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Co-integration Relationship between Urban Population Growth and Forest Area in the Democratic Republic of the Congo

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ABSTRACT
Objective: This study aims to estimate the relationship between forest area (FA) and urban population growth concerning Democratic Republic of the Congo.
Methodology and Results: The data collected from World Bank by documentary technic, covering the period from 1990 to 2020. Phillips-Perron test showed that in first difference; the variables selected are stationary. We used the cointegration estimation after Johannsen test, which revealed that there is a nexus between the variables. The results from the Vector Error Correction (VEC) model showed that if urban population increases to one percent, forest area increases to 21.3%. Moreover, if population density increases to one percent, forest area declines to 11%. However, these results are not significant at 95%.
Conclusion and application of results: It revealed that explanatories variables have not a significant impact on FA. The actors must stabilize peri-urban agricultural population in the same landscapes for a long run, by using some innovative technics. The struggle against rural exodus by rural development policies remains also among solutions. In addition, we recommend the fishing, the aquaculture and the pisciculture like the durable economic activities, which have not a risk for climate.
Keywords: Urban population growth, Forest area, Sustainable development, Democratic Republic of the Congo.

INTRODUCTION

The forest area in Sub-Saharan (SSA) has declined from 29.3% in 1990 to 26.1% in 2007 (Jemal, 2020). The loss of biodiversity passes by habitats destruction caused by anthropic activities in the forest or in the aquatic zone. It means that human population growth can leads to intensification of anthropic activities, and by consequence, a loss of biodiversity. Several studies showed that human population growth and non-respect of policies can always lead to the loss of biodiversity. Notably Oko *et al* (2022) estimated the effect of population growing on biodiversity loss in the Boki rainforest of Nigeria. That study analysed the causes of quick population growing, the nearby causes of deforestation, the impacts of deforestation on biodiversity, and the economic values of tropical forest to Boki groups. Their study collected information on the dynamics that contribute to the population increasing, the pace of biodiversity loss, the sources of deforestation, and the impacts of deforestation on biodiversity. The results showed that a mix of human factors intensified tropical forest degradation in the area concerning by study. These causes contributed to destroy the important flora and fauna species in the study area. Cafaro *et al* (2022) argued that several ways are documented by conservation biologists that anthropic activity leads to global biodiversity loss, moreover, the role of overpopulation are neglected by them. Following them, high numbers of populations contribute to destroy or to worsen species' habitats. By consequence, the decreasing of populations numbers offers the probability of ecological rebuilding. The conservation biologists encouraged to advocate for smaller inhabitants, through improved admission of modern contraception, and underline promotion of small peoples. They affirmed that in the long term, smaller human populations are necessary to preserve biodiversity in both less developed and more developed parts of the world. It was argued that besides other purposes, the reducing of population is necessary. Handayani *et al* (2022) assessed the urban forests role of in adjusting the environment quality. They found that urban development has consequences for the rise of environmental problems. With the increasing development of various activities such as road construction, transportation activities, industry, settlements and other activities, this often results in a decrease in the area of green open space, and is often accompanied by a decrease in the quality of the environment. This resulted in the city becoming unhealthy, polluted and dirty. The development of green open spaces in the form of plants or green parks is needed to maintain the preservation of nature and create healthy conditions for city dwellers. Ecosystems in urban areas have urgency to be carried out immediately and carefully monitored. In several countries of Africa, rural exodus plays an important role in increasing human population in urban centres. That leads to the situations described above. Jiagho *et al* (2021) realized a study on the factors of deforestation at the northern zone of Cameroon. following the socio-economic investigations 4 main crowds of drivers of deforestation and degradation identified: anthropogenic, natural, bioecological and political institutional drivers. Some of them may be direct and immediate causes, and other indirect and underlying. Here, it is essentially the effects of human population growth, which affect the forest area and by consequence, aggravate the biodiversity loss. Ganivet (2020) assessed the impacts population growth on global biodiversity, and climate, the results showed that persistent population growth plays a considerable role in the devastation of biodiversity and in climate change. Saha *et al* (2020) detected that the loss of forests area in

India. Akintande *et al* (2020) developed a renewable energy consumption model in the five most populous countries (Ethiopia, South Africa, Nigeria, DR Congo, and Egypt) in Africa, concerning the period from 1996 to 2016. The results after using Bayesian Model Averaging (BMA) indicated that among the key factors of renewable energy consumption, remains the population growth. However, in DRC, the main source of poor's energy is the wood energy. By consequence, most the human population increases needs of wood energy increase too, and it provokes the pressure on forest exploitation. Bozongo (2019) realized a study on the determinants of deforestation in the Congo basin for the period from 1998 to 2017. The results obtained by estimating the error correction model in the panel through the DOLS technique reveal that the Control of corruption (institutional variable) and population density (demographic variable) explain marginally deforestation in the Congo basin. Still in Congo Basin, Bakehe (2019) analysed the determinants of deforestation of 06 forest countries of the Congo Basin for the period from 1990 to 2010. From a panel model with random effects, he showed that there is no environmental Kuznets curve (U shaped curve inverted) between deforestation rates and per capita income. Conversely, he had a growing and monotonous relationship between these two variables. Regarding the variables of the population, his results showed that the density of the population has a positive and very significant impact on deforestation. However, its growth has no significant influence. The human population growth explains today the deforestation and degradation of forests in Sub-Saharan region, and their effects lead to the loss of biodiversity (Mohammed, 2020). Today, if we want to apply the biodiversity policies with efficacy, it must understand the problems of human population growth. We recall that the anthropic activities remain the key cause of problems in the forest sector. Sarbapriya (2011) assessed the, impacts of population evolution on land, forest and water and energy resources. He found a significant nexus between three factors: high population growth rates, population density and number of people below poverty line. Population pressure leads to land degradation and soil erosion in India. He argued that expanding population numbers and growing determine the energy consumption. As opposed to other searchers, this study purposes to estimate the relationship between urban population growth and the forest area in Democratic Republic of the Congo, country-solution against climate change, and a bastion of biodiversity. Because of its biggest forest, a large part of biodiversity remains there. In addition, be willing to preserve the biodiversity requires else a deep knowledge on the nexus between human population growth and area forest.

MATERIAL AND METHODS

The data collected from World Bank concerning the period from 1992 to 2020, and its gathering helped by using of a Modem and a Laptop. the cointegration was used based on Vector error correction model (VECM) to estimate the relationship between our variables, which are the forest area (FA) which is also the dependent variable, the urban population growth (UP), which is the main explanatory variable, and the population density (PD) served to control the effect of the main explanatory factor. We note that following literature, there is a relationship between FA and UP in two senses in long term. Forest area can influence human population growth and vice versa. That is why we choose to estimate this relationship by a model of long run, which is

VECM. Following the cointegration method, letter Z_t represents a vector that includes different variables. The VAR is represented as:

$$Z_t = \mu + \sum_{i=1}^{n-1} \Pi_i Z_{t-i} + \varepsilon_t \qquad (1)$$

Where Π_i is a $n \times n$ matrix of parameters, μ is a constant term and $\varepsilon_t \approx iid(0, \Omega)$. The VAR system of expression (1).
can be rewritten as a vector error correction (VEC) model

$$\Delta Z_t = \mu + \Pi Z_{t-1} + \sum_{i=1}^{n-1} \Gamma_i \Delta Z_{t-i} + \varepsilon_t \qquad (2)$$

Where Γ_i is the parameter of short-term coefficients, and Δ is an expression for first difference series. The rank of Π, r fixes how many linear combinations of Z_t are stationary. If $r > 1$, one is able to show the indirect association that exists between variables. Concerning this paper, the vector Z_t includes the forest area (FA_t), the urban population growth (UPt) and population density (PD_t) The possible cointegrating nexus, when normalised by FA_t, is expressed as:

$$FA_t = c + \alpha\, UPG_t + \beta PDt + \varepsilon_t \quad (3)$$

with the cointegrating vector given by (1, $-\alpha, -\beta$) in this case.

RESULTS

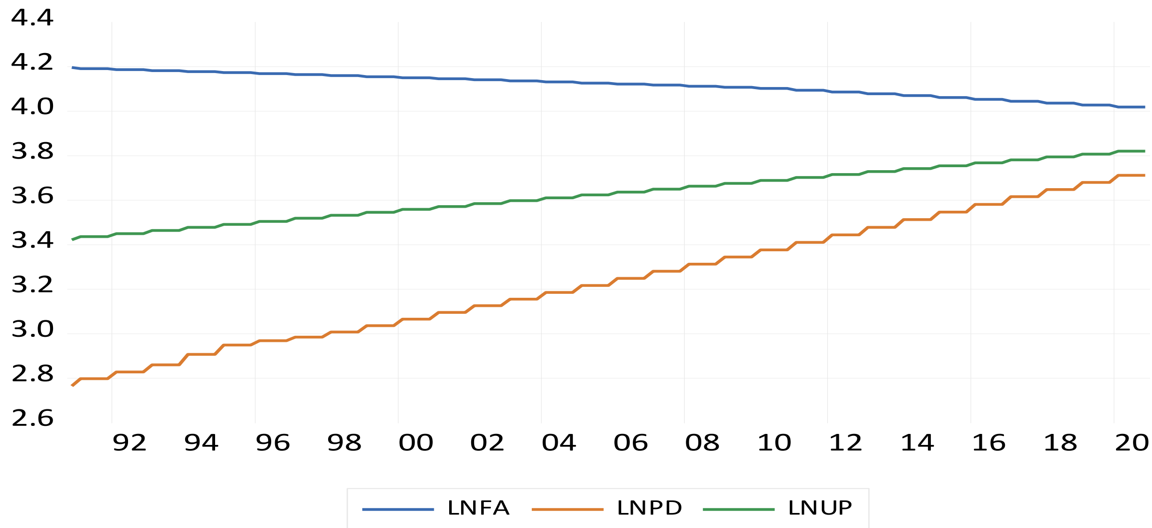
The table 1 gives the condensed from Phillips-Perron test of stationarity of variables.

Table 1: Output of Phillips-Perron test

Variables	Phillips-Perron test stat* level	Critical at value 5%	Phillips-Perron test stat at First dif.	Critical value at 5%	Phillips-Perron test stat at Second dif.	Critical value at 5%	Int. order
lnFA[1]	2.847133	-2.885654	**-16.24578**	-2.885863	-	-	I(1)
lnUP[2]	-1.192313	-2.885654	**-30.85631**	-2.885863	-	-	I(1)
lnPD[3]	-0.297413	-2.885654	**-23.64354**	-2.885863	-	-	I(1)

All variables are integrated in first difference. However, we argue that there is a cointegration relationship between these variables, hence their tendencies in the figure 1 below:

[1] lnFA: natural logarithm of variable forest area
[2] lnUP : natural logarithm of the variable Urban Population
[3] lnPD: natural logarithm of the variable Population Density



All these variables evolve in the same sense. It supposes an existing of cointegration relationship in the end. To test cointegration existing relationship between these variables, we use Johansen test, which is combined of trace and Maximum Eigenvalue tests. The result is in the table 2 below:

Table 2: Output of cointegration test of Johannsen

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.232724	61.36345	47.85613	0.0017
At most 1 *	0.130047	30.63406	29.79707	0.0400
At most 2	0.082095	14.47344	15.49471	0.0708
At most 3 *	0.038355	4.536758	3.841465	0.0332

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level.

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob. ****
None *	0.232724	30.72939	27.58434	0.0191
At most 1	0.130047	16.16062	21.13162	0.2156
At most 2	0.082095	9.936684	14.26460	0.2161
At most 3 *	0.038355	4.536758	3.841465	0.0332

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level.

This result means that exists a long run relationship between these variables. This output allowed us to estimate this nexus that result is in the table 3 below.

Table 3: Output of cointegration estimation by VECM

Cointegrating Eq :	CointEq1		
LNFA (-1)	1.000000		
LNUP (-1)	-21.35963 (9.16013) [-2.33180]		
LNPD (-1)	10.98608 (3.91333) [2.80735]		
C	37.76072		
Error Correction:	D(LNFA)	D(LNUP)	D(LNPD)
CointEq1	-0.001194 (0.00059) [-2.03032]	-0.000586 (0.00123) [-0.47593]	-0.000289 (0.00302) [-0.09558]

$$\boldsymbol{\varepsilon t = 1lnFA + 11lPD - 21.3lnup + 37.7lnFA = -37.7 + 21.3lnUP - 11lnPD + \varepsilon t}$$

This estimation output means that if urban population increases to one percent, forest area increases to 21.3%. Moreover, if population density increases to one percent, forest area declines to 11%. The error correction established that urban population remains the endogenous equilibrium forest area at 95%. However, we can tell that our explanatories variables have a no-significant impact on FA at 95 % following t-statistic test.

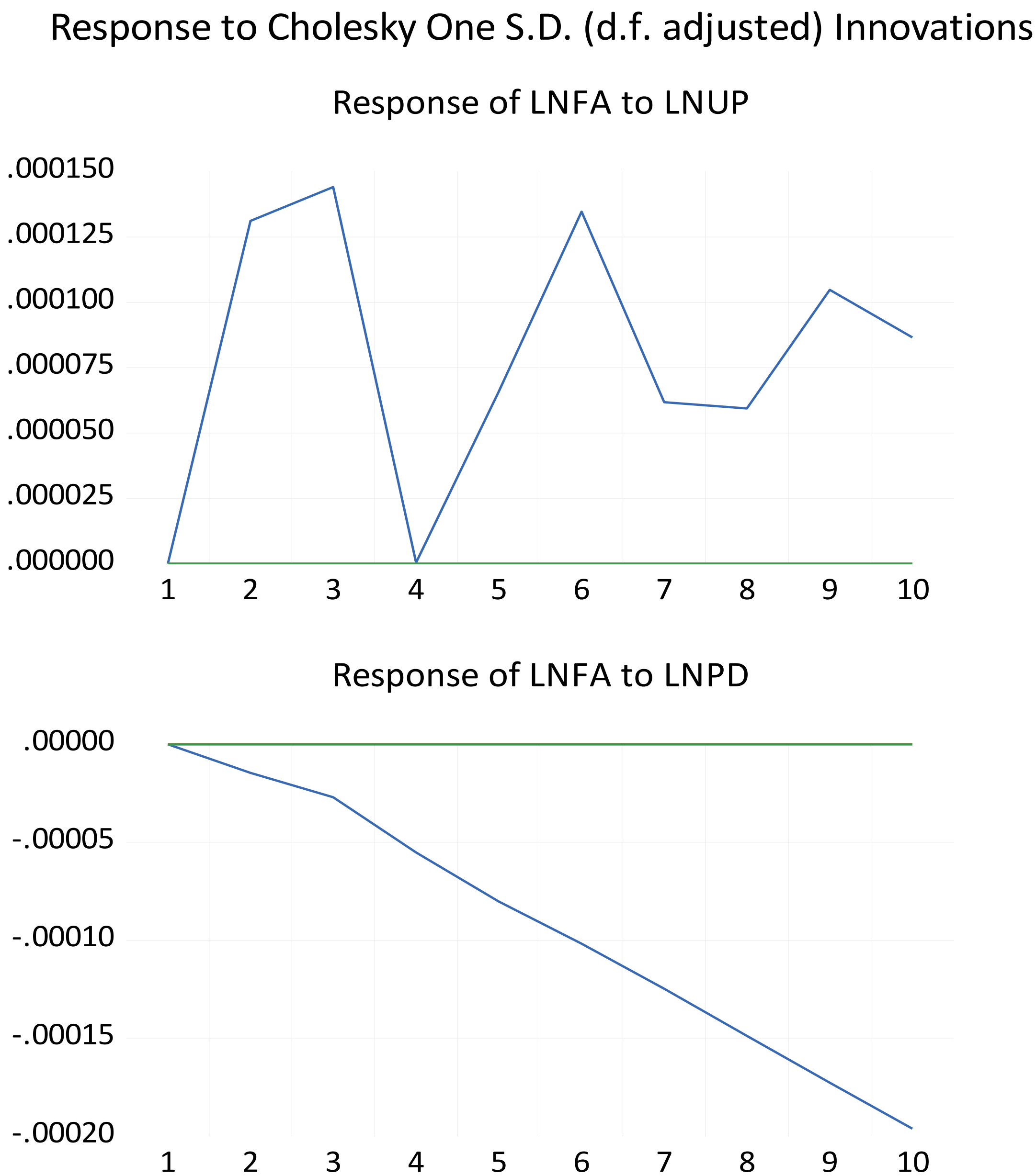


Figure 1. Reponses of FA to UP

The response of FA to UP shock boost negatively the FA. That confirmed the output estimation from VECM confirming that UP constitutes an insignificant factor in short and long run at 95%. We used stability test besides robustness test, to see if the parameters will conserve their stability, and the negative result can remain between these main variables. The result is in the figure 2 below:

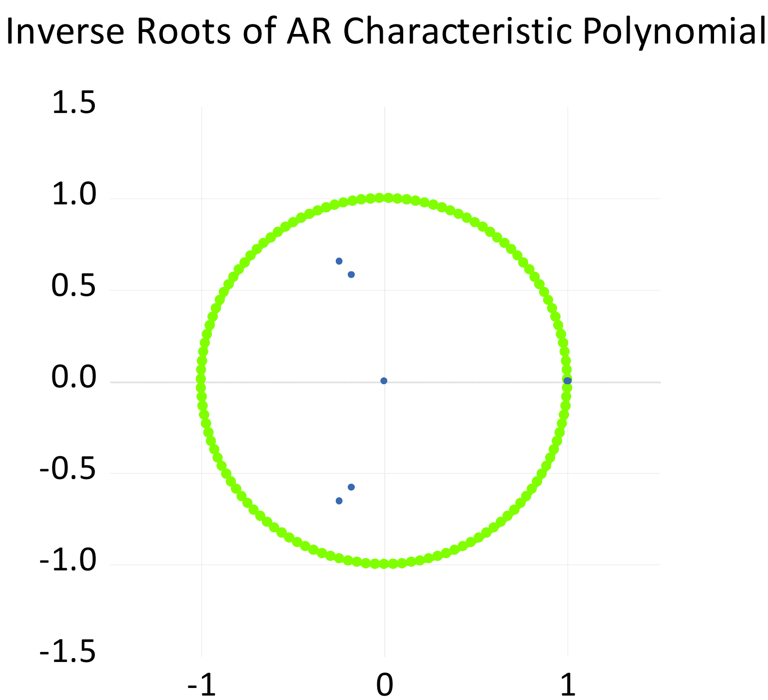


Figure 2

This result shows that our model remains stable and valid.

DISCUSSION

This study results do not confirm those of some researchers, who found that population growth is among the main factors of degradation of forests and deforestation (Akintande *et al.*, (2020); Saha *et al.*, 2020; Ganivet, 2020; Jiagho *et al.*, 2021). They corroborate contrarily, that Bakehe (2019) found that human population growth has a no-significant impact on the deforestation. For the population density, our result corroborates that of Bozongo (2019), who found that population density (demographic variable) explain marginally deforestation in the Congo basin. In DRC, some realities urge to be explained. Urban population grows rapidly because of two reasons: First, the rural exodus caused by severe poverty in rural places, produces the increasing of urban population. Secondly, if peasants arrive in town, they procreate more. Their behaviour of natality contributes largely to increase the urban population. However, in DRC, small party of this urban population exploit the peri-urban forests. In addition, the large party of forest in rural landscapes is reconstituting. Because population has not the financial capital to exploit, and many of them living town after rural exodus. By consequence, it is only the peri-urban forests, which are exploiting with weak effects in terms of forests' degradation and the deforestation. It leads to loss of biodiversity around towns. That is why; Jemal (2020) generally argued that the human population growth explains today the deforestation and forest demoting. It is the same affirmation based on the result of Oko *et al* (2022) who found that a rapid population growth, which conducts to increasing human activities intensified tropical rainforest degradation. Without doubt, following literature, and based on our results, we could affirm that human population growth conducts to destruction of forests, and by consequence, it runs to loss of biodiversity. However, the main result of this study contrasts this affirmation. Two things must be highlighted: firstly, the poverty in rural seats reduces the peasant's capacity to exploit forests. Secondly, the rural exodus conducts to the weak labour in rural places, which could exploit forest. Moreover, only small party of urban population is exploiting the peri-urban forests. In this fact, forests are reconstituting in rural lands, leading to the growing of their area.

CONCLUSION AND APPLICATION OF RESULTS

This article aims to estimate the relationship between urban population growth and forest area in Democratic Republic of the Congo, concerning the period from 1990 to 2020. The data collected from World Bank by documentary technic. After Phillips-Perron test statistic and Johannsen test, we used the cointegration estimation. The results showed that urban population growth has a positive no-significant effect on forest area dynamic. In addition, population density has a no significant negative impact on FA. Because, it is the small party of urban population who destroys the peri-urban forests leading to deforestation and degradation of forests. It implies that is also necessary to stabilize peri-urban agricultural population in the same landscapes for a long run, by using some innovative technics. This will decrease the pressure on peri-urban forest area. The struggle against rural exodus remains also among solutions. We note that the institutions must place in centre of preservation of the biodiversity policies and the population movement. The struggle against rural exodus by rural development policies remains moreover among solutions. In addition, we recommend the fishing, aquaculture and pisciculture like the durable economic activities, which have not a risk for climate. Because, they can stabilize the operators in the same places in long run. Moreover, they can assure the revenues for these operators and several other persons in long term. That can attenuate the forests degradation and deforestation in DRC, which has a biggest quantity of bogs.

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