Section 3. Empirical analysis and discussion are covered in Section 4. Section 5 concludes.

Figure 1: Forest and woodland cover in Africa



Source: ESA / ESA Glob Cover Project, led by MEDIAS-France

From Figure 1, it could be seen that in the heart of Africa lies the world's second largest tropical forest: the Congo Basin. It is a mosaic of rivers, forests, savannas, swamps and flooded forests. This basin which covers 500 million acres of land constitutes one of the most important wilderness areas left on earth and teems with animal, plant and bird species. It spans across six countries, namely: Central African Republic, Cameroon, Democratic Republic of Congo, Republic of Congo, Equatorial Guinea and Gabon. The rainforest there-in provides many benefits including: regional climate regulation, socio-economic value to local communities and water flow, water quality protection, a home for most of Africa's remaining forest elephants and great apes, many minerals used to create consumer electronics, gold and diamonds…etc. One major economic activity of the Congo basin is timber production. The FAO (2001) estimated that the total timber production in six countries of the Congo Basin soared by 47% between 1993 and 2001. Ndoye and Tieguhong (2004) suggest that 61% of these timber species extracted from forests in Cameroon have important non-timber values that contribute to the livelihoods of local communities. These points emphasize the importance of sustainability of forest resources for the livelihoods of local communities; which is the object of this paper.

2. Existing Literature

2.1 Theoretical highlights

Drawing from Adam Smith and Karl Marx to present day political and neoclassical economists, the roles of markets and production forces in shaping and adjusting economic relations of production and social institutions is evident in the forestry industry. Both Smith and Marx asserted that capitalist economic expansion, through investment and trade would inevitably transform pre-capitalist social productive relations. Therefore in line with their positions, depletion of forest-areas could be attributed to market pressures on forest resources. By the same token, some theorists link demographic changes to shifts in relative prices and suggest that the two may move in hand-in-glove and there-by affect the development of market patterns of resources use (North & Thomas, 1973).

Cropper and Griffins (1994) re-characterized the Malthusian theory of population growth based on environmental quality measured by the absence of air and water pollution or the stock of forests. In many developed and developing regions, the effect of demographic change on deforestation and environmental degradation has been buffered to a large extend because higher GDPs, growing economies and sufficient awareness in these regions enable the development and use of clean energy. On the contrary, in the least developed countries and communities, deforestation remains an important concern that endangers the very existence of the local communities who are forest-dependent for a livelihood.

2.2 Strands in the literature

2.2.1 The overpopulation thesis

In the literature of deforestation, food scarcities, soil degradation, loss of biodiversity, underdevelopment and global warming, the concern with population pressure is ubiquitous. Scholars mostly focus on overpopulation when it comes to resource-use (Wilson, 1992; Avise, 1994; Nimai & Debnarayan, 2001; Cochet, 2004; Asongu, 2013a, b). Two themes in the literature about overpopulation merit a critical perspective: the concern with population growth in the developing world and concern with activities of the numerous small producers that exploit land.

These views could be summed-up in the following sentences: "*Exploding human populations are degrading the environment at an accelerating rate, especially in tropical countries*" (Wilson, 1988), "*Many environmental problems including elimination of tropical rain* *forest and reductions in biodiversity are mostly clearly evident in the Third World*", (Bilsborrow & DeLargy, 1990), "*the most important thing the Chinese government can do to break the vicious cycle of overpopulation and deforestation is to promote the practice of family planning and strictly control population growth*" (Li, 1990), "*one view is that macro level socio-economic factors, especially demographic pressures, chiefly affect forest use and that population pressures have contributed to environment degradation*" (Nimai & Debnarayan, 2001). "*Though growth in population may appear not to have an impact on investment in the short spell, in the distant future, it strangles public finances. Therefore measures should be adopted such that, rising unemployment rate resulting from population growth be accommodated by private sector investments".* (Asongu, 2013a).

2.2.2 Market pressure on resources

In the same manner as a vast literature asserts the importance of overpopulation in determining resource depletion, a powerful intellectual tradition ranging from Adam Smith and Karl Marx to present day political and neoclassical economists, emphasize the roles of markets and production forces in shaping and adjusting economic relations of production and social institutions. Both Smith and Marx were confident that capitalist economic expansion, through investment and trade would inevitably transform pre-capitalist social productive relations. Some theorists link demographic changes to shifts in relative prices and suggest that the two move together and thereby affect the development of market patterns of resources-use (North & Thomas, 1973). With regard to these theorists, lower prices that prevail in integrated markets, the constant revolutionizing of production and prices that come about as a result of greater specialization create an ever increasing demand and in-turn ever greater production. Therefore the integration of local resource systems into larger markets while providing for greater economies of scale also exposes them to demand from a larger system and hence, creates greater harvesting and deteriorating pressures on a finite local resource system.

Within this context, the forest in the Congo Basin has become exposed to market pressures and thus timber logging for commercial purposes is regardless of the subsistence needs of local users (predominantly the rural and agricultural population). As market pressures pushes timber companies to extract forest products at higher rates (rendering environmental degradation inevitable), the local communities whose livelihoods are forest-dependent become increasingly threatened. Given the high rate of corruption in the countries making-up the Congo Basin, noncompliance with resource management rules could go unsanctioned.

2.2.3 The importance of local institutional arrangements

This strand of the literature points out the role of institutions, culture and technology in shaping the manner in which human action affects resource management. Whereas many resource management theorists and demographers assert that overpopulation and market pressures results to overharvesting and decrease in local resource management systems, an equally vehement group of scholars champions the positive role of local resource managers (Chetri & Pandey, 1992; McKean, 1992).

Davis (1991) clearly saw the link between population, culture and the environment: *"any theory of population and resources that overlooks cultural phenomena is likely to be deficient. Yet in much of the literature this is exactly what is done"*. This implies most works often fall short of acknowledging the manner in which the impact of population pressures and market forces on forests is mediated by local institutional arrangements. Institutions are human-made constraints that affect human interaction (North, 1990). Thus they (institutions) do not only act as constraints but they also soften, mediate, structure, attenuate, mould, accentuate and create impacts that may lead to less or greater consumption. In a nut shell scarcity in particular forest products could result from modes of production and consumption and local institutions have a role to play in sustainable forest management.

Agrawal (1995), suggests that as market and demographic pressures rise, the condition of the resources diminish. On the contrary, technological change increases efficiency and thus reduces pressure on resources. At the same time greater efficiency resulting from technological advancement leads to lower prices, greater demand and thus an indirect negative effect on the resource's condition. By the same token scarcity can arise from the inability to reproduce a given mode of production that addresses consumption demands and thus "*society runs head log into 'nature' or natural constraints*" (Collins, 1992).

2.3 The Congo Basin

As presented in Table 1, the Congo Basin is the second largest and most important tropical forest region in the world, with a coverage of over 227.6 million hectares (FAO, 2000) or 180.5 million hectares (CBFP, 2006). These forests make-up about 60% of the total land area of the six countries in the central African region. Forest-area in this region is under increasing pressure, decreasing at an average annual rate of 0.35% (FAO, 2001) due to population growth (which averages 2.3%) and other factors.

Table 1: Population and forestry in the Congo Basin

Countries	Area(Km²)	Population	Growth(%)	Forest(Million of H)	PF(Hectare)	PF(% of Total)
Cameroon	475 440	17 340 702	2.47	19.6	12	61
Central .African Republic	622 980	4 303 356	1.53	6.3	3.5	56
Congo Republic	342 000	3 702 314	2.6	22.3	13	58
D. R. of Congo	2 345 410	62 660 551	3.07	108.3	98	83
Equatorial Guinea	28 051	540 109	2.05	1.5	1.5	79
Gabon	267 667	1 424 906	2.13	22.1	17	77
Total	4 081 548	89 971 938	2.30*	180.5	137	76
Source: CIA,2007				Source: CBFP, 2006		

Km²: Kilometers square. D.R: Democratic Republic. PF: Production Forest. CIA: Central Intelligence Agency. CBFP: Congo Basin Forest Partnership.*: Average growth rate. H: Hectares.

The Congo Basin lying in the equator harbors among the richest concentrations of terrestrial biodiversity in the world. It is known to be the habitat of 10000 species of plant of which 80% are academic. The region is also home the world's largest assemblage of tropical forest vertebrates which include 23 threatened species such as western and eastern gorillas, forest elephants, bonobos (pygmy chimpanzees) and chimpanzees (WWF, 2002). The Congo River in the Basin is the world's second richest river system for fish (700 species) and is distinct by exceptional levels of mollusks and fish. The Congo Basin forest also provides valuable global ecological services by sucking and storing carbon dioxide, therefore helping to slow the rate of global climate change.

As far as we have perused; studies highlighting the impact of deforestation on human activity in the Congo Basin have been based on theoretical initiatives and exploratory descriptive statistics without empirical validity (Ndoye, 1995; CARPE, 2001; Ndoye, 2003; Ndoye & Tieguhong, 2004). Thus, this paper adds to the literature by providing an empirical assessment of how deforestation affects the livelihoods of forest-dependent local communities.

3. Data and Methodology

3.1 Data

We examine 4 of the 6 countries making up the Congo Basin in Africa (Cameroon, Central African Republic, Gabon, and Congo Democratic Republic) with data from African Development Indicators (ADI) of the World Bank (WB). Congo Republic and Equatorial Guinea are left out because of absence of data on agricultural growth (agricultural GDP growth and agricultural GDP per capita growth). Owing to data constraints and in a bid to obtain findings with more updated policy implications we restrict our sample to the period 1990-2007. A synthesis of selected variables is presented in Appendix 1. For the purpose of clarity we classify these variables as follows.

3.1.1 Dependent variables

The paper uses "*agricultural GDP growth*" and "*agricultural GDP per capita growth*" as dependent variables. To the best of our knowledge these are the only two proxies for the welfare of forest-dependent indigenes. We do not consider national GDP growth, GDP per capita growth and the Human Development Index as indicators of welfare (resulting from forest related activities) because they are overwhelmed by components that are not forest oriented. Conversely, rural activities are predominantly agricultural oriented; with the agricultural population more averagely forest-focused than the national population.

3.1.2 Endogenous independent variables

Measures that appreciate forest exploitation include: *"percentage of forest-area on total land-area"*, and *"forest-area in kilometers squares"*. From common-sense, changes in these variables account for deforestation.

3.1.3 Instrumental variables

The paper chooses moment conditions (instrumental variables) that are related to agricultural and the rural population. Consistent with the underlying theory of instrument validity, the work uses "*total agricultural exports*", "*rural population growth rate*", "*agricultural population growth rate*", and *"population growth rate"* as moment conditions of forest exploitation and agriculture welfare.

3.1.4 Control variables at first-stage regressions

In the welfare (deforestation)-instrument regressions we control for "*GDP growth*", "*GDP per capita growth*", "*arable land as percentage of total land*" and "*arable land in hectares per person*".

3.1.5 Control variables at second-stage regressions

The choice of control variables at the second-stage of the IV approach is very crucial for goodness of fit . These variables must be valid both from theoretical and empirical perspectives. The paper adopts *"wood fuel"* and *"agricultural-land as a percentage of total land-area"* because theoretically, changes in these variables explain changes in forest-area. Examination of the empirical validity of these endogenous variables of control is covered in Table 3.

3.1.6 Descriptive statistics and correlation analysis

Summary statistics and correlation analysis are represented in Appendix 2 and Appendix 3 respectively. From the descriptive statistics, it could be observed that the variables have distributions that are comparable if used in an empirical model. As concerns correlation analysis, it aims to two main objectives. On the one hand, it helps the paper avoid issues related to multicolinearity and overparametization. On the other hand, it gives the work a foresight on possible links between variables of interest (welfare measurements) and other variables (endogenous independent and control variables).

3.2 Methodology

3.2.1 Endogeneity

Although deforestation affects the livelihoods of rural and agricultural communities, it is also imperative to recognize the reverse effect as well. Variations in the wealth of agricultural regions also determines the manner in which the forest is exploited; whether by means of clearing for cultivation, illegal logging for business, subsistence or private purposes…etc. The issue of endogeneity resulting from reverse causality prompts the paper to consider an estimation technique that accounts for the correlation between the independent variables and the error terms in the equation of interest.

3.2.2 Estimation technique

Borrowing from Beck et al. (2003) we employ an Instrumental Variables (IV) estimation technique. As we have pointed-out earlier, the paper requires an estimation technique that addresses the concern for endogeneity. IV estimates can avoid the bias that Ordinary Least Squares (OLS) estimates suffer-from (absence of consistency) when independent variables in the regression are correlated with the error terms in the equation of interest. Thus the IV model investigates how deforestation affects agricultural population welfare conditional on instruments of agricultural and forest exploitation. In line with Asongu & Jingwa (2012a), the IV process will entail the following steps:

-justify the use of an IV over an OLS estimation technique through the Hausman-test for endogeneity;

-show that instrumental variables (moment conditions) are exogenous to the endogenous components of explaining variables (deforestation measures), conditional on other covariates (control variables);

-verify if the moment conditions are valid and not correlated with the error-term of the main equation through an Over-identifying Restrictions (OIR) test.

Thus our IV methodology will include the following models:

First-stage regression:

$$ForestChannel_{it} = \gamma_0 + \gamma_1 (TAExp)_{it} + \gamma_2 (Ruralpop)_{it} + \gamma_3 (Agripop)_{it} + \gamma_4 (Popg)_{it} + \alpha_i X_{it} + \upsilon \quad (1)$$

Second-stage regression:

$$Welfare_{it} = \gamma_0 + \gamma_1 (ForestChannel)_{it} + \beta_i X_{it} + \mu \qquad (2)$$

In the two equations, *X* is a set of independent control variables. For the first and second equations, v and *u*, respectively denote the error terms. Instrumental variables are *"total agricultural exports"*(TAExp), *"rural population growth"*(Ruralpop), *"agricultural population growth "*(Agripop) and *"population growth rate"(*Popg).

3.2.3 Robustness of results

In our attempt to provide robust findings the following robustness checks are carried-out. (1) Application of alternative IV estimation techniques. These entail, Two-Stage Least Squares (TSLS), Limited Information Maximum Likelihood (LIML), Two-Step Generalized Methods of Moments (GMM-2) and Iterated Generalized Methods of Moments (GMM-Ite). (2) Usage of alternative indicators of welfare and deforestation. (3) Employment of two theoretically and empirically backed endogenous control variables at the second-stage of the IV process.

4. Empirical Analysis

This section presents results from cross-country regressions to investigate the importance of moment conditions (instruments) in explaining cross-country variances in welfare, the ability of moment conditions to explain cross-country differences in the endogenous components of deforestation and the ability of the exogenous components of deforestation to account for cross-country differences in welfare.

4.1 Agricultural welfare and moment conditions

In Table 2 we regress welfare indicators on the instruments conditional on other independent covariates. The results indicates that distinguishing countries in the Congo Basin by moment conditions helps explain cross-country difference in welfare at overall agricultural and agricultural household per capita levels. All significant instruments and control variables have the rights signs. It follows that: (1) agricultural exports improve agricultural welfare; (2) agricultural population growth decreases welfare owing to diminishing agricultural household per capital income; (3) population growth increases agricultural GDP growth conditional on the rural exodus hypothesis where-by movement of agricultural population to urban areas increases agricultural household per capita income; (4) national growth levels effect agricultural wealth in a positive direction; (5) arable land in hectares per person is favorable to agricultural growth while arable land as % of total land doesn't because it could be publicly owned and not destined for private exploitation.

Table 2: Growth, welfare and moment conditions

		Growth		Welfare	
		Agricultural GDP growth		Agricultural per capita GDP growth	
	Constant	**-27.559*** (-3.130)**	**-16.599*** (-3.197)**	**-26.926*** (-3.138)**	**-16.231*** (-3.207)**
Instruments or Moment Conditions (Forest Exploitation)	Total Agricultural Exports	**5.276*** (3.731)**	**1.801*** (3.043)**	**5.152*** (3.738)**	**1.758*** (3.048)**
	Rural Population Growth	---	-0.137 (-0.542)	---	-0.134 (-0.544)
	Agricultural Population	**-1.966*** (-2.842)**	---	**-1.921*** (-2.849)**	---
	Population Growth	**1.408*** (2.101)**	**1.589** (2.138)**	0.409 (0.626)	0.585 (0.808)
Control Variables	GDP Growth	**0.296*** (3.874)**	---	**0.289*** (3.884)**	
	GDP Per Capita Growth	---	**0.291*** (3.550)**	---	**0.285*** (3.559)**
	Arable Land(% of Land)	**-0.360** (-2.031)**	---	**-0.352** (-2.035)**	
	Arable Land(Hectares Per Person)	---	**4.560* (1.780)**	---	**4.456* (1.784)**
	Adjusted R^2	0.305	0.243	0.317	0.256
	Fisher	**7.243***	**5.562***	**7.611***	**5.894***
	Observations	72	72	72	72

GDP: Gross Domestic Product. GDPg: GDP Growth Rate. GDPpcg: GDP Per Capita Growth Rate. AGDPg: Agricultural GDP Growth Rate. AGDPpcg: Agricultural GDP Growth Rate. *, **, ***: significance levels of 10%, 5% and 1% respectively.

4.2 Deforestation and moment conditions

Table 3 addresses the first condition for the IV process as captured by equation (1). We test the strength of the instruments by examining if they are exogenous to the endogenous components of the forest channels, conditional on other covariates (control variables). Clearly it could be observed that all the estimated coefficients are significant and most have the right signs. We also report the Fisher statistics to confirm that instruments taking together (and conditional on other independent covariates) are significant at the 1% level. The right-hand side of Table 3 assesses the empirical validity of the "endogenous variables of control" at the second-stage of the IV approach. This aims to complete the theoretical postulation highlighted in Section 3.1.5. Clearly it can be noticed that the moment conditions taken together are exogenous to the endogenous components of the second-stage independent control variables at the 1% significance level.

Table 3: First-stage regressions

		Endogenous Explaining(EE) Forest Variables				Second-Stage EE Control Variables			
		Forest Area(% of Land)		Forest Area(km²)		Wood Fuel		Agricultural Land	
	Constant	93.696***	149.08**	2.529***	4.630***	4.224***	-0.120	17.863***	-8.112***
		(12.51)	(6.906)	(3.147)	(36.09)	(11.35)	(-0.769)	(4.255)	(-2.663)
Instruments or Moment conditions (Forest Exploitation)	Total Agricultural Exports	-5.099***	-5.535*	0.357***	-0.206***	0.422***	-0.004	7.943***	2.038***
		(-5.973)	(-1.763)	(3.245)	(-10.78)	(9.978)	(-0.177)	(12.69)	(4.895)
	Rural Population Growth	-7.898***	---	0.071***	---	0.319***	---	---	-3.313***
		(-21.64)		(3.442)		(18.26)			(-42.11)
	Agricultural Population	---	-12.33***	---	0.404***	---	1.051***	-9.557***	---
			(-3.998)		(20.66)		(44.05)	(-14.91)	
	Population Growth	10.557***	12.852***	0.195***	0.049***	-0.054	0.041*	2.094***	3.150***
		(10.01)	(4.085)	(3.736)	(2.685)	(-1.052)	(1.836)	(3.413)	(15.89)
Control Variables	GDP Growth	-0.429***	---	---	-0.007***	---	---	---	-0.051**
		(-3.732)			(-3.657)				(-2.203)
	GDP Per Capita Growth	---	---	---	---	---	---	0.084	---
								(1.243)	
	Arable Land(% of Land)	---	---	-0.063***	---	---	---	---	0.369***
				(-4.335)					(6.608)
	Arable Land(HPP)	-48.29***	---	---	-0.864***	-2.834***	-0.609***	-20.52***	---
		(-13.06)			(-12.05)	(-15.46)	(-6.863)	(-8.737)	
	Adjusted R²	0.940	0.408	0.541	0.948	0.919	0.983	0.780	0.974
	Fisher	226.53***	17.340***	21.983***	260.35***	203.97***	1090.20***	51.480***	545.09***
	Observations	72	72	72	72	72	72	72	72

GDP: Gross Domestic Product. GDPg: GDP Growth Rate. GDPpcg: GDP Per Capita Growth Rate. AGDPg: Agricultural GDP Growth Rate. AGDPpcg: Agricultural GDP Growth Rate. Pop: Population. Ex: Exports. Km²: Kilometer Square. *, **, ***: significance levels of 10%, 5% and 1% respectively. HPP: Hectares per person.

4.3 Welfare and deforestation

Table 4 addresses two main concerns: (1) the issue of whether the exogenous components of forest channels explain changes in agricultural welfare and; (2) whether the instruments explain agricultural welfare through other mechanisms beyond forest channels. To make these assessments we use the IV regressions with agricultural welfare and forest exploitation instruments as moment conditions. Thus we add equation (2) to the first-stage regressions: equation (1).

While the first issue is addressed by the significance of estimated coefficients, the second is investigated by the Overidentifying Restrictions (OIR) test, whose null hypothesis is the position that the instruments are valid: not correlated with the error terms in the equation of interest (equation 2). Consequently a rejection of the null hypothesis of the OIR test is a rejection of the position that forest channels are the only mechanisms that affect agricultural welfare (conditional on the moment conditions). For robustness purposes we use four IV estimation techniques, with Sargan, Likelihood Ratio (LR), and Hansen OIR tests for the TSLS, LIML and GMM respectively.

Panel A of Table 4 investigates the impact of deforestation (as a % of total land) on agricultural welfare. We first proceed to justify the choice of the IV estimation technique with the Hausman test for endogeneity. The null hypothesis of this test is the position that estimated coefficients by OLS are consistent: absence of endogeneity. Thus the IV method is invalid if the Hausman test fails to reject this null hypothesis. The significance of estimated coefficients address the first concern and the following could be inferred: (1) deforestation significantly improves agricultural welfare both at overall-rural and household per capita levels; (2) increases in agricultural land improves the wellbeing of the agricultural population. As regards second issue, failure to reject to null hypothesis of the OIR test in all eight regressions suggests the instruments are valid. In other words, the moment conditions of forest exploitation and agricultural productivity do not explain agricultural welfare through other mechanisms beyond deforestation channels.

In Panel B, we assess the importance of deforestation (by Km²) in explaining agricultural population welfare. Results are consistent (robust) with (to) those of Panel A from all dimensions. The positive-significance of wood-fuel in the livelihoods of rural and agricultural populations confirms the positive effect of deforestation on the subsistence needs of forest-dependent indigenes.

Table 4: Second-stage regressions

	Panel A: With Forest Area(% of Land)							
	Agricultural GDP growth				Agricultural GDP per capita growth			
	TSLS	LIML	GMM(2)	GMM(Ite)	TSLS	LIML	GMM(2)	GMM(Ite)
Constant	**2.739***	**2.734***	**2.872****	**2.780***	6.820	6.855	6.634	6.760
	(1.827)	**(1.819)**	**(1.977)**	**(1.916)**	(1.408)	(1.413)	(1.521)	(1.550)
Forest Area(% of Land)	**-0.074****	**-0.075****	**-0.064****	**-0.064****	**-0.118*****	**-0.119*****	**-0.107*****	**-0.107*****
	(-2.214)	**(-2.207)**	**(-2.536)**	**(-2.565)**	**(-3.708)**	**(-3.718)**	**(-4.379)**	**(-4.404)**
Wood Fuel	---	---	---	---	-0.704	-0.707	-0.661	-0.675
					(-1.210)	(-1.213)	(-1.162)	(-1.187)
Agricultural Land(% of Land)	**0.270*****	**0.271*****	**0.219*****	**0.226*****	**0.311*****	**0.313*****	**0.263*****	**0.263*****
	(2.685)	**(2.688)**	**(3.012)**	**(3.106)**	**(3.190)**	**(3.203)**	**(3.759)**	**(3.765)**
Hausman test	**5.655***	---	---	---	**10.513****	---	---	---
GMM Q-Criterion	---	---	0.025	0.0240	---	---	0.0133	0.0132
OIR(Sargan/LR /Hansen) test	**1.716**	**1.736**	**1.827**	**1.730**	**1.095**	**1.103**	**0.959**	**0.951**
P-value	**[0.190]**	**[0.187]**	**[0.176]**	**[0.188]**	**[0.295]**	**[0.293]**	**[0.327]**	**[0.329]**
Cragg-Donald	41.621	---	---	---	39.057	---	---	---
Adjusted R²	0.076	---	---	---	0.112	---	---	---
F-Statistics	**3.755****	---	---	---	**5.494*****	---	---	---
Observations	72	72	72	72	72	72	72	72
Instruments(Moments)	Constant; Agricultural Product Exports; Rural Population Growth; Population Growth.				Constant; Agricultural Product Exports; Rural Population Growth; Agricultural Population Growth; Population Growth.			

	Panel B: With Forest Area(logarithm of km²)							
	Agricultural GDP growth				Agricultural GDP per capita growth			
	TSLS	LIML	GMM(2)	GMM(Ite)	TSLS	LIML	GMM(2)	GMM(Ite)
Constant	**19.879***	**30.642*****	**21.739*****	**21.658*****	**31.859*****	**32.055*****	**29.270*****	**29.455*****
	(1.810)	**(3.565)**	**(3.152)**	**(3.141)**	**(3.256)**	**(3.265)**	**(3.628)**	**(3.650)**
Forest Area(log. of km²)	**-6.261****	**-8.405*****	**-6.023*****	**-6.013*****	**-9.243*****	**-9.304*****	**-8.376*****	**-8.414*****
	(-2.246)	**(-3.370)**	**(-3.277)**	**(-3.272)**	**(-3.698)**	**(-3.709)**	**(-4.409)**	**(-4.428)**
Wood Fuel	**2.561****	**2.729*****	**2.115****	**2.120****	**2.839*****	**2.860*****	**2.554*****	**2.558*****
	(2.482)	**(2.615)**	**(2.546)**	**(2.552)**	**(2.836)**	**(2.850)**	**(3.224)**	**(3.228)**
Agricultural Land(% of Land)	---	---	---	---	0.008	0.008	-0.008	-0.008
					(0.105)	(0.104)	(-0.135)	(-0.134)
Hausman test	**7.588****	---	---	---	**11.001****	---	---	
GMM Q-Criterion	---	---	0.0508	0.0492	---	---	0.0126	0.0125
OIR(Sargan/LR /Hansen) test	**2.685**	4.918*	**3.660**	**3.547**	**1.037**	**1.043**	**0.909**	**0.902**
P-value	**[0.101]**	[0.085]	**[0.160]**	**[0.169]**	**[0.308]**	**[0.306]**	**[0.340]**	**[0.342]**

Cragg-Donald	16.789	---	---	---	38.785	---	---	---
Adjusted R^2	0.060	---	---	---	0.107	---	---	---
F-Statistics	**3.206****	---	---	---	**5.463*****	---	---	---
Observations	72	72	72	72	72	72	72	72
Instruments(Moments)	Constant; Agricultural Product Exports; Rural Population Growth; Population Growth.				Constant; Agricultural Product Exports; Rural Population Growth; Agricultural Population Growth; Population Growth.			

TSLS: Two-Stage Least Squares. LIML: Limited Information Maximum Likelihood. GMM(2): Two-Step Generalized Method of Moments. GMM(Ite): Iterated Generalized Method of Moments. (): z-statistics. Chi-square statistics for Hausman test.OIR: Overidentifying Restrictions Test. LM statistics for Sargan test. Chi-Square statistics for LR OIR-test. Chi-Square statistics for Hansen OIR test. [ ]:p-values. Cragg-Donald Weak Instrument test. *, **, ***: significance levels of 10%, 5% and 1% respectively. Log; logarithm.

4.4 Discussion and policy implications

The forests of the Congo Basin are exploited by rural communities and timber companies at different degrees to meet various conflicting interests. The forest contributes in several ways to rural livelihoods and the growing importance of timber exploitation poses a threat to this livelihood fabric as well as the conservation of biodiversity. For instance Ndoye & Tieguhong (2004) highlight that 61% of the top 23 timber species exported from Cameroon have important non-timber values to local communities. Our findings broadly suggest that the wellbeing of rural people is linked to all forms of development that impact the forest: which is relevant to local economies in providing jobs, income, health and environmental services. With current distressing trends in climate change our findings further suggest that deforestation: while hampering the global ecosystem represents an importance source of livelihood to local communities.

With such a divergence of stakeholder interests, there is need for a well-defined mutually beneficial partnership between local communities, logging companies and international norms in forest sustainability. Therefore policies need to be established through a balanced approach that takes account of the interest of all parties concerned. For instance the integration of social, cultural, economic, ecological and legal aspects in timber and non timber forest products could be a step to better policy formulation and improved management. This could involve the exclusion of certain timber species of local and ecological importance from exploitation and providing compensation to timber companies for such exclusions. It could also be interesting if timber companies were to sign social responsibility agreements with local communities.

Governments would have to monitor and legally enforce adherence to these agreements by ensuring that companies tendering for timber cutting permits are assessed in terms of how they abide by social and environmental regulations. Illegal logging must also be checked by government agents to reduce the vulnerability of local communities to clandestine logging practices. These could be based on a fairly simple, cost-effective, accountable system that supports sustainable and socially responsible logging.

5. Conclusion

The paper has examined the effects of deforestation on the welfare of rural communities in the Congo Basin. Using moment conditions of agricultural and forest exploitations, findings indicate deforestation significantly ameliorates welfare both at overall-rural and agricultural household per capita income levels. As a policy implication, in the process of deforestation, a balanced approach is needed to take account of the interests of both rural communities and timber companies. This should require among other things, the development and implementation of sustainable forest management plans by timber companies, exclusion from harvesting species that are important to local communities, compensation of timber companies for compliance with management plans as well as involvement of rural communities in monitoring the activities of timber companies.

Appendices

Appendix 1: Variables definitions

Variable	Sign	Variable Definitions	Sources
Agricultural GDP Growth	AGGDPg	Agricultural GDP Growth Rate(Annual %)	World Bank(WDI)
Agricultural GDP Per Capita Growth Rate	AGDPpcg	Agricultural GDP Per Capita Growth Rate(Annual %)	World Bank(WDI)
Forest Area 1	Forest(%)	Forest Area(% of Land)	World Bank(WDI)
Forest Area 2	Forest(Km)	Log. of Forest Area(Km²)	World Bank(WDI)
Wood Fuel	Wood. F	Log . of Wood Fuel(CUM, solid volume units)	World Bank(WDI)
Agricultural Land	Agriland(%)	Agricultural Land(% of Land Area)	World Bank(WDI)
Total Agricultural Exports	TAExp	Log. Total Agricultural Exports(FAO, Current US Dollars	World Bank(WDI)
Rural Population Growth	Ruralpopg	Rural Population Growth rate(Annual %)	World Bank(WDI)
Agricultural Population Growth	Agripop	Log. Agricultural Population (FAO Numbers)	World Bank(WDI)
Population Growth	Popg	Population Growth Rate(Annual %)	World Bank(WDI)
GDP Growth	GDPg	GDP Growth Rate(Annual %)	World Bank(WDI)
GDP Per Capita Growth	GDPpcg	GDP Per Capita Growth Rate(Annual %)	World Bank(WDI)
Arable Land 1	Ara(%)	Arable Land(% of Land Area)	World Bank(WDI)
Arable Land 2	Ara(HPP)	Arable Land(Hectares per person)	World Bank(WDI)

Km²: Kilometer Square. Log: Logarithm. %: Percentage. WDI: World Development Indicators. GDP: Gross Domestic Product. FAO: Food and Agricultural Organization. US: United States. CUM: Cubic Meters.

Appendix 2: Summary Statistics

Variables	Mean	S.D	Min.	Max.	Skewness	Kurtosis	Obser.
Forest Area(% of Land)	57.615	17.883	36.430	85.097	0.455	-1.141	72
Forest Area(Km²)	5.547	0.341	5.318	6.147	1.149	-0.669	72
Wood Fuel	6.713	0.762	5.655	7.864	0.143	-1.221	72
Arable Land(Hectares)	0.332	0.151	0.107	0.638	0.164	-1.058	72
Arable Land(% of Land)	5.019	4.585	1.144	12.806	1.062	-0.726	72
Agricultural Land(% of Land)	14.495	5.438	8.035	20.026	-0.043	-1.938	72
Rural Population Growth	0.932	1.655	-2.266	3.673	-0.448	-0.888	72
Agricultural Pop. Growth	6.623	0.681	5.601	7.563	-0.191	-1.214	72
Population Growth	2.574	0.554	1.555	3.914	0.287	-0.402	72
Total Agricultural Exports	7.742	0.646	6.525	8.904	0.243	-0.891	72
GDP Growth	0.871	4.775	-13.469	7.883	-0.893	0.038	72
GDP Per Capita Growth	-1.652	4.782	-16.683	4.536	-1.040	0.352	72
Agricultural GDP Growth	2.340	3.467	-11.700	11.605	-0.814	2.947	72
Agricultural GDPpcg	-0.225	3.410	-13.741	8.274	-0.749	2.402	72

S.D: Standard Deviation. Min : Minimum. Max : Maximum. Obser : Number of observations. GDP: Gross Domestic Product. GDPpcg: GDP Per Capita Growth.

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Appendix 3: Correlation Analysis

Dependent Variables		Endogenous Explaining Variables				Instrumental Variables				Control Variables				
AGDPg	AGDPpcg	Forest(%)	Forest(Km)	Wood F.	Agriland(%)	TAExp.	Ruralpopg	Agripop	Popg	GDPg	GDPpcg	Ara(%)	Ara(HPP)	
1.000	0.987	-0.147	-0.236	-0.075	0.146	0.319	0.0008	-0.039	0.027	0.365	0.354	0.273	0.200	AGDPg
	1.000	-0.191	-0.306	-0.124	0.144	0.324	-0.043	-0.080	-0.129	0.398	0.402	0.284	0.248	AGDPpcg
		1.000	0.061	-0.357	0.582	-0.481	-0.702	-0.476	0.281	0.011	-0.020	-0.424	-0.616	Forest(%)
			1.000	0.825	-0.487	0.010	0.578	0.755	0.454	-0.312	-0.352	-0.252	-0.726	Forest(Km)
				1.000	-0.420	0.505	0.740	0.984	0.316	-0.230	-0.258	0.286	-0.432	Wood F.
					1.000	0.186	-0.801	-0.447	0.009	0.211	0.204	0.413	-0.117	Agriland(%)
						1.000	0.317	0.560	-0.044	-0.034	-0.027	0.888	0.133	TAExp.
							1.000	0.783	0.282	-0.305	-0.326	0.082	0.098	Ruralpopg
								1.000	0.264	-0.217	-0.239	0.366	-0.321	Agripop
									1.000	-0.221	-0.324	-0.082	-0.315	Popg
										1.000	0.994	0.088	0.076	GDPg
											1.000	0.095	0.108	GDPpcg
												1.000	0.217	Ara(%)
													1.000	Ara(HPP)

GDP: Gross Domestic Product. GDPg: GDP Growth Rate. GDPpcg: GDP Per Capita Growth Rate. AGDPg: Agricultural GDP Growth Rate. AGDPpcg: Agricultural GDP Per Capita Growth Rate. Forest(%): Forest Area(% of Land). Forest(Km): Forest Area(in Km²). Wood F: Wood Fuel. Agriland: Agricultural Land(% of Land Area). TAExp: Total Agricultural Exports. Ruralpop: Rural Population Growth Rate. Agripop: Agricultural Population. Popg: Population Growth Rate. Ara(%): Arable Land in % of Land Area. Ara(HPP): Arable Hectare Per Person.

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