The Perplex of Deforestation in sub-Saharan Africa

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Abstract

Deforestation has been a complex phenomenon to study in sub-Saharan Africa. The average annual deforestation rate in the region is by far higher than the world average. What causes and drives deforestation in the region are debated to date. The present paper is motivated by this debate. It attempts to test whether the maintained hypotheses on the causes of deforestation can give answer to the problem in sub-Saharan Africa. It used average cross-national data of forty eight countries in the region. The data are retrieved from international sources. The Spearman's rank correlation coefficients between two deforestation indicators and five often-cited causes of deforestation were computed. The role of public forest ownership, share of forest and agricultural products in total exports, and the year of forest laws enacted are also discussed. However, it finds no clear, strong, and systematic pattern to argue that population density, rural population, rural poverty, industrial logging for exports, economic growth, late enactment of forest laws, and public ownership of forests are underlying causes of deforestation in the region. The trends of forestland in Rwanda and Zimbabwe vividly present the finding. Therefore, future studies related to the topic in the region shall focus on sub-national panel data.

Keywords: deforestation, population, economy, institutions, sub-Saharan Africa

1. Introduction

Deforestation is one of the major environmental problems in sub-Saharan Africa (SSA). The share of forest area in SSA has declined from 29.3% in 1990 to 26.1% in 2007 (World Bank, 2010). Africa has lost about 3.4 million hectares of forest each year in 2000-2010 (FAO, 2010). The average annual rate of deforestation of the region (0.8%) is still by far higher than the world average (0.15%) in 1990-2010 (FAO, 2010). Nevertheless, Africa has settled at the bottom in terms of public expenditure on forest sector per hectare (FAO, 2010). In contrast of its clear trend, however, deforestation in SSA has been a very complex phenomenon to study (Sieboek, 2002; Rudel, 2013). What exactly causes deforestation in the region is open to debate. With poor score to halt deforestation and scientific consensus on what causes and exacerbates deforestation in the region, the success of recent forest management initiatives such as Clean Development Mechanism (CDM) and Reducing Emissions from Deforestation and forest Degradation (REDD and REDD+) will be questionable because, without proper understanding of true causes, effective policies cannot be designed and implemented (Pearce,

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2001). Among others, testing the maintained theoretical hypothesis that links different demographic, economic, and institutional factors with deforestation helps to identify and understand the root causes of deforestation in the region. This is the main motivation of this paper. For data consistency and completeness, international data sources, World Bank, FAO, OECD, and Penn World Tables were used. It uses two methods of analysis. First, each maintained hypothesis was tested against the data from SSA. However, it finds no clear, strong, and systematic correlation to argue that population density, rural population, rural poverty, industrial logging for exports, economic growth, late enactment of forest laws, and public ownership of forests as underlying causes of deforestation in SSA. Second, partial rank correlation coefficients (Spearman's rho) were calculated for orderable factors. But, it only affirms the afore mentioned conclusion. The findings based on average cross-national data undermine the importance of incumbent hypothesis to explain the deforestation in SSA. At the same time, it is hardly possible to provide simple generalisation on the relative importance of some factors over the others. Therefore, future studies should focus on sub-national panel data. Better research funds should be available from SSA countries themselves to unpin researchers from international data. The rest of the paper is organised as follows. Section 2 discusses the methodology while Section 3 presents and discusses the results. The conclusions are given in Section 4.

2. Methodology

2.1 Data and data sources

The study used secondary data from international sources on forests, demographic, economic, and institutional indicators. The demographic, economic, and institutional factors considered here are based on the theoretical and empirical literature on the causes of deforestation in tropical regions (Butler and Laurance, 2008; Titenberg, 2000; Laurance, 1999), in the SSA region (Rudel, 2013; Mitchard and Flintrop, 2013; Diarrassouba and Boubacar, 2009; Boahene, 1998; Barnes, 1990) and countries in the SSA (Sieböck, 2002; Rusing, 2000).

Table 1: Description of the data and data sources.

Variable	Description	Measure	Data of	Data source
Lfa	Net loss of forest area as percentage of total land area	%	2007 & 1990	World Bank 2010
Adr	Average annual rate of deforestation	%	1990-2010	FAO 2005, 2010
YSFL	Year of specific forests laws was enacted	Year	Country specific	FAO 2010
Pbc	Share of total forest under public ownership	%	2005	FAO 2010
Pvt	Share of total forest under private ownership	%	2005	FAO 2010
Othr	Share of total forest under other than public & private	%	2005	FAO 2010
Egr	Average annual economic growth rate (at 2005 price)	%	1990-2007	Heston et al. 2009
Ge	Average government effectiveness	Index	1996-2012	Kaufmann et al. 2013
Ag/GDP	Average share of agriculture in GDP	%	1990-2010	World Bank 2013
Exp	Share of forest and agricultural commodities in the total exports	%	2008	OECD 2010
Pd	Population density (Number of people per square kilometer)	%	2004 & 2008	FAO 2005, 2010
Pr	Rural Population (% total population a country)	%	2004 & 2008	FAO 2005, 2010
Prp	Rural poverty (% of rural poor in the total rural population of a country)	%	1990-2010 (of available years)	OECD 2010, World Bank 2010

The international data sources were preferred for comprehensiveness of factors and consistency of the data. Data is averaged overtime to compensate the missed as well as lagged effects of the factors. Table 2 below summarises the data.

Table 2: Summary of data.

	Forests		Demographic			Economic			Institutional				
Country	Lfa	Adr	Pd	Pr	Prp	Ag/GDP	Egr	Exp	Ge	Pbc	Pvt	Othr	YSFL
Angola	1.97	0.2	12.6	53	94	9.63	3.8	0	-1	100	0	0	1955
Benin	9.95	1.1	70.2	57	33	33.7	1.1	38	-0	99	1	0	1993
Botswana	3.55	1	3.03	44	NA	3.48	2.9	0	0.6	24	5	71	1968
Burkina Faso	1.49	1	50.6	81	52	35.2	2	63	-1	100	0	0	1997
Burundi	6.05	2.2	300	90	37	45.3	-2	53	-1	100	0	0	1985
Cameroon	7.91	1	37.6	45	50	22.8	-1	15	-1	100	0	0	1994
Cape Verde	-6.6	-1.4	122	42	55	10.9	5	0	-0	100	0	0	NA
Central African Rep	0.81	0.1	6.67	59	NA	52.1	-1	46	-2	91	0	9	2008
Chad	1.07	0.7	8.01	74	67	31.5	3.8	95	-1	100	0	0	2008
Comoros	4.08	7.5	366	68	NA	44.3	-1	63	-1	100	0	0	NA
Congo	0.85	0.1	11.2	43	58	7.58	-0	0	-1	100	0	0	2000
Cote d'Ivorie	-0.7	-0.1	59.5	53	NA	25.8	-1	29	-1	99	1	0	1965
Djibouti	0	0	33.9	15	49	3.49	0.4	24	-1	100	0	0	NA
DR Congo	3.33	0.2	26.1	67	76	48.2	-6	0	-2	100	0	0	2002
Equatorial Guinea	9.22	0.7	20.5	56	NA	28.2	23	0	-1	100	0	0	1997
Eritrea	0.57	0.3	46.7	79	NA	20	0.7	8	-1	NA	NA	NA	2006
Ethiopia	1.97	1.1	72	84	45	52.1	1.6	54	-1	100	0	0	NA
Gabon	0.67	0	5.67	15	45	6.8	-1	1	-1	100	0	0	2001
Gambia	-3.3	-0.4	155	59	63	22.7	0.4	49	-1	94	6	0	1998
Ghana	9.5	2.1	97.8	52	39	39	1.8	43	-0	100	0	0	1998
Guinea	3.08	0.5	36.4	65	NA	22.1	0.7	0	-1	99	1	0	1989
Guinea-Bissau	5.84	0.5	55.3	68	NA	56	0.9	93	-1	100	0	0	1991
Kenya	0.37	0.3	62.5	69	49	29.3	0.3	22	-1	39	61	0	2005
Lesotho	-0.1	-0.5	63.8	79	NA	13.9	2.5	54	-0	14	0	86	1998
Liberia	10.6	0.7	37.4	46	NA	67.8	-2	13	-2	100	0	0	1973
Madagascar	1.6	0.4	31.4	72	74	28.4	-1	17	-0	98	2	0	1997
Malawi	5.95	0.9	138	82	47	35.6	1.1	67	-1	NA	NA	NA	1997
Mali	1.39	0.6	9.89	68	76	42.2	2	77	-1	100	0	0	1995
Mauritania	0.16	3.3	2.92	48	61	32	0.9	0	-0	97	3	0	2007
Mauritius	1.18	0.3	620	57	NA	7.76	3.8	29	0.6	48	52	0	1983
Mozambique	1.08	0.5	26.2	63	55	30.6	3.4	0	0.5	100	0	0	1999
Namibia	1.52	0.9	2.74	65	NA	10.6	1.4	0	0.1	NA	NA	NA	2001
Niger	0.56	1.9	10.8	81	66	39.4	-0	0	-1	100	0	0	2002
Nigeria	7.65	3.3	160	52	NA	37.2	3.1	0	-1	100	0	0	NA
Rwanda	-8.8	-1.9	367	81	63	38.1	2.8	30	-1	79	21	0	1988
Sao Tome and Principe	0	0	167	51	NA	18.6	0.2	68	-1	NA	NA	NA	NA
Senegal	3.97	0.5	58.7	54	NA	18.1	0.9	0	-0	100	0	0	1998
Seychelles	0	0	186	47	NA	3.33	2.7	0	0	77	23	0	1955
Sierra Leone	4.59	0.9	77	61	79	50.9	-2	0	-1	14	86	0	1988
Somalia	2.08	1	14.9	64	NA	NA	-2	26	-2	NA	NA	NA	NA
South Africa	0	0	39.3	41	NA	3.6	1.6	0	0.7	60	40	0	1998
Sudan	4.21	0.3	15.7	59	NA	37.4	3.6	0	-1	91	9	0	2002
Swaziland	-4.6	-0.9	66.6	76	75	10.6	1.5	35	-1	78	22	0	2001
Tanzania	7.91	1.1	44.7	69	39	37.6	2.1	12	-0	100	0	0	2002
Togo	6.23	4.6	105	61	NA	36.8	-1	56	-1	27	73	0	2008
Uganda	7.46	2.4	146	86	42	36.2	3.4	39	-0	32	68	0	2003
Zambia	10.2	0.3	15.6	64	74	21.5	2.5	0	-1	100	0	0	1973
Zimbabwe	13.8	1.8	33	64	48	17.8	-2	12	-1	63	37	0	1949
SSA average	2.92	0.84	85.4	61	58	28.2	1.3	26	-1	84	12	4	

Source: Author compilation based on sources given in Table 1.

NA: data not indicated in these data sources. Zero values in column 9 do imply the forest and agricultural (raw or processed) items are not reported in the first three main export items of that country.

2.2 Research method

The overall method of analysis is comparing and contrasting the relative position of a country (or a group of countries) in terms of deforestation and in terms of sources of deforestation which are demographic, economic, and institutional variables. In that way, if a country (or a group of countries) is placed in close positions in terms of deforestation and hypothesised cause of deforestation, then that specific hypothesis holds true in SSA. In other words, the nearer is the distance between the ranks, the more is that demographic, economic or institutional factor is responsible for deforestation in the region.

First, each hypothesis linking a demographic, economic, or institutional factor with deforestation is compared with the empirical data in SSA. Such discussion helps to see the role of factors where ranking makes less sense. For example, all forests are under public ownership right in half of the countries. In addition, for some factors like rural poverty, data is available for only 28 countries.

Then, partial rank correlation coefficients between the two deforestation indicators and five often-cited drivers of deforestation are computed. Partial rank correlation coefficients (Spearman's rho, ρ) measure the dependence between two orderable variables. For a sample size of *n*, rank correlation coefficient is computed as in equation 1:

$$\rho = 1 - \frac{6.\sum_i^n di^2}{n(n^2-1)} \qquad (1)$$

where: d_i = the difference between the ranks of the dependent variable and the independent variable

The dependent variable is either of the two deforestation indicators. The independent variable is any of the five socio-economic factors. For deforestation, countries are ranked from highest to lowest value. The rank of countries for the socio-economic factors is from the expected association with the rank of deforestation. For instance, government effectiveness was ranked from worse (negative) to better (positive) as deforestation is expected to be higher in countries with ineffective governments. The ranks are given in Table 3 in the following section.

3. Results and Discussion

3.1 Maintained hypotheses versus empirical data in SSA

Population and deforestation

Population and its growth have been argued long to cause deforestation in developing countries (Laurance, 1999; Pearce, 2001). Increase in population increases demand for agricultural products and hence agricultural land. The search for extra agricultural land induces forest clearance. If the population growth specially happens in rural areas, it increases the fuelwood demand which still threatens forest (Barnes, 1990). In addition, as population increases the demand for industrial wood products will increase which in turn escalates the industrial logging. Hence, the fact that population and its growth puts pressure on the environment is indisputable. Nevertheless, linking population and its growth directly with deforestation is oversimplification (Sieböck, 2002). Therefore, population density may better metrics (Sieböck, 2002). Therefore, average population density (number of peoples per square kilometer) was used as proxy to population pressure on forestlands.

Only Mauritius (620), Rwanda (367), Comoros (366), and Burundi (300) have population density greater than 200 km^{-2}. Among the four, Burundi lost 6% forest area (% total land) in the period of 1990-2007. While the average annual deforestation rate (1990-2010) is 2.2% well above the world and SSA average rate of deforestation in the two decades. The net loss of forest area in Comoros is 4.08% (1990-2007) but with highest annual rate of deforestation 7.5% (1990-2010). Linking population density and deforestation is also cogent enough to explain the deforestation (in terms of both indicators) in Uganda, Nigeria, Malawi, and Togo which all have population density between 100 and 200, and rate of deforestation above the SSA's average. In contrast, this maintained hypothesis cannot explain for the case of Rwanda, Seychelles, Sao Tome and Principe, Gambia, and Cape Verde which still do have population density above 100 km^{-2} but gained net area of forest in terms of both indicators in the period.

Alternatively, we can test the hypothesis if there is no or little deforestation in countries with low population density. The average annual deforestation rate in Mauritania, a country with the lowest population density (3 km^{-2}), is 2.7%. The population density in Zimbabwe, which lost about 13% forest area and annual deforestation rate 1.8%, is 39 km^{-2}. Likewise, Equatorial Guinea, Cameroon, Niger, Liberia, and Benin do have population density below SSA's average (which is 85 km^{-2}). Whereas the deforestation rates in this countries are above the SSA average in both indicators of deforestation. In sum, the empirical data supports little to generalise that population density is a main force behind deforestation in SSA.

Rural Poverty and deforestation

Natural resources represent important part of the asset base of the poor (Pearce, 2001). Many poor families find many forest products (timber, herbal medicines, fruits, and firewood) in the basket of their basic necessities (Diarrassouba and Buobacar, 2009). Thus, poor always tend to place higher discount rate on environment (Nayak, 2004). Nor rural poor invest in land development (Sieböck, 2002). Rural peasants will see forestland as an opportunity to become landowner (Tietenberg, 2000). Therefore, some tend to conclude that poverty is the primary cause of deforestation in the tropics (Diarrassouba and Buobacar, 2009). Rural population (% national population) and rural poverty were taken as a proxy to rural society. We consider each in turn.

The average rural population in SSA is 61% of the total population. The two countries with lowest rural population are Djibouti (14.5%) and Gabon (15.3%). Coincidentally the deforestation (in terms of both indicators) in both countries is negligible. Of the 26 nations with proportion of rural population higher than SSA's average, only 12 of them have experienced average annual rate of deforestation higher than the SSA's average. In contrast, in 14 countries that loss of 5% and higher, only 5 have rural population which is higher than the SSA's average.

Cameroon, Liberia, Ghana, Nigeria, and Benin have low percentage of rural population but higher deforestation rate (in both measures) compared to Rwanda, Lesotho, and Swaziland which have higher rural population percentage. Countries placed at bottom in terms of rural population (<40%) Uganda, Ghana, Tanzania, Burundi, and Benin assumes the reverse rank in terms of deforestation. Rural poverty data was available only for 28 countries. Even though about 60% rural population lived under poverty, Rwanda and Swaziland still gained forest areas. Republic of Congo and Cape Verde have rural poverty ratio higher than Zimbabwe, Malawi, and Ethiopia but scored better when it comes to deforestation.

Taken together, the analysis based on average data offers no systematic relationship between rural population and rural poor and deforestation in SSA. Being poor and rural dweller is not a sufficient reason to be blamed for deforestation. This goes with Angelsen et al. (1999) (cited in Sieböck, 2002) which finds that there is little empirical evidence to support that poverty is the underlying cause of deforestation. Nayak (2004) also finds no clear pattern between poverty and environmental degradation in rural India. Opposite to this, there are even some experiences in which rural and poor community has used forests and other natural resources in very sustainable manner (Sieböck, 2002). Especially if forest (other natural resources) management power is devolved to the local community, forests can successfully be used in poverty reduction beyond controlling deforestation (Shyamsundar et al., 2005).

Agriculture and deforestation

Shifting cultivation for subsistence agriculture, cash crops cultivation, and overgrazing involve clearing forests. One way to look at the linkage between agriculture and deforestation is through what happens to forests in countries which heavily depends on agricultural products, i.e., livestock, sesame, coffee, cocoa, cotton, cashew nuts, tea, fruits, flower cuts, tobacco, and sugar cane exports. As to 2008, agricultural commodities are among the three main export items in 21 SSA countries (OECD, 2010). Of these countries, only 10 exhibit average deforestation rate higher than the SSA average. This leaves us with no strong evidence in defense of tradable cash crop cultivation is underlying cause of deforestation in SSA. Another way to test the linkage is through the share of agriculture in Gross Domestic Product (GDP) and deforestation[1]. Agriculture accounts more than 30% of GDP in 13 of the 18 SSA nations with higher average rate of deforestation. In 10, out of 14 countries with high forest area lost, agriculture contributes more than 30%.

Excepting Botswana, in all countries where agriculture contribution less than 10% of GDP, deforestation is meager. Another exception is the situation in Zimbabwe and Rwanda where, respectively, agriculture contributes 17% and 38% of GDP. This contrasts the 13% loss and 8.7% gain, respectively in Zimbabwe and Rwanda. Keeping these exceptions, the view that agricultural encroachment causes or triggers deforestation loosely explains the situation in SSA.

Industrial logging and deforestation

Industrial logging without tree replacement depletes forest (Butler and Laurance, 2008; Tietenberg, 2000; Laurance, 1999). Commercial logging also opens up previously inaccessible forests for new settlers which exacerbates deforestation. In addition, industrial forest products are seen as means of generating foreign exchange earnings for debt repayment in low-country income countries (Tietenberg, 2000). This premise holds true for SSA where industrial logging is primary for export. Thus, we can intertwine the two views together. The view whether industrial logging leads to deforestation in SSA can be captured by the deforestation in countries where forest products constitute the three main export items. Forest products (lumber, tropical hardwoods and natural rubber latex) are among the three main export items in Cameroon (8.1% of total exports), Liberia (12.8% of total exports) Central Africa Republic (45.5% of total exports), and Chad (94% of total exports). The deforestation

[1]Agriculture, value added (% of GDP) here corresponds to ISIC divisions 1-5 and it includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources (World Bank, 2013).

data, however, shows the reverse. Thus, linking industrial logging and the share of forest products export directly, therefore, may be oversimplification as the discussion here does not substantiate the industrial logging-deforestation nexus in Titenberg (2000) and Laurance (1998). However, it goes in line with (Sieböck, 2002) which pointed "there are several examples for commercial logging operators carrying out sustainable forest management in the tropics such as Precious Woods in Costa Rica and the Amazon or Compagnie Équatoriale des Bois (CEB) Thanry in Gabon".

Economic growth and deforestation

Economic growth imposes detrimental effects on forests especially in countries where forest and agricultural products take the largest share in total exports and real GDP. In other words, if high economic growth rate is recorded in countries with high rate of deforestation (or net loss of forest area), then the share of agriculture in GDP and/or agricultural and forest products in total exports in the same countries is expected to be high[2].

Agriculture contributes more than 50% of the GDP in Liberia, Guinea-Bissau, Central Republic Africa, Ethiopia, and Sierra Leone. While forest products constitute among the three main export items in Liberia and Central Republic Africa, agricultural products are among the three main exports in Ethiopia, Guinea-Bissau, and Liberia. Therefore, economic growth, if it happens, in Liberia, Central Republic Africa, Ethiopia, and Guinea-Bissau would trigger deforestation either due direct export purpose and/or due to land encroached for agricultural purpose. Liberia is highly deforested in both indicators but with only -2% average rate of real GDP growth.

Guinea-Bissau has lost about 6% of its forest area (% of total land area), but scored only 0.9% average rate of real GDP growth. Alternatively, we can see whether countries with high deforestation rate (and at the same time high GDP growth rate) are dependent on agriculture and forests for livelihood and export. Equatorial Guinea scored an average of 23% real GDP growth rate and lost 9% of its forest area (% total land area). However, neither agricultural nor forest items are mentioned in the three main export items in Equatorial-Guinea.

On the reverse, forest products constitute 94% of the total export in Chad and ranked fourth in terms of real GDP growth rate (3.77%). But, the deforestation rate in Chad is modest. This leaves us with little evidence to conclude that economic growth causes or exacerbates deforestation in agriculture and forest dependent nations in SSA.

Weak institutions and deforestation

Very recent studies in the environment-society nexus place more on emphasis on the role of institutions and governance. Accordingly, lack of good governance drives of deforestation rather than industrial logging, rural poverty, and agricultural encroachment *per se* (Sieböck, 2002). This lack of governance in forest management is manifested through lack of government commitment, corrupted and rent-seeking bureaucrats and bureaucracy, weak monitoring and law enforcement, political instability, and highly centralised power structures. Three indicators of institutional aspects were considered here. These are Government Effectiveness (GE) indicator, the years of forest laws enacted, and public ownership of forest in different countries of the region.

[2]The economic growth rate after 2007 is excluded in order to control the effect of global financial and economic crisis especially on oil and mineral exporting nations so that will not affect the ranking and, the economic growth rates refer to real GDP growth rates measured at 2005 price (Heston *et al.*, 2009).

GE is one of the six major Worldwide Governance Indicators calculated and updated since 1996 by Kaufmann and others.[3] GE reflects "perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies" (Kaufmann et al., 2013).

The value of GE ranges between -2.5 (weak) and 2.5 (strong). Somalia (-2.05) scores the most ineffective government and South Africa (0.66) the better one. However, deforestation in Somalia is far less than deforestation in Ghana, Benin, Tanzania, and Uganda where the average GE indicates good governance even by the SSA standard.

Early year of specific forest law enactment indicates early acknowledgment of the problem. Then, it is natural to presume that efforts to have been placed to arrest the problem since the specific forest laws are introduced in the country. Zimbabwe (in 1949), Liberia (in 1976), Burundi (in 1985) (1993), Cameroon (1994) are among the pioneers to enact specific of forest laws but unable to halt deforestation in 1990-2010. Out of 15 nations that enacted in 2000-2008, only four, Togo, Mauritania, Uganda, Tanzania and Niger reported high deforestation rate. In sum, it can be concluded that neither higher government effectiveness nor earlier implementation of forest laws have saved forests in SSA.

Private property right regime leads efficient and sustainable use of natural resources (Tietenberg, 2000). In other words, public ownership and management of natural resources (or forests in our case) may be sources of deforestation. Government failure for sustainable forest management can easily be captured if deforestation is high in countries with high percentage of public ownership and management of forests. Deforestation in Togo (73% non-public) and Uganda (86% non-public) is as high as the deforestation in Nigeria, Ghana or Liberia where all forests are owned by the public. Deforestation in South Africa, Seychelles, Swaziland and Rwanda where 80% and 60% are public is almost negligible. Though public ownership is Zimbabwe than in Rwanda and Swaziland, deforestation in the former is by far higher than the latter.

Therefore, we see that neither private nor public ownership *per se* can be blamed for deforestation. In closing, the qualitative discussion does support little the maintained hypotheses on the causes and drivers of deforestation in developing countries. The following section goes further to check the validity of the discussion in this section by computing partial correlation coefficients between the two deforestation indicators and five orderable factors.

[3]The six dimensions include: voice and accountability, political stability and absence of violence/terrorism, government effectiveness, regulatory quality, rule of law and control of corruption. All the available data (1996-2012) is used to compensate for the years in 1990-1995.

Table 3: Rank of countries.

Country	Lfa	Adr	Egr	Ag/GDP	Pd	Ge	Pr
Zimbabwe	1	9	47	35	31	16	23
Liberia	2	21	45	1	28	3	41
Zambia	3	30	14	31	37	22	21
Benin	4	10	23	20	16	38	31
Ghana	5	7	18	11	13	42	37
Equatorial Guinea	6	20	1	26	35	6	32
Tanzania	7	11	15	13	25	37	13
Cameroon	8	14	36	28	27	26	42
Nigeria	9	3	9	15	7	18	36
Uganda	10	5	7	17	9	36	2
Togo	11	2	40	16	12	5	26
Burundi	12	6	43	7	4	7	1
Malawi	13	17	24	18	10	28	4
Guinea-Bissau	14	27	26	2	22	10	16
Sierra Leone	15	19	44	5	14	9	25
Sudan	16	31	6	14	36	13	29
Comoros	17	1	42	8	3	8	15
Senegal	18	26	27	34	21	41	33
Botswana	19	16	10	46	46	47	43
DR of the Congo	20	35	47	6	34	2	18
Guinea	21	25	29	30	29	19	19
Somalia	22	13	46	…	38	1	22
Ethiopia	23	12	20	4	15	20	3
Angola	24	34	3	40	39	12	34
Madagascar	25	28	38	25	32	34	12
Namibia	26	18	22	39	48	45	20
Burkina Faso	27	15	17	19	23	31	5
Mali	28	23	16	9	42	27	17
Mauritius	29	33	5	41	1	46	30
Mozambique	30	24	8	23	33	35	24
Chad	31	22	4	22	43	15	11
Congo	32	37	34	42	40	11	44
Central African Republic	33	36	39	3	44	4	27
Gabon	34	39	37	43	45	29	47
Eritrea	35	32	28	32	24	17	8
Niger	36	8	35	10	41	23	7
Kenya	37	29	32	24	19	32	14
Mauritania	38	4	25	21	47	40	39
Djibouti	39	38	31	45	30	24	48
São Tomé and Príncipe	40	40	33	33	6	30	38
Seychelles	41	41	12	47	5	44	40
South Africa	42	42	19	44	26	48	46
Lesotho	43	45	13	36	18	39	9
Côte d'Ivoire	44	43	41	27	20	14	35
Gambia	45	44	30	29	8	33	28
Swaziland	46	46	21	38	17	21	10
Cape Verde	47	47	2	37	11	43	45
Rwanda	48	48	11	12	2	25	6

Source: Based on Table 1.

3.2 Evidence from rank-correlation coefficients

Table 4 below summarises the partial rank correlation coefficient. It affirms the conclusion from the previous discussion. That is rank based on average data provides no/little ground to support weak institutions, high proportion of rural population, higher economic growth, and high population density cause deforestation in SSA. It is only the share of agriculture in GDP which loosely supports the established view.

Table 4: Summary of partial rank correlation coefficients.

ρ ar	ρ a1	ρ a2	ρ a3	ρ a4	ρ a5
0.7084	-0.0200	0.0695	0.4188	-0.0996	0.2828
ρ ra	ρ r1	ρ r2	ρ r3	ρ r4	ρ r5
0.7084	-0.0200	0.2408	0.4931	-0.1420	0.1324

Source: Based on the Table 3

ρ=Spearman's rho, a=net forest area lost, r=average annual deforestation rate, 1=average population density, 2=average percentage of rural population, 3=average share of agriculture in GDP, 4=average economic growth rate, and 5=average government effectiveness.

3. Conclusion

Average empirical data from SSA was used to test the maintained hypotheses on drivers of deforestation in developing countries. However, this paper finds no strong, clear and systematic pattern to defend that population density, rural population and poverty, industrial logging, forest product export, economic growth and lack or late enactment of forest laws causes deforestation in SSA. Considering Rwanda and Zimbabwe makes the findings more vivid. Looking at the hypotheses on causes of deforestation (population density, rural poverty, percentage of rural population, agricultural share in GDP, and enactment of forest laws), one may contemplate that deforestation in Rwanda to be alarming than in Zimbabwe whereas the deforestation statistics confirms the opposite. Between 1990 and 2007, the forest area as percentage of total land area increased by 8% in Rwanda while it decreases by in Zimbabwe 13%. The annual average rate of deforestation (1990-2010), respectively, was -1.9% in Rwanda and 1.8% in Zimbabwe. This contradicts Laurance (1999) which generalised that population pressure, weak government institutions and poor policies and industrial logging for export is the four key drivers of deforestation in tropical regions in which Africa was its sample.

The results also challenge Sieböck (2002) which strongly concluded that deforestation in SSA is mainly due to governance problems. High deforestation rate is reported in countries with better government effectiveness in the region like Botswana, Ghana, and Benin. Nor it agree with Rudel (2013) which associated lower deforestation in wetter Congo basin with the transition to minerals and oils revenues coupled with declines in agriculture and increased imports of cereals from abroad because countries with high share of oil and mineral exports in their total exports (i.e., Nigeria, Zambia, Zimbabwe of Benin, Liberia, Equatorial-Guinea and Ghana) have also scored high rate of deforestation.

Better information would have been gleaned from sub-national panel data on the loss of different forests overtime in different countries. Such data, however, is hardly available in SSA countries. Therefore, it requires SSA countries themselves to avail better research funds to detach researchers from international data and incumbent hypotheses based on studies in other developing regions like Latin America and South Asia. In addition, governments shall look beyond merely enacting specific forest laws. Law enforcements should be improved. Otherwise, the success of recent forest management initiatives such as CDM and REDD+ in the region will be under question.

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