1. Introduction

Carbon storage in forests is not permanent and considered as such under the Clean Development Mechanism (CDM). In contrast, emissions of greenhouse gases (GHGs) are considered to persist permanently in the atmosphere.

At the international negotiations on the Kyoto Protocol, the difference between temporary carbon storage in forests and permanent GHG emissions has been particularly difficult to address because carbon credits from afforestation and reforestation project activities under the CDM (AR-CDM) will be used to increase GHG emission allowances in Annex 1 countries (those countries that have acquired a quantified emission limitation or reduction commitment under the Kyoto Protocol).

To address the "non permanence" problem, several carbon accounting methods have been proposed. The purpose of these methods is to establish an environmentally integer accounting system of emission allowances and carbon credits under the Kyoto Protocol.

We analyzed the impact of those accounting methods that we considered climatically sound on the minimum scale at which AR-CDM project activities would be financially feasible. The results of this research were presented at several international meetings to help official delegations at the United Nations Framework Convention on Climate Change to take informed decisions.

2. Methods

The issuance of Certified Emission Reductions (CERs = carbon credits) is subject to modalities and rules that have been negotiated and defined internationally. Complying with these modalities and rules generates costs that are above business-as-usual in the reforestation entrepreneurship. AR-CDM project activities are viable if these additional "transaction costs" are equal or above the present value of the CERs.

We developed a model to calculate the project area at which the present value of transaction costs and CERs are equal (Locatelli and Pedroni 2003). The model is based on assumptions about forest grow, planting, and thinning/harvesting regime. It also considers different values for the following parameters:
- 5 accounting methods (as discussed internationally)
- 4 projects types (2 agro-forestry and 2 reforestation)
- 3 present CER prices (from 3 to 9 US$/tCO2)
- 5 variation rates of CER price (from -5% to 5% annual)
- 4 insurance rates (from 0,5% to 3,5% of the insured amount each year)
- 3 crediting period lengths (10 to 50 years)
- 4 economic discount rates (from 3% to 12%)
- 3 levels of transaction costs, e.g.
  - Design and validation: from 40 to 200 K$
  - Verification: from 15 to 75 K$

We run the model 43,200 times, the number of possible parameter combination. For each run, a minimum project area was calculated.

Data from the CASCA project (by Kristell Hergoualc'h) were used to simulate a multi-stakeholder shadowed coffee agro-forestry system, and data from teak plantations in Costa Rica as example of a reforestation project. In both cases, two scenarios were considered: a "fast" scenario (all trees introduced in 5 years) and a "slow" scenario (all trees introduced in 25 years).

3. Results

Figure 1 illustrates the CO2 storage curves used in the simulation of the "slow" reforestation project. R is the length of the
harvesting cycle in the different parcels of the project; \( t_{\text{CO2/ha}} \) is the running \( \text{CO}_2 \) average storage per hectare in the project, and \( \text{Ton-Year} \), the amount of permanent emissions offset by the project under the assumption that storing 1 ton of \( \text{CO}_2 \) during a period of 100 years offsets the cumulative radiative forcing effect exerted by a similar amount of \( \text{CO}_2 \) during its residence time in the atmosphere (IPCC, 2000).

The percentage of model runs representing projects that are viable under 500 ha is low, particularly in the case of the coffee agro-forestry system:

"Fast" reforestation: 23.6%
"Slow" reforestation: 7.6%
"Fast" shadowed coffee: only 0.5%
"Slow" shadowed coffee: only 0.02%

The median value of minimum project area indicates that few agro-forestry projects will be feasible, unless significant organizational efforts will be made to pool together numerous small projects in a large "umbrella project" (Fig. 2).

The minimum project scale is also a function of the carbon accounting method used (Fig. 3). The temporary crediting method (tCERs) results in the highest probability of viable small projects (Fig. 4). tCERs are expiring credits. The buyers will have to replace them with new tCERs or with other Kyoto Protocol currencies. Because tCERs expire, they will have a lower price than other currencies of the Kyoto Protocol accounting system. If the buyers expect higher future prices of permanent currencies, the demand and price of tCERs will decrease. Under the likely scenario of increasing prices of per-
The issuance of long-term credits insured against the risk of non-permanence (iCERs) is a viable and environmentally integer accounting option. Model results predict that it could also be the most favorable to small scale projects if the project design is a low risk one, and if the insurance fee is calculated as a function of the quantified project risk.

4. Conclusion

- It appears that only large projects (kha) will benefit from the CDM.
- Low risks projects would benefit from the iCER accounting approach, particularly if the CER price is going to increase (which is likely to occur if the Kyoto Protocol enters into force).
- tCERs are good for addressing non-permanence, but there could be a very low demand (and price) for them.
- tCERs and iCER (with ton-year liability) could co-exist (they are not mutually exclusive). The minimum viable project scale depends on how the non-permanence and accounting issues will be addressed.
- The ninth Conference of the Parties (UNFCCC 2003) decided to address these issues through the temporary crediting approach (tCERs and iCERs):
  - tCERs will expire after 5 years
  - iCERs will expire at the end of the project crediting period (20 or 30 years)

**References**


Locatelli, B; Pedroni, L. Accounting methods for carbon credits: impacts on the minimum size of CDM forestry projects. Climate Policy (accepted in July 2003).


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