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## Extended abstract

### **Analysis of current patterns of deforestation in Latin America and the Caribbean**

#### **Introduction**

Climate change is a major threat to human and natural systems, and particularly to the functionality of ecosystems and the services they provide (IPCC, 2014). Tropical deforestation contributes to 12-14% of global greenhouse gas emissions (Harris et al., 2014). Deforestation also reduces the capacity of forests as key above ground sinks of carbon, and has considerable effects upon biodiversity (Peres et al., 2010 and Pereira et al., 2012). Forest conservation and management offers a strategy for climate change mitigation through restoration of the capacity of forest carbon sequestration.

Latin American and Caribbean forests in particular have been subject to extensive deforestation in recent decades, being responsible of 54% of greenhouse gas emissions from deforestation. Between 1990 and 2010 Ecuador saw a 28% reduction in its forest cover, Paraguay 16% and Brazil 10% (FAO, 2010). The causes behind such deforestation can be attributed to agricultural expansion, infrastructure development and timber extraction (Geist and Lambin, 2002). However, the forces behind these local-scale activities stem from large-scale factors including; economic (Richards et al., 2012; Aide et al., 2012 and Asner et al., 2013), governance and policy (Araujo et al., 2009 and Paneque-Galvez et al., 2013), social (Killeen et al., 2008 and Bonilla-Moheno et al., 2012) and biophysical (Müller et al., 2011 and Müller et al., 2012).

A number of international initiatives and cooperation activities are being developed with the aim of protecting forests and biodiversity, and reducing the contributions of deforestation to climate change (the UN Convention on Biological Biodiversity Strategic Plan 2011-2020 and the Aichi Biodiversity Targets, the UN-REDD Program, etc). However, the success of such programs will be determined by the context of countries in which they are developed and by the causes

of deforestation in those countries. Therefore, there is a need to understand what those underlying causes are and what different patterns are found across countries.

In light of this, the aim of this research is to identify the socio-economic, institutional, biophysical and technical factors that determine deforestation at the national level in Latin America and the Caribbean and contribute to characterize the different deforestation patterns in the region.

### **Methodology**

To address this challenge, statistical analysis and econometric modeling were applied using a database developed for 27 Latin American and Caribbean countries. The database development started with an extensive literature review of over 80 peer-reviewed articles that considered drivers and causes of deforestation in Latin America and the Caribbean. This review guided the selection of 70 variables including information on biophysical characteristics, socio-economic development, forest and agricultural sector characteristics, technologies and infrastructures, governance and implementation of REDD Programs and forest protection initiatives. The database was populated using country-level data for the years 2000, 2005, 2010, for which forest cover data were available. Data sources include publicly available datasets from FAOStat, The World Bank, UNDP and REDD+ databanks.

The first phase of the analysis included the description of country characteristics including current land uses, forest cover and deforestation rates, socio-economic and institutional contexts, physical and geographical features, and technical developments. Countries were clustered according to the key deforestation-related endogenous variables identified.

A second phase of the analysis included a selection of key potential explanatory variables using Principal Component Analysis (PCA) followed by the estimation of a model for deforestation at the country level. According to the available dataset, a short panel regression model is estimated using data for years 2005 and 2010 and using as endogenous variable average annual deforestation for the periods 2000-2005 and 2005-2010 respectively.

### **Results and discussion**

The analysis of forest cover and deforestation in the two time periods across the 27 countries considered showed that these two variables are rather independent. Therefore, although

deforestation is the subject of analysis, forest cover was also used to identify types of countries in relation to deforestation.

Cluster analysis established five categories of countries. Cluster 1 (Uruguay, Puerto Rico, Cuba and Costa Rica) shows medium to low forest cover and reforestation (negative deforestation). Cluster 2 (Guyana and Suriname) includes countries with a high forest cover (above 75%) and almost zero deforestation. Cluster 3 (Chile, Bahamas, Dominican Republic, Jamaica, Colombia, Peru, Mexico, Trinidad and Tobago, Panama, Bolivia, Brazil, Venezuela, Belize and Paraguay) is made of countries with medium forest cover (40-60%) and low to medium deforestation levels. Clusters 4 (Haiti, Argentina and El Salvador) and 5 (Ecuador, Guatemala, Honduras and Nicaragua) are those that represent the highest risk of deforestation including countries that present low to medium forest cover and medium to high deforestation rates.

PCA underlined the relevance of different types of variables in determining deforestation. On the one hand, we find the frequently considered proximate causes of deforestation that include agricultural and cattle ranching expansion that are competing land uses for forest. On the other hand we find what are often considered underlying drivers of deforestation that include social and economic elements that account for economic development, social welfare, demographic aspects and policy elements.

The econometric model for deforestation is a short panel two-stage regression model. In the first stage, *forest cover* is estimated using *arable land*, *permanent crop land* and *rural population growth* as instrumental variables. Then in a second stage the deforestation equation is estimated using the instrumented *forest cover*, and *total population growth*, *mortality rate*, and *control of corruption* (a governance indicator) as explanatory variables.

Results of the model estimation demonstrate that the exogenous variables in the model are highly significant. They are able to represent 68% of variability of the average annual deforestation rate of the countries included in the analysis. Looking at the countries' characteristics, it is remarkable that those countries with the highest risk of deforestation (clusters 4 and 5) are also those with the lowest level of control of corruption, in line with other research (Smith et al., 2003). These countries also show mortality rates (both male and female) above the average, and forest cover below the average of all countries analyzed. These results highlight the relevance of governance and social factors in the success of forest protection programs.

An evident limitation of the study is the low data availability that prevents the development of long panel data models that are able to capture patterns of deforestation along time.

However, in spite of the limitations of the dataset the model's goodness of fit is rather high in light of the adjusted  $R^2$  and statistical tests.

### **Conclusions**

Understanding the causes and drivers of deforestation is crucial for designing policies that address the challenges of biodiversity conservation and climate change mitigation. This research provided a national scale analysis that underlined different patterns of deforestation in Latin America and Caribbean countries. The analysis evidenced that there may be different underlying drivers of deforestation risk related to institutional, social and demographic aspects. The results obtained in the analysis support the need to develop forest protection policies that account for the different national contexts that shape deforestation. They also need to consider not only the immediate threats to forests, such as the economic incentives to farming and grazing expansion, but also the need to develop institutional and social mechanisms that can contribute to sustainable socio-economic development and to the effective implementation of current policies and rules.

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