Accounting for institutional quality in global forest modeling

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ABSTRACT

The current state of the art in modeling forest cover change is to combine a detailed representation of biophysical processes with economic decision-making principles. Yet, there is an increasing consensus that the quality of political institutions is another relevant component in determining forest cover change patterns.

In this paper, the Global Forest Model is used to analyze whether including an index, measuring the capacity of political institutions to guarantee sustainable natural resource management, allows to improve the precision of the modeled forest cover trend. The analysis shows that incorporating the index indeed allows reducing the gap between the estimated and observed forest cover trends for the 2000 to 2010 calibration period.

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1. Introduction

Deforestation accounts for 12% of anthropogenic CO_2 emissions (Smith et al., 2014), causes biodiversity loss (Gibson et al., 2011), soil erosion (Smith et al., 2016), ground water stress, and changes in local rainfall patterns (Garcia-Carreras and Parker, 2011). The literature has widely acknowledged the conversion of forest land to agricultural land as the main driver of deforestation (Busch and Ferretti-Gallon, 2017; Gibbs et al., 2010; Mayaux et al., 2013). This logic is typically reflected in land use change models. In the Global Forest Model (G4M global v.4.0), a representative land owner makes a return-maximizing land use decision, based on a comparison of net present values of agricultural and forest land. The biophysical properties and the agricultural suitability of the land are taken into account for the decision (Kindermann et al., 2006, 2008).

After Brazil's historic success in curbing deforestation by more than 70% (Tollefson, 2015) through enhanced enforcement and fining of illegal deforestation (Cisneros et al., 2015; Hargrave and Kis-Katos, 2013; Nepstad et al., 2014), more recent literature on deforestation suggests that next to economic and biophysical factors, the quality of political institutions is a key parameter influencing land use change decisions (Bhattarai and Hammig, 2001, Bhattarai, 2004; Buitenzorgy and Mol, 2011; Galinato and Galinato, 2012; Koyuncu and Yilmaz, 2013) .[1] Furthermore, examples such as Costa Rica and Colombia, with similar gross national income income trends (World Bank, 2015c), but diverging forest cover trends from 1990 to 2015, suggest that non-economic factors also significantly influence deforestation outcomes. Costa Rica experienced a 7.5% forest cover gain and Colombia a 9% forest cover loss (FAO, 2015a,b).

By providing intertemporal contracts, institutions help generate regularity in social behavior and can prevent the overuse of common goods (Aoki, 2001). In this article we refer to this capacity with the concept of 'environmental institutional quality'. It measures the extent to which existing political institutions lead to a sustainable use of common environmental resources. In order to measure environmental institutional quality, this paper builds on the FAO

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[1] In spite of this success, deforestation rates in the Brazilian Amazon have recently increased again by 29% between 2015 and 2016 (INPE, 2017).

Table 1
Data sources for the composition of the environmental institutional quality index.

Indicator	Source	Institution	Availability
Environmental policy	Hartmann and Reimann (2010)	Bertelsmann Foundation	2006–2014
Number of days to start a business	Porter et al. (2008)	World Economic Formum	2003, 2006–2014
	The World Bank Group (2015a)	World Bank Group	2004–2014
Structural constraints	Hartmann and Reimann (2010)	Bertelsmann Foundation	2006–2014

and PROFOR's (2011) forest governance framework that suggests that the quality of political institutions in the forest sector can be measured by three main components, which are (i) regulatory frameworks, (ii) planning and decision making processes, and (iii) the implementation and enforcement of policies. Despite the increasing attention that is paid to the quality of political institutions in deforestation processes in the empirical literature, it is still uncommon to take differences in the quality of institutions into account when modeling forest cover change trends (Benítez et al. (2007) and Wang et al. (2016) represent notable exceptions). Magliocca et al. (2015) make a strong case for using synthesis knowledge to improve process-based land change models. This resesarch project aims at taking this new trend in the empiricial literature into account for future forest cover change simulations of the Global Forest Model. In the Global Forest Model, all factors causing deviations of purely economically motivated land use change decisions are captured by the residual calibration factor. This factor is multiplied by the estimated net present value of forestry, to yield an adjusted net present value of forest land use.

This paper tests the hypothesis whether the residual calibration factor can be reduced by including an additional parameter into the model, which measures the quality of political institutions that are relevant for the sustainable management of environmental resources like forests. Reducing the residual calibration factor would reduce unexplained factors influencing the forest cover change decisions and thus improve the representation of deforestation processes in the model. The hypothesis is first tested through a regression analysis using the residual calibration factor for the 2000 to 2010 period as a dependent variable and an environmental institutional quality indicator as independent variables. In a second step, the indicator is applied to the model, to evaluate, in a third step, whether this can substantially improve the simulation. Finally, a test of the significance of the findings is conducted using forest cover data for 2015. The test indicates that for the countries selected, a better match between the model forecast and observed forest cover change trends can be achieved by accounting for environmental institutional quality.

The remainder of the paper is organized as follows: in section 2 the data and the construction of the environmental institutional quality indicator are presented. Section 3 presents the methodological steps taken to integrate the indicator into the model. Section 4 presents the results, and section 5 discusses the relevance of the findings for other forest cover change models and ecological process models in general.

2. Data

2.1. Environmental institutional quality index

An in-depth review of existing data sources reveals that comprehensive cross country datasets, measuring differences in the quality of institutions affecting the management of natural resources and forests in particular, are unavailable. At the same time, Kishor and Belle (2004) highlight that general governance indicators are unsuitable to measure the performance of institutions charged with the management of natural resources and

forests in particular, because general and specific environmental governance trends can be fundamentally different. In the absence of specific measures on the quality of forest sector institutions, an indicator is constructed relying upon the FAO and PROFOR's (2011) forest governance framework. The index aims at representing the three pillars of the forest governance framework, which are (i) the quality of regulatory frameworks, (ii) the effectiveness of decision making processes, and (iii) the enforcement of existing policies. Existing indicators on the quality of institutions are used as a proxy for these components and aggregated to form the composite environmental institutional quality index.[2]

More precisely, component 1 is represented by the indicator "*Environmental Policy*" developed by Hartmann and Reimann (2010). This indicator is defined as measuring the extent to which "*the externalization of costs or inadequate time horizons are avoided or restrained by environmental regulation*" (Hartmann and Reimann, 2010). Indicator values are based on expert assessments and provided in an ordinal scale ranging from low (1) to high (10). Component 2 is represented by the indicator "*number of days to start a business*" by Porter et al. (2008), which is complemented with the same indicator produced by the World Bank (2015a) taking data for Niger, the Democratic Republic of the Congo, Belize, Tajikistan, Laos, Myanmar, Dominican Republic, Brunei, Sierra Leone, Togo, Uzbekistan, Liberia, Eritrea, Republic of Congo, Gabon, Sudan, Central African Republic, Belarus Guyana, Bhutan, Suriname, and Gambia. The indicator measures the time required to start a business by the number of "*calendar days needed to complete the procedures to legally operate a business*" (World Bank, 2015a; Porter et al., 2008). It refers to a standard business that is 100% domestically owned. The indicator is used as a proxy for component 2 of the FAO and PROFOR's (2011) forest governance framework, reflecting how long it takes for an administration to make a decision and thus how effective decision making processes are. Data is provided in cardinal units, counting the number of days. Component 3 is represented by the indicator "*structural constraints*" devised by Hartmann and Reimann (2010). This indicator is defined as measuring "*structural difficulties* [that] *constrain the political leadership's governance capacity*" (Hartmann and Reimann, 2010). Structural difficulties include "*a lack of educated labor force*" and "*severe infrastructural deficiencies*" (Hartmann and Reimann, 2010). It is therefore used as a proxy for the government's ability to implement existing environmental and forest conservation policies. The indicator is based on an expert assessment on an ordinal scale ranging from 0 to 10 points. A score of 10 corresponds to a low level of structural constraints. Table 1 presents details on data sources for each of the components. The complete dataset is available upon request.

In order to construct the index, the values of different indicators have to be normalized. Values for the variables "*number of days to start a business*" and "*structural constraints*" are rescaled, such that for all components of the composite index a high value represents

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[2] In the absence of suitable specific measures on the quality of forest sector institutions, we revert to more general measures on the quality environmental institutions in order to approximate the quality of forest institutions.