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Transaction and abatement costs of carbon-sink projects in developing countries

OSCAR J. CACHO*
School of Economics, University of New England, Armidale NSW 2351, Australia.

GRAHAM R. MARSHALL
Institute for Rural Futures, University of New England, Armidale NSW 2351, Australia.

MARY MILNE
Geoscience Australia, Symonston ACT, Australia.

ABSTRACT. Projects in the forestry sector, and land-use change and forestry projects more generally, have the potential to help mitigate global warming by acting as sinks for greenhouse gasses, particularly CO_2. However, concerns have been expressed that participation in carbon-sink projects may be constrained by high costs. This problem may be particularly severe for projects involving smallholders in developing countries. Of particular concern are the transaction costs incurred in developing projects, measuring, certifying, and selling the carbon-sequestration services generated by such projects. This paper addresses these issues by reviewing the implications of transaction and abatement costs in carbon-sequestration projects. An approach to estimating abatement costs is demonstrated through four case studies of agroforestry systems located in Sumatra, Indonesia. A typology of transaction costs is presented and related to existing pilot projects. The paper concludes with recommendations to reduce the disadvantages that smallholders may face in capturing the opportunities offered by carbon markets.

1. Introduction

Concerns over global warming have led to proposals for the establishment of markets for greenhouse-gas emissions. Tree-based systems are a convenient way of sequestering carbon from the atmosphere to reduce net emissions. Through the process of photosynthesis, trees absorb carbon dioxide (CO_2) which remains fixed in wood and other organic matter in forests for long periods. This is particularly relevant for tropical countries, such as Indonesia and Brazil, with large areas of rainforest as well as deforested degraded land.

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The demand for climate mitigation will have to be met largely by the energy sector, the main emitter. However, land-use change and forestry (LUCF) projects may also have an important role to play, partly because of cost differentials with other forms of mitigation and partly because of asset fixity; adopting new technologies for efficient use of fossil fuels may require scrapping existing infrastructure and require considerable capital investment.

Under the Clean Development Mechanism (CDM) of the Kyoto Protocol, greenhouse-gas emission offsets are measured in metric tonnes of CO_2 equivalents and are called 'Certified Emission Reductions' (CERs). Different sources of supply of CERs, such as energy projects, large-scale forestry, or small-scale agroforestry, will exhibit different abatement costs, expressed as costs per CER. They can be expected to differ also in the transaction costs of integrating them in a market. These include the costs of monitoring and certifying carbon sequestration rates and any other costs required to give investors confidence that the good they are purchasing actually exists. Additional transaction costs may occur at the market level, some borne by sellers and some by buyers.

In this paper, we focus on LUCF projects involving smallholder agroforestry or industrial plantations. Energy sector projects are not considered. It is recognized that carbon sequestration may be only a temporary and insufficient solution to the problem of global warming, and that longer-term solutions will have to be technological and also involve changes in consumer and producer behavior.[1] However, LUCF projects are more likely to benefit smallholders in developing countries by increasing their income and allowing them to diversify, while assisting in the reversal of land degradation and conservation of biodiversity.

Section 2 presents a brief overview of the use of biomass as a carbon sink and the potential of tropical countries like Indonesia to contribute to greenhouse-gas (GHG) emission reductions. In section 3, a simple economic model is used to explain the influence of abatement and transaction costs on landholders' supply of CERs. Four case studies of agroforestry systems in Sumatra, Indonesia, are presented in section 4 to illustrate how the abatement costs of landholders participating in the CER market can be estimated. Section 5 presents an analysis of the transaction costs of a selection of existing projects. Strategies for reducing the transaction costs of smallholders participating in the CER market are considered in section 6. Section 7 summarizes the paper and presents conclusions.

2. Biomass accumulation as a carbon sink

The Intergovernmental Panel on Climate Change (IPCC, 2001) points out that biological mitigation of global warming can occur through three strategies: (i) conservation of existing carbon pools; (ii) augmenting CO_2 sequestration by increasing the size of existing pools; and (iii) increased dependence on sustainably produced biological products (for example, using wood instead of energy-intensive construction materials, or using

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biomass to replace energy production from fossil fuels). Options (i) and (ii) result in higher carbon stocks but can lead to higher carbon emissions in the future (for example, through fires or land clearing for agriculture), whereas (iii) can continue indefinitely.

The global potential of biological mitigation has been estimated to be equivalent to about 10–20 per cent of projected fossil-fuel emissions expected between 2000 and 2050 (IPCC, 2001). The largest potential is in the subtropical and tropical regions, but realization of this potential will depend on land and water availability and rates of adoption (Watson *et al*., 2000; IPCC, 2001).

The large opportunities for biological mitigation in tropical countries cannot be considered in isolation of broader policies in forestry, agriculture, and other sectors. Barriers to reaching the potential level of mitigation include: (i) lack of funding and human and institutional capacity to monitor and verify mitigation efforts and outcomes; (ii) food supply requirements; (iii) people subsisting from the natural forests; (iv) existing incentives for land clearing; (v) population pressure; and (vi) conversion of forests to pastures because of demand for meat (IPCC, 2001).

Much of the land in the tropics is managed by semi-subsistence farmers and shifting cultivators, so their willingness to participate in biological mitigation projects needs to be considered (de Jong *et al*., 2000). Since the CDM requires sustainable-development goals to be met as well as sequestration goals, these types of land users (hereafter referred to as smallholders) are likely to be important foci for this mechanism.

Carbon sequestration services do not need to be transported in order to be sold. Hence, obstacles faced by smallholders in remote areas are lessened in carbon markets relative to markets for other commodities. Another attractive feature of carbon is that a molecule of carbon is the same independently of where it resides, so the problem often faced by smallholders, of not being able to achieve the quality required by international markets in agricultural commodities (for example, see Glover and Kusterer, 1990), does not apply here. However, despite the homogeneous nature of a carbon molecule, differentiation in the carbon market can be envisaged when projects have different attributes in terms of environmental and social outcomes. Given proper disclosure in carbon certificates, buyers may give their preference to these niches.[2]

Carbon sequestration in LUCF projects can be monitored using well-established sampling techniques (MacDicken, 1997; Cacho *et al*., 2004). In order to receive certification and enter the CER market however, a project will have to demonstrate that it is reducing net emissions compared with its absence. In other words, emission reductions must be additional to a business-as-usual scenario. Consequently, project proponents will have to estimate a baseline and demonstrate 'additionality'. Also, the project will have to account for possible 'leakage' and deal with the problem of 'permanence'. These various aspects of accounting for carbon sequestration are defined, and their implications discussed, by many authors, including

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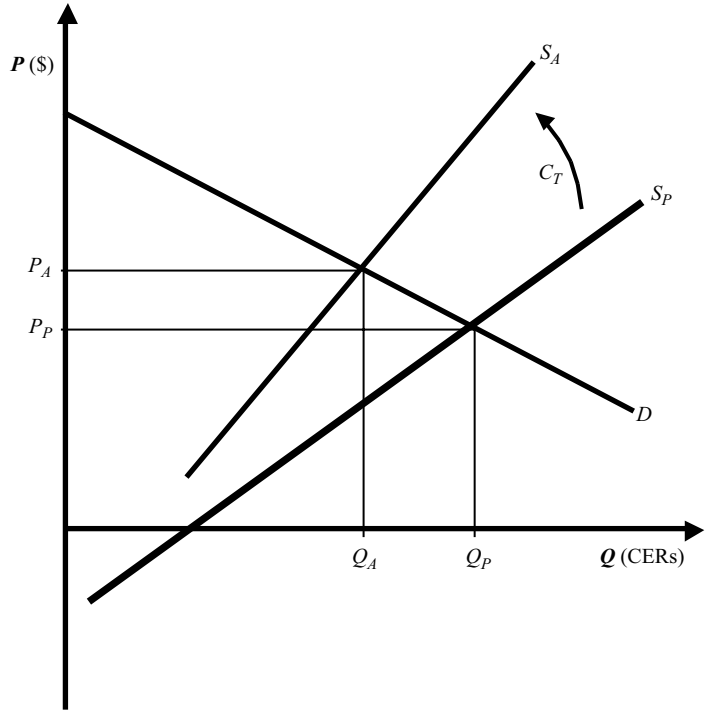


Figure 1. *The market for Certified Emission Reductions*

Smith *et al*. (2000), Smith and Scherr (2002), Moura Costa *et al*. (2000), Brown (2001), Cacho *et al*. (2003), and Marland *et al*. (2001).

3. Abatement costs, transaction costs, and the supply of CERs

The supply of CERs depends on the availability and costs of relevant technologies and resource endowments, and these will be partly determined by location. In China, for example, CDM projects in the energy sector (particularly clean coal-burning technologies) may be the favored (least-cost) option. In Brazil, in contrast, the preferred option may be forest conservation. In figure 1, the potential supply function (S_P) represents the marginal abatement costs of providing different cumulative levels of emission reductions through feasible projects in both the energy and the LUCF sectors.

For a given potential supply function, as determined by current technology and resource endowments, the equilibrium levels of price and quantity (Q_P, P_P) depend on the demand function (D). The position and slope of the demand function will depend to a large extent on the success of international mitigation agreements, regulations imposed by individual

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governments, channeling of overseas development assistance funds, and the extent to which the private sector is required to offset emissions. The rules of the game are by no means resolved, but we can expect a demand function sloping downwards from left to right.

Whatever the demand turns out to be, we need to understand the options available and their ancillary benefits and costs. Here we will focus on the supply side, with emphasis on carbon-sequestration projects involving reforestation or afforestation. The curve S_P shows the prices that would be required to motivate different levels of abatement, or mitigation, of atmospheric carbon in a perfectly competitive world of zero transaction costs.

In this paper, abatement costs are defined as the costs of producing one unit of (uncertified) carbon-sequestration services, or the cost of producing one unit of biomass carbon. In any given location, abatement costs can be estimated as the opportunity cost of undertaking a carbon-sequestration activity, or the cost of switching from the current land use to the proposed land use. This cost includes the present value of the stream of revenues foregone as a result of participating in the project. It may also include additional risk exposure or loss of food security arising from this participation.

The equilibrium quantity of CERs traded based on abatement costs only (Q_P in figure 1) over estimates what is likely to happen. Purchasers, investors, and landholders can be expected to incur significant transaction costs to participate in the CER market. To the extent that transaction costs (C_T) are positive, the supply function illustrated in figure 1 (S_P) shifts upwards (to S_A), and the equilibrium level of trade in CERs declines accordingly (to Q_A). If the transaction costs are sufficiently high, the market will not develop at all.

Transaction costs are the costs 'of arranging a contract to exchange property rights *ex ante* and monitoring and enforcing the contract *ex post*' (Matthews, 1986: 906). A number of studies have highlighted transaction costs as a potential impediment to landholders, and particularly smallholders, participating in carbon markets (for example, Baumert *et al.*, 2000; IPCC, 2001; Smith, 2002).

Various detailed transaction-cost typologies for application in choosing natural-resource policy options have been developed in recent years (for example, McCann and Easter, 1999; Thompson, 1999). Dudek and Wiener (1996) developed a typology of transaction costs incurred in projects designed to mitigate emissions of atmospheric CO_2. We follow Dudek and Wiener's typology but add a category called 'administration costs'. Each of the categories in our modified typology is briefly described below.

Search costs are incurred as investors, project developers, and hosts seek partners for mutually advantageous projects. In projects involving smallholders, search costs would include gathering agricultural, social, and economic information about their region, and contacting and establishing relationships with individual smallholders and any associations they may have formed.

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Negotiation costs are the costs of reaching an agreement. In projects involving smallholders, the cost of negotiating with individuals, including farm visits and establishment of personal relationships can be high.

Approval costs include time delays incurred after submission of project design documents. According to Lile *et al*. (1998), investors in AIJ projects identified the approval costs as a major transaction cost.

Administration costs are associated with the resources expended in administering the translation of a project design into practice. Costs in this category include keeping records of project participants, administering payments, and dealing with problems and disagreements. These activities may require the establishment of a project office in close proximity to the site.

Monitoring costs are the costs of verifying compliance with the agreed terms of the transaction. The carbon sequestration actually achieved by the project (as opposed to forecasts) must be measured, verified, and certified (Moura-Costa *et al.*, 2000).

Enforcement costs are the expenses of insisting on compliance if monitoring detects divergences from the agreed terms of the transaction. When dealing with smallholders, there may be limited legal recourse to enforce contracts due to the slowness of court proceedings and the difficulty and cost of recovering small debts.

Insurance costs arise from the risk of project failure, which might occur if, for instance, fire destroys trees planted as part of the project, the host fails to carry out its responsibilities under the contract, or if the host carries out its responsibilities but the investor fails to pay.

Dudek and Wiener (1996) observed that the various categories are likely to differ in the degree to which they represent fixed costs *vis-à-vis* variable costs. For instance, they suggested that approval costs may be relatively fixed, since the task of seeking approval is unlikely to be affected much by whether the proposed project is small or large. On the other hand, they suggested that monitoring and insurance costs would be relatively variable, increasing with the size of the transaction.

4. Case studies of abatement costs

Some simple case study analyses are presented here to illustrate how abatement costs can be estimated. The analysis focuses on agroforestry systems that are common on the island of Sumatra, Indonesia: rubber, cinnamon, damar, and oil palm. The data for the oil palm system are based on an actual plantation-run project covering 10,700 hectares, whereas the data for the other three systems are based on actual smallholder-run projects. The analysis is from the standpoint of landholders. Hence, private prices are used and performance is measured in financial terms. Although evaluation of a project from a social standpoint should be based on shadow prices, the purpose of this paper is to identify the private incentives actually experienced by landholders; therefore, market prices are used.

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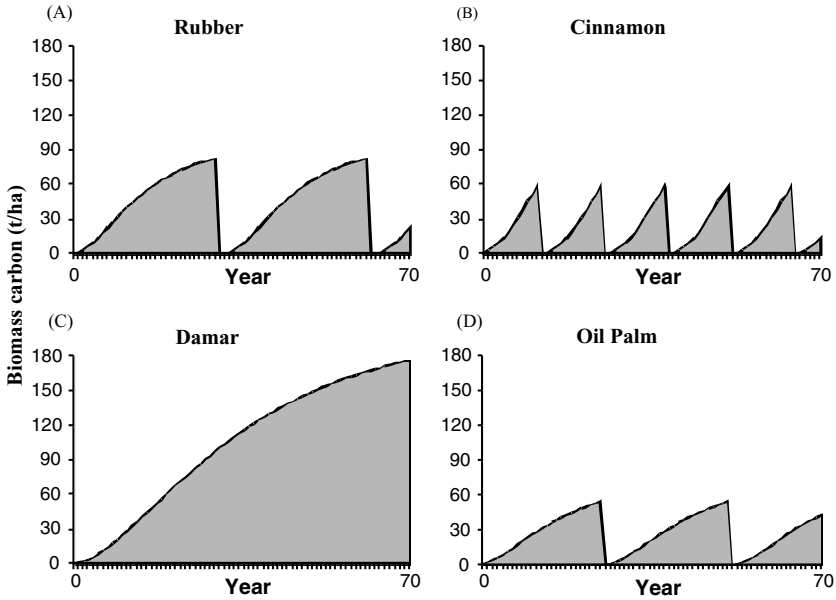


Figure 2. *Carbon-sequestration trajectories of selected agroforestry systems: simulated results for southern Sumatra, Indonesia*

The amount of carbon sequestered by aboveground biomass for each of the four systems, assuming good-quality land, was estimated with simple growth models based on available data and using allometric equations from Brown (1997) and Ketterings *et al*. (2001). The simulated growth in carbon stocks of the four agroforestry systems over 70 years is presented in figure 2. A planning horizon of 70 years was used, based on the age of damar systems sampled by Vincent *et al*. (2002).

The average stock of carbon in each system can be calculated by dividing the area under the corresponding curve in figure 2 by 70 years. This is an estimate of the 'permanent' increase in carbon stocks, assuming that the land use will not change and land productivity does not decrease with subsequent production cycles.

Good-quality land is likely to be recently deforested and therefore not eligible for a CDM project. Our case studies must also consider reforestation of degraded land, which should be an acceptable CDM activity under both sustainability and additionality criteria. The productivity of degraded land, and hence its carbon sequestration capacity, will be considerably lower than that of good-quality land. For the analysis that follows, we defined a simple land-productivity index (*LPI*) to represent yields of crops and trees. The index has a value of 1.0 in good-quality land and decreases linearly as land productivity declines. In our base case, we assumed that the yields of the four agroforestry systems are one half of those obtained on good-quality land ($LPI = 0.5$). This assumption is subjected to sensitivity analysis later.

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Table 1. *Financial performance and costs of selected agroforestry systems: modeling results for Sumatra, Indonesia. NPVs were calculated for a period of 70 years at a discount rate of 20 per cent and a land productivity index of 0.5*

	Agroforestry system			
	Rubber	*Cinnamon*	*Damar*	*Oil palm*
Average biomass carbon (t C/ha)	21.29	11.34	51.34	13.30
NPV (US$/ha)	− 94.04	115.32	− 31.58	− 91.31
Opportunity cost* (US$/ha)	381.54	172.18	319.08	378.81
Abatement cost (US$/t C)	17.92	15.19	6.22	28.48

Note: *The cost in terms of foregone NPV of switching land use from cassava to each agroforestry system.

The opportunity cost of changing to a particular agroforestry system depends on the current (that is, without-project) land use. Common land uses in the peneplains of Sumatra are upland rice/bush-fallow rotation, and cassava monoculture, degrading to *Imperata* grassland (Tomich *et al*., 1998). The former land use is unprofitable, whereas the yields of the latter vary considerably. Whitmore *et al*. (2000) state that cassava yields in Sumatra can be as high as 40 t/ha; they assume a target yield of 20 t/ha in weathered acid upland soils in Lampung, Sumatra. Using their data, we estimated the NPV of continuous cassava production, our without-project land use, to be US$287/ha (calculated over 70 years at a discount rate of 20 per cent). The opportunity cost of a given agroforestry system was estimated by subtracting its net present value (NPV) from the NPV that would have been obtained with continuous cassava cropping. In other words, the opportunity cost was calculated as *NPV without project minus NPV with project*. This is the opposite of the common project evaluation criterion used to estimate additionality, so a positive opportunity cost indicates that the proposed system meets the additionality requirement on financial grounds (the project is less profitable than the current land use). Note that aboveground carbon associated with continuous cassava production is assumed to be zero because the carbon is removed at harvest every year.

The financial analyses of the four agroforestry systems are summarized in table 1. The base-case analysis assumes a discount rate of 20 per cent. This is a realistic estimate of rates of discount faced by smallholders in Indonesia who may not have access to formal credit markets. The discount rate is subject to sensitivity analysis later. Further details on the assumptions and methods used in the analyses, including prices, costs, and formulae used to estimate carbon-sequestration rates, can be obtained from Ginoga *et al*. (2002).

The results of the financial analysis for degraded land (table 1) indicate that only the cinnamon system would be financially attractive to landholders, as the NPVs of the other three systems are negative. Calculating the opportunity cost of changing to an agroforestry system helps to answer the question: 'given existing prices, how much do we need to

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pay landholders to entice them to change land-use practices?' The positive opportunity costs for all systems in table 1 suggest that the landholder would not adopt those systems in order to supply to the CER market unless he or she were paid an inducement not less than the opportunity cost in each case.

A measure of the average cost of sequestering carbon in each system – namely, its average abatement cost – is presented in the last row of table 1. These values were obtained by dividing the opportunity cost of changing to a system by its average biomass carbon. Damar is the cheapest option for sequestering carbon (US$6.22/tC), with oil palm the most expensive (US$28.48/tC), and rubber and cinnamon intermediate (US$17.92/tC and US$15.19/tC). Therefore, a rational carbon investor faced with these options would select damar first, followed by cinnamon, rubber, and oil palm. For agroforestry projects to compete in carbon markets, their sequestration cost needs to be lower than the market price of carbon. Smith *et al*. (2000) cite a range of carbon prices from US$5/tC to US$23/tC. The sequestration costs for rubber, cinnamon, and damar fall within these price bounds, while the sequestration costs for oil palm exceed the upper bounds.

Even though the opportunity cost per hectare is about half for cinnamon (US$172/ha) of what it is for damar (US$319/ha), the damar system captures almost five times as much carbon (51 t/ha v. 11 t/ha). Hence, damar provides the cheapest alternative for carbon sequestration. Incidentally, the damar system also provides more biodiversity benefits than the other three systems. Typically, a mature damar agroforest exhibits about 70 per cent of the bird biodiversity of a natural forest (ASB, 2001).

The results so far are based on plausible but arbitrary assumptions regarding land productivity and discount rate. These two assumptions were subjected to sensitivity analysis to test the robustness of the results. NPVs and abatement costs were calculated at discount rates of 5 per cent, 10 per cent, and 15 per cent and land productivity indexes of 0.4, 0.75, and 1.0, in addition to the base case already discussed. The sensitivity analysis for NPV is presented in table 2.

The NPVs for the systems considered are, as expected, negatively related to discount rates and positively related to land productivity (table 2). Some systems are more sensitive to discount rates and land productivity than others, because the timing of expenses and revenues differs. As a result of these differences in sensitivity, interesting patterns arise in abatement costs. Recall that abatement cost (the cost per 'permanent' tonne of carbon sequestered) is calculated by subtracting the cassava NPV from the agroforestry NPV and dividing the result by the average carbon stock. The information required to calculate abatement costs for all the combinations of discount rate and land-productivity level are available in table 2. Only a selection of these results is presented in figure 3. Oil palm was excluded from further analysis because it represents an industrial plantation and is also the most expensive option in terms of abatement costs.

The base-case rankings of the three smallholder systems in terms of abatement costs (damar < cinnamon < rubber) are presented as the right-most points in figure 3A and the points along a vertical line at an *LPI* of 0.5 in figure 3B. It is interesting to note that, although the rankings are consistent

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Table 2. *Sensitivity analysis results, net present values (NPV) calculated over 70 years, rounded to the nearest dollar*

Land Productivity Index	*Average C stock (t/ha)*	*NPV (US$/ha) at discount rate*			
		5%	10%	15%	20%
Rubber					
0.40	17.0	264	13	−89	−138
0.50	21.3	677	177	−8	−94
0.75	31.9	1,693	581	192	17
1.00	42.6	2,733	1,001	407	141
Cinnamon					
0.40	9.1	777	235	56	−24
0.50	11.3	1,349	521	243	115
0.75	17.0	2,780	1,236	711	463
1.00	22.7	4,211	1,951	1,179	811
Damar					
0.40	41.1	471	21	−123	−188
0.50	51.3	998	320	85	−32
0.75	77.0	2,314	1,067	604	360
1.00	102.7	3,630	1,815	1,124	752
Oil palm					
0.40	10.6	−309	−198	−147	−115
0.50	13.3	−56	−103	−102	−91
0.75	20.0	574	136	10	−32
1.00	26.6	1,204	374	123	27
Cassava (baseline)					
0.40	0	609	315	210	157
0.50	0	1,112	574	383	287
0.75	0	2,369	1,223	817	612
1.00	0	3,627	1,873	1,250	937

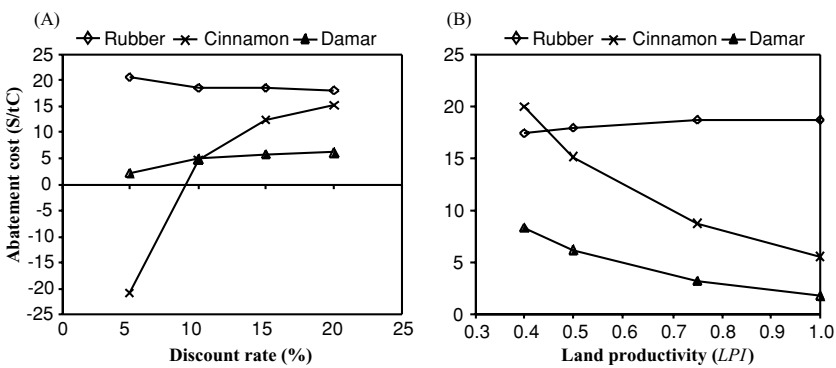


Figure 3. *Effect of discount rate (A) and land productivity (B) on CO_2 abatement costs for three smallholder agroforestry systems*

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at higher discount rates and land productivity values, cinnamon becomes cheaper than damar at discount rates below 10 per cent (figure 3A), and cinnamon becomes more expensive than rubber at *LPI* values below 0.45 (figure 3B).

As shown above, it is possible to estimate abatement costs associated with agroforestry-based carbon-sequestration projects through fairly simple economic analysis. This can be useful as a screening device to identify potential agroforestry systems for a particular site. However, the actual costs of a project must be estimated based on local data, as the opportunity costs and baselines can vary considerably between sites and so will transaction costs.

5. Transaction costs of existing projects

Due to a lack of relevant data, it was not possible to estimate transaction costs of landholders supplying to the CER market by adopting the agroforestry systems addressed in the case studies above. So we resorted to analyzing existing projects within the Activities Implemented Jointly (AIJ) program of the UNFCCC. Transaction-cost data for six AIJ projects were obtained. The projects were: SIF in Chile; Klinki in Costa Rica; Scolel Te in Mexico; Profafor in Ecuador; and Rusafor and Vologda in Russia. The data were obtained from the reports submitted to the UNFCCC[3] and from personal communication with the project personnel. AIJ reports were submitted to the UNFCCC before the start of a project, so they are only indicative of expected transaction costs. These reports provide estimates of development (*ex ante*) and implementation (*ex post*) costs and the amount of expected funding to be received for the project. The estimates for number of hectares to be planted and additional carbon sequestered are based on approved but not necessarily guaranteed funding. To date, a number of projects have not met their planting targets and some have varied the length of their contracts.

Project developers were not required to submit reports to the UNFCCC, and the system of providing project details and calculations was voluntary. Care was therefore necessary in interpreting the data. Nevertheless, given the lack of available and accessible data on each of the projects, the reports submitted to the UNFCCC serve as a useful starting point in considering expected transaction costs of projects.

There was no standardized framework for reporting the costs of AIJ projects, and hence a great deal of variation exists in the types of costs reported. Some projects did not provide a complete set of costs, leading to a number of data gaps, which limit the extent to which cross-project comparisons can be made. Four of the selected projects (SIF, Klinki, Rusafor, and Vologda) provided both development and implementation costs in their reports. In the case of Scolel Té, implementation-cost data were obtained from the project directly.

[3] UNFCCC list of AIJ projects, http://unfccc.int/program/coop/aij/aijproj.html, accessed 25/03/04.

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Transaction costs as a percentage of total costs ranged from 6 per cent to 45 per cent and transaction costs per metric tonne of carbon ranged between US$0.57 and US$3.95. For two reasons, no definite conclusions can be drawn from this sample: firstly the figures are forecasts and not actual costs; secondly data were obtained from reports that are not in a standard format, so all costs may not have been reported. This highlights the importance of having a standard classification of transaction costs that will allow us to measure and compare them accurately. The classification presented in section 3 of this paper addresses this need. The discussion that follows relates features of AIJ projects to our transaction-cost typology.

In the AIJ program, *search costs* were primarily borne by the Annex 1 country partners. Project developers incurred transaction costs in searching both for partners in host countries and investors in Annex 1 countries. Where significant funding for project establishment and ongoing operations was not ascertained, the project developers incurred higher search costs. This was the case in the Klinki project, where the project developer was unable to raise the required funding to support the initial proposal approved by the UNFCCC. Consequently, donations were sought directly from US organizations, such as schools, rotary clubs, churches, universities, and small businesses. This additional effort resulted in relatively high search costs.

Negotiation costs, have been high in some AIJ projects. For example, the SIF project in Chile was predominantly established and implemented by Chilean parties. The project developers spent between one and two years negotiating contracts with project partners, which included forestry companies, the owners of standing forests and the owners of lands to be planted (Golodetz pers. com.).

Approval costs of AIJ projects may have been smaller than what could be expected from the CDM. LUCF projects under the CDM must meet a number of requirements that AIJ projects need not meet, including that the proposed project be based on sound science, use consistent methodologies for estimation and reporting, contribute to biodiversity and sustainable resource use, and account for reversal of the LUCF activity at the appropriate time. CDM projects must also undergo validation during the approval phase. Validation is to be undertaken by a Designated Operational Entity (accredited by the CDM Board) and requires confirmation that: (i) parties meet eligibility requirements; (ii) comments by local stakeholders have been considered; (iii) analysis of environmental impacts has been undertaken; (iv) the project meets additionality requirements; and (v) the project uses approved baseline, monitoring, and reporting methodologies.[4] Clearly, these requirements are likely to impose sizeable transaction costs.

The ninth session of the Conference of the Parties (COP 9), held in December 2003, agreed to prepare a technical paper on simplified modalities and procedures for small-scale afforestation and reforestation project

[4] Modalities and procedures for afforestation and reforestation project activities under the Clean Development Mechanism in the first commitment period of the Kyoto Protocol, (Draft Decision CMP.1) http://unfccc.int/cop9/latest/sbsta127.pdf, accessed 29/01/04.

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activities, for adoption by the Conference of the Parties at its tenth session. Small-scale projects are those expected to result in greenhouse-gas removals of less than 8,000 t of CO_2 per year and are developed or implemented by low-income communities and individuals as determined by the host Party. It remains to be seen how these simplified procedures affect transaction costs of smallholder projects.

Administration costs can be reduced in the long term if good information systems are developed and maintained during the project. The Profafor project and the FACE Foundation (the main project investor) use a monitoring and information system that stores administrative, financial, and technical information for each forestation plan. They have also developed infrastructure including geographic information systems, database and modeling tools, and protocols for monitoring and certifying carbon stocks. This means that project design and baseline estimation should be lower for new projects.

Monitoring costs under AIJ projects are expected to be lower than under the CDM. A number of AIJ projects are not willing to certify their carbon credits due to the non-existence of the carbon-credit market and the additional costs involved in external certification. The community-based Scolel Té project in Mexico verifies the carbon sequestered at the local level and the verified credits are sold to the American Automobile Association. In contrast, the CDM requires emission offsets to be verified and certified by a Designated Operational Entity.

With regard to *enforcement costs*, ensuring trees remain on the land for the duration of projects is one of the greatest challenges facing managers of forest-carbon projects. AIJ projects have dealt with this problem in a number of ways. Scolel Té and Klinki are working closely with project participants to instill a forestry culture and long-term commitment, whilst Profafor has established legally binding contracts with heavy fines for land conversion and early cutting.

These AIJ case studies do not provide much insight regarding *insurance costs*. Most existing AIJ projects did not insure all partners against project failure. In the case of Profafor, contractual conditions partly protect the investor against land-use change and allow for contracts to be terminated in the case of natural disasters. However, there is no compensation or insurance provided to the beneficiaries (Jara pers. com.). In the Scolel Te project, 10 per cent of the calculated emission reductions are put into a contingency fund in case of loss of carbon stores. As an extra insurance, farmers are required to lodge 5 per cent of the revenues from the sale of the trees with the project manager, which is then repaid to the farmer after replanting of the next rotation.[5]

6. Reducing the costs of smallholder participation in the CER market

As illustrated in section 5 of this paper, smallholder projects can be competitive in terms of abatement costs, and this competitiveness can

[5] SGS and ECCM (2001), The Plan Vivo System – verification status review, http://www.eccm.uk.com/climafor/verification.html. Accessed 04/02/04.

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be enhanced through improved technology (i.e., better tree varieties), extension services, and credit programs. However, enhancing competitiveness of smallholders in terms of transaction costs may not be as easy. In this section, we present a selection of strategies that may assist in reducing transaction costs of smallholder projects under the CDM.

Generate and disseminate information

Establishment of baselines can be an expensive activity, particularly in areas subject to rapid changes in population and government policies. Moura-Costa *et al*. (2000) suggest that generic baselines based on sector, region, or country could be developed and integrated in a system of 'technology matrices', similar to those used in the energy sector. Generic baselines may be acceptable for small-scale projects under the simplified modalities and procedures being developed by the IPCC. These methods need to be developed and refined, and these tasks may represent efficient use of development research assistance.

Dissemination of information among smallholders and farmer groups can reduce transaction costs, as well as abatement costs. This can be done by host country extension services as well as by NGOs and international research centers. Once a few examples of successful systems are established, word of mouth may work well. This has been the case in the Scolel Té project in Mexico, where farmers have approached the investor after learning about the project from other farmers in the area. It is also necessary to disseminate information to potential buyers about the prospects for the smallholder sector to supply carbon credits.

Bundle projects and payments

Given the relatively high transaction costs associated with small-scale projects, there is wide support for the creation of institutions and financial intermediaries to bundle projects in a portfolio, such that investors would not be tied to a particular project (Michaelowa and Dutschke, 2000). This is likely to provide potential project hosts with access to a broader capital base and thus access to more diverse projects than available under a bilateral system (Wexler *et al*., 1994). Another advantage of this approach is that transaction costs can be reduced by pooling technical skills for developing baselines and monitoring plans (Baumert *et al*., 2000).

There is also scope for exploiting common goals between the UNFCCC and other international agreements, such as the Convention on Biological Diversity. Where projects provide services relevant to several conventions, it may be possible to bundle payments to smallholders and communities. Non-government organizations, such as Conservation International and the Nature Conservancy, may become important sources of funding and/or expertise for projects in environmentally sensitive areas.

Another sort of bundling can occur at the national level, where responses to climate change can be deployed as a portfolio of policy instruments in ways that reduce disincentives for agroforestry investment. Costa Rica has been particularly innovative in its use of bundling strategies.

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Engage groups of smallholders in projects, rather than individuals

Developing projects with groups of smallholders, run as common property rather than individual property, will spread the fixed transaction costs of designing and implementing a project. There is now considerable evidence from research into common property systems that arrangements of this kind can, in many circumstances, reduce total transaction costs compared with systems of individual property (for example, Baland and Platteau, 1996; Ostrom, 1990). Monitoring and enforcement of social norms and customs often occurs as a by-product of a group's normal day-to-day social interaction. Piggy-backing on these informal arrangements can lessen considerably the need for external imposition of formal institutional arrangements.

A well-established strategy for integrating local knowledge, including beliefs and preferences, in policy making involves facilitating inclusive participation of all stakeholders in the decision process. However, facilitating inclusive participation in institutional choice can be expected to increase the transaction costs of reaching agreement on the new arrangements. In other words, facilitating participation is likely to reduce the *ex post* transaction costs of institutional change, while increasing the *ex ante* transaction costs (Hanna, 1995). It is important therefore to think through the likely effects on transaction costs over the entire planning horizon before concluding prematurely that facilitating participation only adds to costs.

Teach smallholders to measure carbon

There is anecdotal evidence that, when farmers learn the value of carbon biomass, they could monitor their plots at low cost. Farmers in Sumatra are able to assess the volume of wood in their trees by sight; they are accurate within the $0.25\,m^3$ increments used in the timber market (Hairia *et al*., 2001). In field tests undertaken by Delaney and Roshetko (1999), two days were required for a crew to learn inventory methods for measuring carbon in agroforestry gardens in Java. This evidence suggests that training smallholders to identify and measure their own trees and complete a sample sheet may be a good investment. The sample sheet could be delivered to the project office in order to receive payment for the carbon sequestered. The project office would enter the data into a database and estimate carbon stocks based on approved methods. This strategy would require a system of randomly checking reports from smallholders that, if combined with substantial penalties for misreporting, will prevent cheating. This strategy can be further enhanced if a peer-monitoring system can be established. There are some success stories with peer-monitoring of credit contracts involving groups of smallholders (for example, Stiglitz, 1990; Armendariz, 1999); for instance, where groups of farmers are mutually responsible for repaying their loans and other members of the group cannot obtain credit until existing loans are repaid. These experiences may provide some lessons in the design of smallholder LUCF projects under the CDM.

The appeal of a self-monitoring strategy is further enhanced by the fact that the accuracy of carbon measurements depends on the number of sampling sites (for example, see Cacho *et al*., 2004). Involving smallholders

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in self-monitoring can achieve high measurement accuracy by allowing high sampling intensity at a fairly low cost.

7. Summary and conclusions

This paper was motivated by opportunities in some developing countries for emerging markets for carbon-sequestration services to help achieve their sustainable-development goals. Its focus in this context was on agroforestry and tree plantations. After briefly reviewing the significant potential of such activities to sequester carbon, and noting that carbon sequestration is a product that smallholders might trade in markets more easily than many other products open to them, a number of challenges particular to operationalizing such carbon-sink projects were discussed.

A typology of transaction costs in the context of landholders supplying to the CER market was discussed. Such a typology is a prerequisite for systematically estimating the transaction costs of alternative institutional strategies for carbon-sink projects, and thus for identifying the institutional arrangements most likely to promote the competitiveness of projects in specific circumstances.

The need to consider both abatement and transaction costs when assessing the viability of landholders undertaking agroforestry projects in order to supply to the CER market was emphasized. Four case studies of agroforestry systems in Sumatra, Indonesia, were presented to illustrate how the abatement costs of such projects might be estimated. The estimated abatement costs showed that smallholder agroforestry can be competitive in the carbon market under a broad range of discount rates and land productivity classes.

The influence of transaction costs on the competitiveness of landholders in developing countries supplying to the CER market was then explored. The paper concludes with a number of suggestions for making projects involving smallholders more competitive relative to large commercial plantations. These suggestions can be broadly classified as provision of information, involving smallholders in project design and monitoring, and bundling payments for other environmental services with those for abatement of global warming.

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