Land Use Policy 41 (2014) 45–60

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Estimating the opportunity costs of reducing carbon dioxide emissions via avoided deforestation, using integrated assessment modelling

Koen P. Overmars[a,b,*], Elke Stehfest[a], Andrzej Tabeau[c], Hans van Meijl[c], Angelica Mendoza Beltrán[a], Tom Kram[a]

[a] PBL Netherlands Environmental Assessment Agency, PO Box 30314, 2500 GH The Hague, The Netherlands
[b] Koen Overmars Consultancy, 2e Buurkerksteeg 7, 3511 KA Utrecht, The Netherlands
[c] LEI, Wageningen University and Research Centre, PO Box 29703, 2502 LS The Hague, The Netherlands

ARTICLE INFO

Article history:
Received 12 March 2013
Received in revised form 4 April 2014
Accepted 21 April 2014

Keywords:
REDD
Scenario analysis
Carbon price
Marginal cost curve
IMAGE
LEITAP

ABSTRACT

Estimates show that, in recent years, deforestation and forest degradation accounted for about 17% of global greenhouse gas emissions. The implementation of REDD (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) is suggested to provide substantial emission reductions at low costs, although cost estimates show large uncertainty. Cost estimates can differ, as they depend on the approach chosen, for example: giving an economic stimulus to entire countries, taking landowners as actors in a REDD framework, or starting from protecting carbon-rich areas. This last approach was chosen for this analysis. Proper calculation of the economic cost requires an integrated modelling approach involving biophysical impact calculations and their associated economic effects. To date, only a few global modelling studies have applied such an approach. In modelling REDD measures, the actual implementation of REDD can take many forms, with implications for the results. This study assumes that non-Annex I countries will protect carbon-rich areas against deforestation, and therefore will refrain from using these areas as agricultural land. The opportunity costs of reducing deforestation within the framework of REDD were assessed using an integrated economic and land-use modelling approach comprising the global economic LEITAP model and the biophysical IMAGE model. One of the main methodological challenges is the representation of land use and the possibility to convert woodlands land into agricultural land. We endogenised the availability of agricultural land by introducing a flexible land supply curve, and represented the implementation of REDD policies as a reduction in the maximum amount of unmanaged land that potentially would be available for conversion to agriculture, in various regions in the world. In a series of model experiments, carbon-rich areas in non-Annex I countries were protected from deforestation. In each consecutive scenario the protected area was increased, starting off with the most carbon rich lands, worldwide systematically working down to areas with less carbon storage. The associated opportunity costs, expressed in terms of GDP reduction, were calculated with the economic LEITAP model. The resulting net reduction in carbon dioxide emissions from land-use change was calculated with the IMAGE model. From the sequence of experiments, marginal cost curves were constructed, relating carbon dioxide emission reductions to the opportunity costs. The results showed that globally a maximum of around 2.5 Gt carbon dioxide emissions could be avoided, annually. However, regional differences in opportunity costs are large and were found to range from about 0 to 3.2 USD per tonne carbon dioxide in Africa, 2 to 9 USD in South America and Central America, and 20 to 60 USD in Southeast Asia. These results are comparable to other studies that have calculated these costs, in terms of both opportunity costs and the regional distribution of emissions reduction.

Introduction

Emissions from deforestation and REDD

Deforestation and forest degradation in 2004 accounted for about 17% of global greenhouse gas emissions (Rogner et al.,

* Corresponding author. Present address: Koen Overmars Consultancy, 2e Buurkerksteeg 7, 3511 KA Utrecht, The Netherlands. Tel.: +31 6 48010758.
E-mail address: koenovermars@hotmail.com (K.P. Overmars).

http://dx.doi.org/10.1016/j.landusepol.2014.04.015

2007). A large part of the emissions from deforestation and forest degradation occurred in developing countries, where the share of deforestation-related greenhouse gas emissions was estimated at around 25% (Houghton, 2005). Deforestation is a complex process, with a wide range of drivers interacting across different scales (Geist and Lambin, 2002). Although deforestation dynamics vary between regions, agricultural expansion generally is recognised as one of the major proximate causes of deforestation in most regions (Geist and Lambin, 2002).

Despite the large contribution of deforestation in developing countries to global greenhouse gas emissions, it is not included in any climate treaty. The Kyoto protocol does take land-use activities (Land Use, Land-Use Change and Forestry (LULUCF)) into account for Annex I countries (industrialised countries and transition economies). Therefore, mechanisms for Reducing Emissions from Deforestation and forest Degradation in developing countries (REDD) was put on the agenda of the UNFCCC at the 13th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) held at Bali in 2007. REDD strategies aim to make forests more valuable when standing than they would be cut down, by creating a financial value for the carbon stored in trees (UN-REDD programme, 2012). The United Nations REDD (UN-REDD) Programme has been in place since 2008, and is aimed at assisting developing countries to prepare and implement national REDD strategies (UN-REDD programme, 2012). Going beyond the reduction in emissions from deforestation and forest degradation, REDD has been extended, the so-called REDD+, which also includes conservation, sustainable management of forests and enhancement of forest carbon stocks. Because this paper is about deforestation reduction, we use the term REDD (without the +). As, to date, no post-Kyoto climate treaty has been drafted, REDD is not part of any existing climate treaty. Thus, and without having a globally agreed financing mechanism for REDD, REDD activities are carried out in a variety of ways at various locations. At the COP16 in Cancun, a REDD agreement was reached, which encourages all countries to engage in activities aimed at halting and reversing forest loss, although important questions related to permanence, reference emissions and financing remain unaddressed (UNFCCC, 2011).

REDD mechanisms aim to create an incentive for developing countries to follow a more sustainable (land) development path and, in doing so, to reduce emissions. The actual implementation of these mechanisms can take many forms, ranging from international agreements between countries similar to that of the Kyoto protocol, bilateral agreements such as those between Norway and Indonesia (MFAMFAI, 2010), to smaller scale activities where project-based initiatives offer carbon credits (at sub-national level or by individual landowners).

Three types of costs related to REDD measures can be distinguished: opportunity costs, implementation costs and transaction costs. Opportunity costs result 'from the forgone benefits that deforestation would have generated for livelihoods and the national economy' (World Bank, 2011). These could be direct, on-site opportunity costs as well as indirect off-site opportunity cost and socio-cultural opportunity costs, which are not easily valued in monetary terms. Implementation costs, the second cost type, are related to the efforts of setting up forest protection. The third type, transaction costs, includes all costs made by all parties involved during the transaction process around a REDD payment (e.g. establishing a REDD Programme, negotiating the costs, monitoring, and reporting and verifying emission reductions). Transaction costs are different from implementation costs, as they do not directly relate to actions that reduce deforestation. (World Bank, 2011).

Many suggest that reducing deforestation is one of the most cost-effective ways to reduce carbon emissions (see e.g. Agrawal et al., 2011; Strassburg et al., 2009). However, to date, the costs of CO_2 emission reduction via REDD schemes has been assessed in relatively few studies, some at the global scale, using modelling approaches (Golub et al., 2009; Kindermann et al., 2008; Reilly et al., 2012; Sohngen and Sedjo, 2006; Strassburg et al., 2009), and some at local scales (Bellassen and Gitz, 2008; Grieg-Gran, 2006; Nepstad et al., 2007), often also using some form of modelling framework. However, the question of what mechanisms may be the most effective and efficient in reducing deforestation, and at which scale, remains largely unanswered. Most studies assume individual landowners to be the actors in a REDD framework. These studies introduce a carbon price (i.e. tax) associated with land use change, including deforestation (Reilly et al., 2012; Golub et al., 2012), and/or reward carbon sequestration (Golub et al., 2012) in their modelling approach to evaluate the opportunity costs related to the reduction in CO_2 emissions from deforestation (and other land use changes). Other studies explicitly assess the behaviour of landowners who receive payments for REDD (e.g. Bellassen and Gitz, 2008). In the first stage in the UNFCCC REDD approach to implement REDD policies direct action from national governments is a more likely REDD strategy. National governments can take the initiative to, for example, protect forests from conversion. This is quite a different approach than tax incentives with landowners and land managers as the primary actors. The (opportunity) costs of such protection incentives are less studied than the taxing approach. This paper aims at filling this gap. From a modelling perspective this is potentially leading to similar relations between costs and emission reductions, although the starting point is different. The approach of this study has clearly an economy-wide effect, through the CGE and the large-scale protection imposed on the model, and therefore indicates the macro-economic costs.

Objectives

This paper estimates the opportunity costs of REDD from the perspective of a REDD framework in which countries are the principal actors. The methodology focuses on the economic income foregone by countries and regions as a result of the protection of carbon-rich areas. Non-Annex I countries (developing countries) are assumed to protect carbon-rich areas from deforestation, and thus do not have the opportunity to convert these areas to agricultural land. We focus on developing countries since the REDD program aims at these countries. To the best of our knowledge, this is one of the first assessment of opportunity costs REDD that takes the perspective of protecting forested area by countries, rather than that of influencing landowners by taxation.

Methods

Modelling and scenario set-up

For this study, we performed a modelling experiment with a combination of the economic (computable general equilibrium) model LEITAP and the integrated, biophysical model IMAGE, which includes the carbon cycle and climate change effects from land-cover and land-use changes. Both models are described in more detail below. The modelling exercise was performed for the 2005–2030 period.

A baseline scenario, developed for the OECD Environmental Outlook to 2050 (OECD, 2012), which follows conventional wisdom and excludes specific climate policies, was used as point of reference for our calculations. Leaving all other assumptions in the baseline scenario unchanged, we developed a series of scenarios with increasing levels of protection of carbon-rich areas. The stepwise exclusion of certain areas from agricultural expansion, ordered according to decreasing carbon content per unit of area, was based on a terrestrial carbon map available from IMAGE 2.4