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Site identification for carbon sequestration in Latin America: A grid-based economic approach

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Abstract

Latin America harbors a large potential for carbon sequestration and biomass production. This paper deals with the estimation of carbon supply curves for afforestation and reforestation and its implicit carbon sequestration in wood products. The methodology presented aims at determining sequestration costs for individual geographical entities, based on unit-specific land use and ecosystem information, and economic data. This approach allows us to supplement local statistics that are typically scarce and unreliable in developing countries, with independent remotely sensed data in order to have a consistent method that can be applied over a large region. The results are mapped, which allows in-depth appraisal of results in an interactive mode and quick identification of least-cost carbon sequestration sites. The model is dynamic to support decision making at various stages in the Kyoto process. After model calibration and sensitivity analysis, we conducted scenario analysis. For a carbon price scenario of $20/tC, we find that the cumulative carbon sequestration by 2012 and 2020 is about 125 MtC and 337 MtC, respectively. The net benefit by 2020 could amount up to US$ 2.3 billion using less than 4% of the area suitable for afforestation and reforestation in the next 20 years. Our long-term estimates of the cumulative sequestration potential for 100 years imply that tree planting could compensate for more than 7 years of current CO_2 emissions of the region's energy sector at low costs.

Keywords: Carbon sequestration; Climate change; Afforestation; Reforestation; Kyoto Protocol; Clean development mechanism

1. Introduction

Global warming as a consequence of human-induced emissions of greenhouse gases (GHG) is perceived as a major environmental concern threatening future welfare. Scientists predict that by 2100, the globally averaged surface air temperature will increase by 1.4–5.8 °C leading to major disturbances

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for human settlements and natural ecosystems (IPCC, 2001). The Kyoto Protocol of Climate Change aims at capping GHG emissions from industrialized countries and allows emission trading between industrialized countries and developing countries through the Clean Development Mechanism, CDM (UNFCCC, 1998).

The CDM is applicable for energy-related projects as well as for afforestation and reforestation projects, where the latter are referred to as CDM-sinks or AR-projects. While for the first commitment period of Kyoto, 2008–2012, the market for CDM-sinks is limited (den Elzen and de Moor, 2002), the importance of CDM-sinks is in the large potential for afforestation and reforestation in developing countries that could be used beyond 2012. According to Nilsson and Schopfhauser (1995), the area available for plantations in the developing world is twenty-six times larger than in Europe, eleven times larger than in the US and three times larger than in the Former Soviet Union. Therefore, there is a need to develop methods for deriving cost curves of carbon sequestration in these regions and identify areas where carbon sequestration is cost-efficient. We take Latin America as a case study because of its land availability and ecological conditions favoring forestry projects, as well as its active participation for implementing carbon sequestration projects in the early stage of the Kyoto process (Brown et al., 2000). We estimate carbon supply curves for AR-projects and its potential benefits for carbon trading under the Kyoto agreement, and provide a geographic representation of the distribution of carbon costs.

Economic studies on carbon sequestration in Latin America have so far provided single point estimates of sequestration costs associated with particular sequestration levels [e.g., Fearnside (1995) for Brazil, Pereira et al. (1997) for Venezuela, Masera et al. (1997) for Mexico and, Olschewski and Benítez (in press) for Ecuador]. These studies provide information on average costs of carbon sequestration for particular regions, but do not assess how these costs increase when large-scale afforestation and reforestation programs are implemented. In contrast to these studies, we evaluate how the heterogeneity of prices (e.g., land and timber prices), and the heterogeneity in land attributes (e.g., net primary productivity and suitability for agriculture) influence sequestration costs and determine carbon supply patterns. In addition, we provide a framework for identifying least-cost sites for carbon sequestration by means of a grid-based analysis that scrutinizes all the available area for plantations in the region.

2. Methods

A myriad of economic land use change models have been developed to derive supply curves of carbon sequestration measures. Some are based on cost–benefit analysis (Sathaye et al., 2001), while others involve more comprehensive analyses like partial and general equilibrium approaches (Callaway and McCarl, 1996), econometric models (Plantinga et al., 1999; Stavins, 1999), timber supply models (Sohngen et al., 1999; Sohngen and Sedjo, 2000), and land use optimization models (Parks and Hardie, 1995). For our purpose, econometric models and general equilibrium models have limited applicability due to data constraints for our study region. For example, Stavins (1999) used a 50-year panel on land use and agricultural output for estimating the parameters for an econometric model of land use in the US. Such detailed information does not exist in most Latin American countries. In order to overcome these problems, we propose an approach where we evaluate afforestation and reforestation decisions by comparing net benefits of current agricultural practices with forestry. In estimating such benefits, we make use of the latest spatial data in order to overcome the limitations of local statistical data.

The analysis starts by creating a homogenous geographical grid (with a grid-cell size of 0.5 degrees) for the whole study area and selecting grid-cells that are suitable for AR-projects, i.e., non-forest areas where tree planting is viable and will not compromise food security of the region. We then estimate sequestration costs for each grid-cell based on estimates for net primary productivity (NPP), plantation costs, expected timber and land prices, and carbon storage in products. Finally, we obtain the cumulative sequestration cost curve by aggregating cell results, taking into account that AR-projects would take place only in cells where the carbon price exceeds sequestration costs. Besides obtaining the cost curve, the method allows identifying the geographic distribution of carbon costs and forest growth potentials throughout the region.