SMALLHOLDER AGROFORESTRY PROJECTS: POTENTIAL FOR CARBON SEQUESTRATION AND POVERTY ALLEVIATION

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Abstract
This paper provides an assessment of the potential for small-holder agro-forestry projects to be competitive in markets for carbon emission reduction credits, and explores the ways in which small-holder participation in such markets may be facilitated. The paper begins with an overview of the issue of global warming and the role of carbon sinks in mitigating climate change. Then an economic model of the carbon emission reduction (CER) market is presented, which includes the impact of transactions costs. An in-depth survey of the economic literature on transactions costs and their implications in the design of markets for CER follows. An assessment of the emission abatement and transaction costs likely to be associated with smallholder agro-forestry projects is presented, based on case study information from Latin America and Indonesia. The paper concludes with policy recommendations on how to design carbon sequestration projects to benefit small-holders and suggests institutional reforms which will be necessary for reducing the transactions costs associated with small-holder participation in the market. The paper also includes a detailed annex with information on carbon sequestration projects involving small-holders which are already under implementation.

Key Words: Agroforestry, Carbon Sequestration, Poverty Alleviation
JEL: O13, Q24, O17

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1. INTRODUCTION

Concerns over global warming have led to proposals for the establishment of markets for greenhouse gas emissions. Although formal markets have not emerged, a number of international exchanges have occurred and a number of pilot projects have been designed. 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 time periods. This is important for tropical countries, such as Indonesia and Brazil, with large areas of rainforest as well as deforested degraded land.

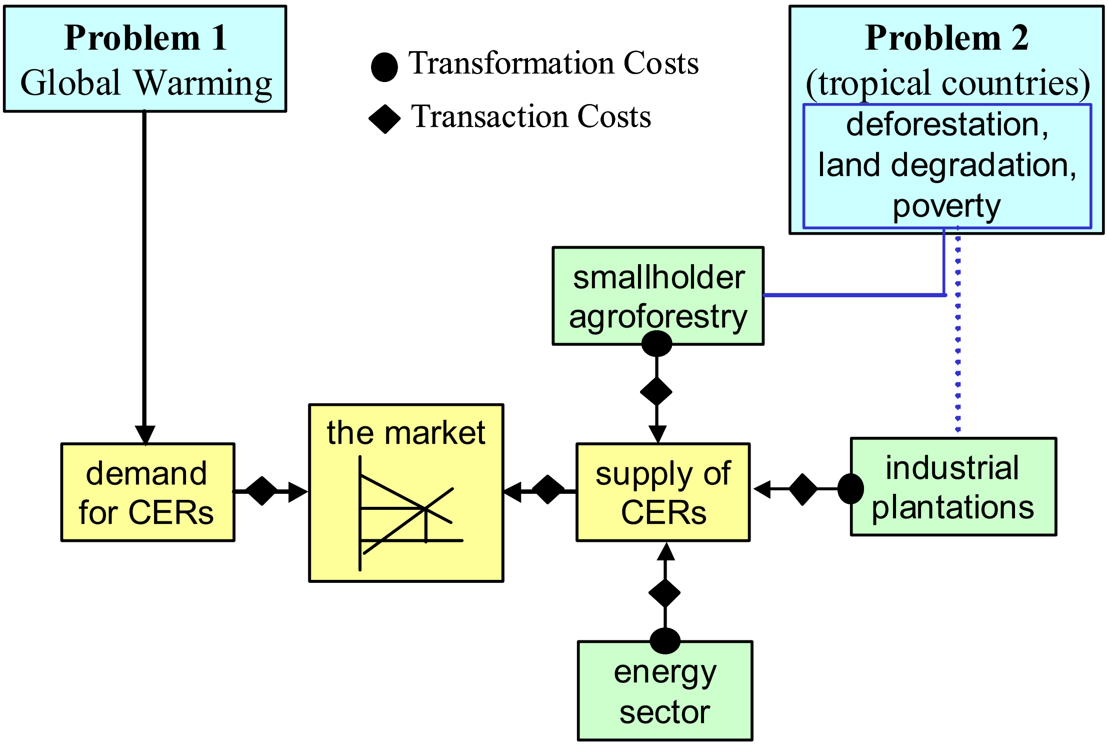

Figure 1. Conceptual framework

The conceptual framework of this study is presented in Figure 1. On one side, we have the global warming problem that creates a demand for certified emission reductions (CERs). On the other side, we have tropical countries which tend to have problems with deforestation, land degradation and poverty.

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

LUCF projects act as sinks for greenhouse gasses and hence reduce net emissions. LUCF projects in tropical countries can be roughly split into projects involving smallholders and industrial plantations. Smallholder projects consist of activities undertaken by farmers who manage small land areas and whose production system may be a mix of subsistence and marketable crops. Industrial plantations generally consist of monoculture of commercial trees for timber, pulp or fruit production. These systems are common in government-owned land, and operate through concessions.

The three sources of supply of CERs (Figure 1) will exhibit different transformation (production) costs, expressed as costs per unit of emission reductions. In order to participate in the CER market, suppliers will also incur transaction costs. These are defined in section 4, but they 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. The sellers of CERs may not be the same as the suppliers. Sellers may be intermediaries who finance project design and implementation either to earn a profit or to contribute to development objectives. Table 1 presents a list of possible market participants.

Table 1. Potential participants in the market for Certified Emission Reductions, based on Baumert *et al*. 2000

Investor	Objective
Annex 1 government	meet emission reduction commitment
Non-Annex 1 government	promote sustainable development
Energy company	offset emissions
Institutional investors	portfolio diversification, socially responsible investment
NGOs	promote environmental and development benefits
Brokers	profit

In this paper, we focus on LUCF projects (smallholder agroforestry and industrial plantations). By February 2002, 135 energy projects had been approved for activities implemented jointly (AIJ) , while only 20 land use, land-use change and forestry (LULUCF) projects had been approved. This reflects the prevalence of the energy sector as a source of global warming; however, the supply of CERs by the energy sector is not considered in this paper. One question we address is whether the aggregate transaction costs of meeting a given target for emission reductions are likely to be higher if the target is met through a large number of projects involving smallholders in isolated areas rather than through fewer projects involving industrial plantations. In this paper we also discuss the possibility of designing projects that will reduce this disparity, if it exists, and thereby help developing countries to tap into carbon payments to assist poverty alleviation.

Section 2 presents a brief overview of global warming, the use of biomass as a carbon sink and the potential of tropical countries to contribute to greenhouse gas (GHG) emission reductions. Section 3 presents a simple economic model to explain the role of transformation and transaction costs in the supply of CERs. Section 4 presents a literature review of transaction cost economics. Section 5 presents a brief review of problems associated with accounting for carbon in sequestration projects. Section 6 identifies the potential costs associated with carbon projects. Section 7 presents a discussion of possible ways to reduce these costs, and other barriers to implementation of projects, and thereby enhance the prospects of smallholders participating in these projects. Section 8 presents a discussion of existing and proposed organisational initiatives and their potential in reducing transaction costs. Section 9 presents a summary of the paper and a few concluding comments.

2. GLOBAL WARMING AND CARBON SINKS

The Greenhouse Effect is a naturally occurring process whereby gases that prevent infrared radiation from escaping the earth's atmosphere cause global temperatures to rise. Over the last 150 years this process has been exacerbated by increasing quantities of GHG emissions into the atmosphere, largely caused by burning fossil fuels. The Greenhouse Effect will result in global climate change that, in turn, will lead to sometimes severe socio-economic and environmental consequences (McCarthy *et al*. 2001).

The Kyoto Protocol has provided the context within which much of the policy debate on global warming occurs. The recent withdrawal of the US from the Kyoto protocol represents a temporary setback. Agreement on the Protocol has been reached by a limited number of countries, without US participation. An important question is whether the US will eventually join under the Kyoto Protocol or whether a new climate-change treaty will emerge to which the US agrees. Considerable scientific contributions have been made to the United Nations Framework Convention on Climate Change (UNFCCC) over the last decade, particularly through the Intergovernmental Panel on Climate Change (IPCC), which has produced a number of technical reports. Many of these contributions will influence the shape of the agreement that may eventually be reached to replace the Kyoto Protocol. The Kyoto Protocol contains two articles of special relevance to this paper (Kyoto Protocol to the Convention on Climate Change, 1997):

Article 6, Joint Implementation Jointly (JI)**,** states that "any Party included in Annex I[1] may transfer to, or acquire from, any other such party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gasses in any sector of the economy", subject to certain provisos. The proposed medium of exchange under this Article is the ERU (Emission Reduction Unit).

Article 12, The Clean Development Mechanism (CDM), has the purpose of assisting "Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments...". The proposed medium of exchange under this Article is the CER (Certified Emission Reduction).

In this paper, we concentrate on the CDM and CERs, although many of the principles discussed would also apply to the exchange of credits under the JI scheme. A CER is a measure of the amount of carbon dioxide kept from the atmosphere either by avoiding an emission or creating a sink. There are several greenhouse gases, including Methane (CH_4), Nitrous oxide (N_2O) and Carbon dioxide (CO_2). CO_2 is the focus of this study, since it is the main gas emitted by burning fossil fuels and it is the gas sequestered by growing forests.

[1] Annex I countries include the OECD countries (except Mexico and Turkey) and transition economies in Eastern Europe.

2.1. The Carbon Cycle

CO_2 is cycled through four main global carbon stocks: the atmosphere, the oceans, fossil fuels, and terrestrial biomass and soils (Figure 2). According to Watson *et al.* (2000, p. 30), over the period 1989 – 1998, activities in the energy and building sectors increased atmospheric carbon levels by 6.3 Gigatons of carbon per year[2] (Gt C yr^{-1}). LUCF activities released 60 Gt C yr^{-1} into the atmosphere and absorbed 60.7 Gt C yr^{-1} with a net effect of decreasing atmospheric carbon levels by 0.7 Gt C yr^{-1}. Oceans removed about 2.3 Gt C yr^{-1} from the atmosphere. The net result of these fluxes over the last 10 to 15 years is that atmospheric carbon levels have increased by about 3.3 Gt C yr^{-1}.

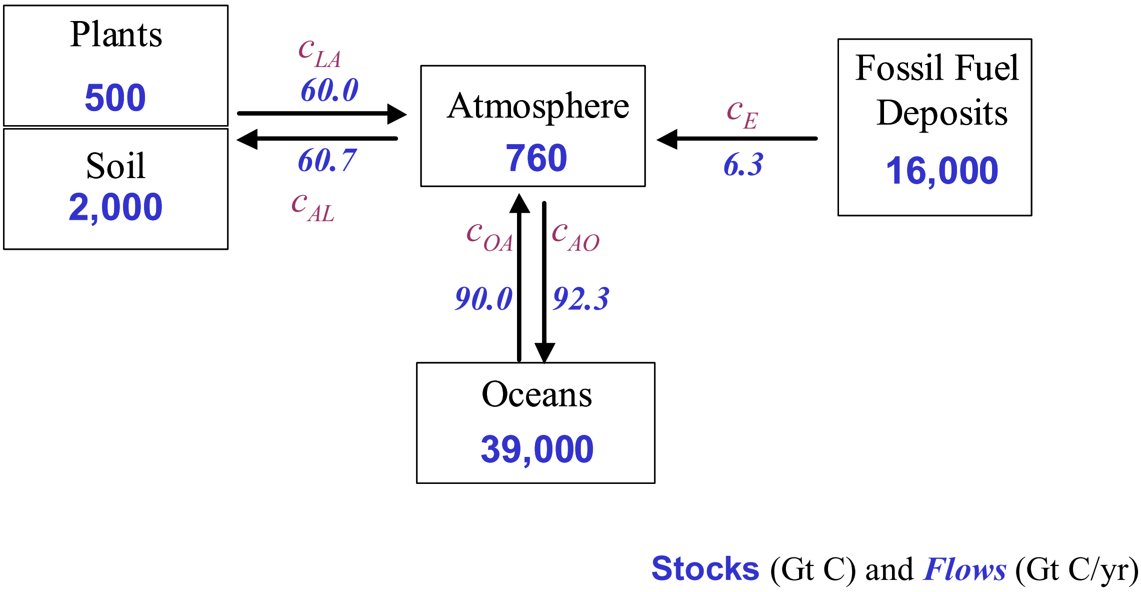

Figure 2. The global carbon cycle (Based on Watson *et al.* 2000)

Although the main contributor to mitigation of global warming will have to be the energy sector (represented by reducing the size of c_E in Figure 2), the focus of this study is on the flow between terrestrial ecosystems and the atmosphere. The rate C_{LA} (Figure 2) includes emissions caused by respiration and deforestation, whereas C_{AL} includes carbon sequestered by afforestation and reforestation projects. Mitigation can be achieved by the LUCF sector by decreasing C_{LA}, increasing C_{AL} or both. The balance of these exchanges is referred to as *biological mitigation*.

2.2. Biomass Accumulation as a Carbon Sink

Biological mitigation can occur through three strategies: (i) conservation of existing carbon pools; (ii) sequestration by increasing the size of existing pools; and (iii) substitution of sustainably produced biological products, such as using wood instead of energy-intensive construction materials, or using 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

[2] A gigatonne is 10^9 tonnes.

the future (e.g., through fires or land clearing for agriculture), whereas (iii) can continue indefinitely (IPCC 2001).

The global potential of biological mitigation has been estimated at 100 Gt C (cumulative) by 2050, equivalent to about 10 per cent to 20 per cent of projected fossil fuel emissions during that period (IPCC 2001). The largest potential is in the subtropical and tropical regions, but realisation 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 living off the natural forests, (iv) existing incentives for land clearing, (v) population pressure and (vi) switch from forests to pastures because of demand for meat (IPCC 2001).

Bloomfield and Pearson (2000) present a review of estimates of the potential of LUCF activities to offset greenhouse gas emissions. Some of their figures are presented in Table 2. Brown *et al*. (1996) estimate that, by 2050, plantations in tropical countries have the potential to capture as much as 16.4 Gt C whereas agroforestry has the potential to capture 6.3 Gt C. The estimates of Trexler and Haugen (1994) are much lower than this, especially for agroforestry (Table 2), indicating that there is a large degree of uncertainty regarding estimates of potential carbon sequestration at a global scale.

Table 2. Potential for carbon sequestration in tropical countries (in Gt C by 2050), based on Table 1 of Bloomfield and Pearson (2000)

	Production System		
Source	Plantations	Agroforestry	Forest regrowth
Trexler and Haugen (1994)	2.0 - 5.0	0.7 - 1.6	9.0 - 23.0
Brown *et al* (1996)	16.4	6.3	11.5 - 28.7

Afforestation and reforestation of degraded forests and wastelands offer attractive opportunities. But the mitigative capacity[3] may be weak, and enough land and water may not be available (IPCC 2001). Also, 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 may be an important factor (de Jong *et al*. 2000). The CDM requires sustainable development goals to be met as well as sequestration goals. This means that smallholders are likely to be an important group. However, projects must be in line with the sustainable development goals of the host country, which does not necessarily mean large plantations will not qualify for CDM. Employment benefits to local people may meet the host country's sustainable development objectives. All that has been agreed on so far, is that in the first commitment period the eligibility of land use, land-use change and forestry project activities under the CDM is limited to afforestation and reforestation.

[3] Mitigative capacity refers to the social, political and economic structures, and other conditions, that are required for effective mitigation (IPCC 2001).

2.3. A Potential Role for Smallholders in Tropical Countries

Selling carbon sequestration services has the advantage that the output does not need to be transported. Hence it can benefit people in remote areas, many of whom are poor. Another attractive feature of carbon is that there are no quality differences. A molecule of carbon is the same independently of where it resides, so the problem often faced by smallholders in not being able to achieve the quality required by international markets in agricultural commodities (e.g., see Glover and Kusterer 1990) does not apply here.

The UNFCCC included development, equity and sustainability (DES) as conditions to be met when setting its principles for stabilizing GHG concentrations through mitigation policy. Large-scale adoption of mitigation activities in tropical countries could contribute to these objectives through biodiversity conservation, rural employment and watershed protection (IPCC 2001). The definitions of reforestation, afforestaton and deforestation are still not clear. Hence the classification of agroforestry is still undecided. ICRAF (the International Centre for Agroforestry Research) seems confident that establishment of agroforestry (particularly in degraded land) will qualify under the CDM in its current form

Deforestation is a major cause of land degradation, and population pressure is one of the major causes of deforestation. Forest conversion for farming by shifting cultivators and migrants, as well as the establishment of large plantations for timber and tree crops are common in tropical countries. Suyanto *et al*. (2001, p. 103) state that "as population pressure increases, the comparative advantage of agroforestry[4] over shifting cultivation tends to increase". The establishment of agroforestry requires significant investment in terms of labour and capital; activities such as land preparation, tree planting, weeding, and pruning need to be undertaken. Hence agroforestry has the potential of increasing employment opportunities compared to slash-and-burn systems (Suyanto *et al*. 2001, Otsuka and Place 2001b), while also contributing to sustainable land management.

Three questions arise: (i) how do smallholders compare with other landholders in terms of efficiency in sequestering carbon? (ii) how likely is it that smallholders will want to adopt carbon sequestering activities? (iii) what policies need to be changed to make this more likely? The answers to these questions depend partly on biophysical characteristics of specific sites and partly on socio-economic characteristics, as well as the institutional environment provided by national and local governments.

To answer the first question, we need to determine whether it is likely that smallholders will be efficient providers of sequestration. Here we are referring to the cost of sequestration *per se*, excluding the cost of participating in the market. Factors such as current status of the forest, agro-climatic zone, technology utilized and human capital availability will determine this. The second question refers to incentives. If landholders perceive agroforestry better satisfies their goals than their current land use practices, and if they believe that it does not introduce unacceptable risks, they are likely to adopt it. The third question is related to a number of policy issues such as land tenure security, the costs of participating in the carbon market, the level of technical expertise required, availability of training and finance, and so on. These issues are discussed in the remainder of the paper.

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[4] Agroforestry refers to land-use systems and practices where woody perennials are deliberately integrated with crops and/or animals on the same land management unit (ICRAF).

3. AN ECONOMIC MODEL OF THE CER MARKET

Mitigation projects will differ in terms of cost per unit of carbon emissions avoided or carbon sequestered, and they will also differ in terms of other environmental and social benefits provided. For example, a complex agroforest in the tropics may represent an efficient use of family labour, provide sustenance and contain higher biodiversity than a monoculture of palm oil or other trees. A large-scale monoculture plantation, on the other hand, may accumulate more carbon and provide employment, but it may provide little biodiversity and social benefits besides employment. These issues will have to be considered by host countries when designing policies to encourage the adoption of carbon sequestration projects. In particular, governments will need to ensure that their mitigation policies do not conflict with, and if possible that they complement, other development goals. This will be partly determined by the guidelines issued under the CDM for project qualification. However, the issue of national sovereignty, raised by a number of non-Annex 1 countries, is likely to lead to national rather than international guidelines on the acceptance criteria for carbon sequestration projects in terms of meeting sustainable development objectives.

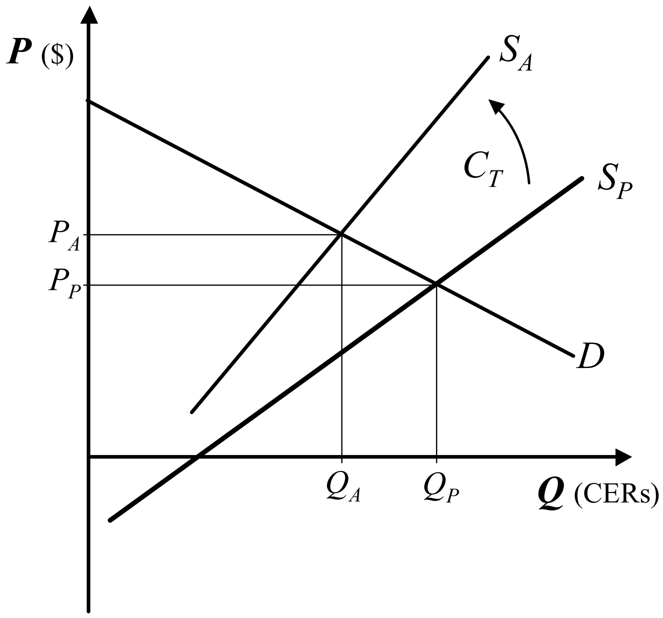

Figure 3. The market for CERs and the role of transaction costs.

Before turning to these issues, we need to understand the basic incentives that may encourage landholders to adopt land uses that increase biomass carbon stocks relative to their current practices. To do this, we use a simple model of the CER market (Figure 3).

The supply of CERs depends on availability and costs of different 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 favoured (least cost) option. In Brazil, in contrast, the preferred option may be forest conservation. In Figure 3, the potential supply function (S_P) represents the marginal transformation costs of providing different cumulative levels of emission reduction through feasible projects in both the energy and the LUCF sectors.

For a given supply function, as determined by current technology and land availability, 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 governments, channelling 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 downward sloping demand function.

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.

In the context used here, the term mitigation means the same as 'abatement', as used in the resource economics literature (e.g., Randall 1987). The transformation costs of producing GHG mitigation can therefore be regarded as abatement costs. The curve S_P shows the prices that would be required to motivate different levels of abatement, or mitigation, in a world of zero transaction costs, where supply decisions depend simply on abatement, or transformation, costs.

In order to participate in the market, however, suppliers will have to incur transaction costs (e.g., to certify the abatement services they provide). Purchasers will also incur transaction costs, but we ignore these due to our focus on the supply side. Transaction costs (C_T) make the supply function shift up and to the left (from S_P to S_A), hence reducing the size of the market (Figure 3). The new equilibrium point (Q_A, P_A) represents a lower quantity of CERs at a higher price compared to the original equilibrium (Q_P, P_P). If the transaction costs are too high, the market will not develop at all.

If we could decrease transaction costs and move from S_A towards S_P, we could obtain more mitigation services at a lower cost. Transaction costs can be decreased through innovation in institutional design (e.g., through devising standardised contracts and simplified guidelines for verification and reporting, as discussed later in the paper). Transaction costs will differ between projects, affecting their market shares and even possibly driving some projects out of the market.

3.1. Distribution of market share

The market supply is made up of the summation of individual supply functions. This is illustrated graphically in Figure 4A for a simple market with two suppliers and zero transaction costs. These suppliers are assumed to reside in a small country, so the demand they face is perfectly elastic at a fixed price (P). For the sake of our argument, we assume that s_1 represents the supply of CERs by the smallholder sector and s_2 is the supply by the plantation sector. The horizontal summation of s_1 and s_2 results in the potential market supply S_P. This results in an equilibrium quantity $Q_P = q_1 + q_2$, with q_1 CERs supplied by smallholders and q_2 CERs supplied by plantations. Note that the individual supply curves are also the marginal abatement cost curves for each sector, and thus will shift with changes in abatement technologies.

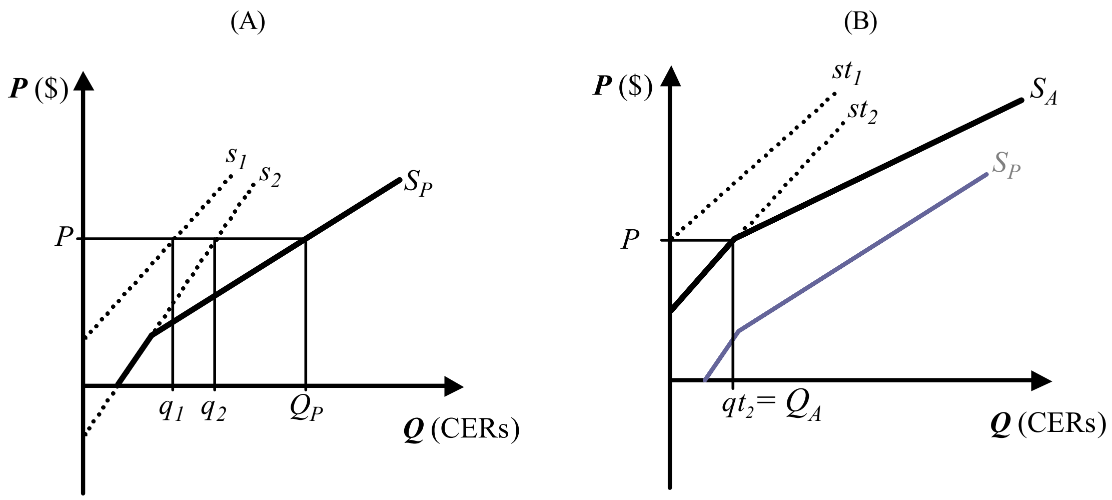

Figure 4. Supply shifts caused by transaction costs in a market with two suppliers.

In this example, there is scope for both types of projects, smallholders and plantations, to participate in the market, but this analysis accounts only for abatement costs. Now assume that market participation by the smallholder and plantation sectors involves transaction costs which cause the supply functions to shift to st_1 and st_2, respectively (Figure 4B). The new (actual) aggregate supply is S_A and the equilibrium quantity of CERs is $Q_A = qt_2$ (where qt_2 is the supply from the plantation sector), since the smallholder sector has been driven out of the market by high transaction costs. This is an arbitrary example used to illustrate the problem discussed in the remainder of this paper.

To guide our efforts in attempting to identify the types of transaction costs likely to be faced in carbon sequestration projects, a review of the relevant literature on transaction-cost economics was undertaken and is presented in the next section. Although abatement or transformation costs are obviously also important for comparing the efficiency of projects undertaken in the smallholder and plantation sectors, analysis of the significance of this category of costs is amply treated in the discussions of production economics and resource economics found in standard textbooks.

4. A REVIEW OF SELECTED LITERATURE ON TRANSACTION COSTS

4.1. Origins of transaction-cost economics

Resource economics has its origins in Adam Smith's insight — in his *Inquiry into the Nature and Causes of the Wealth of Nations* published in 1776 — that individuals maximising their self-interest in market transactions would, under certain conditions, act as if an "invisible hand" were guiding them to contribute to the collective good. Publication of Arthur Pigou's *Economics of Welfare* in 1912 spawned a "Pigovian" tradition in neoclassical welfare economics concerned with specifying more rigorously the conditions required for pursuit of self interest by individuals to coincide with the collective good. These became known as the conditions for "perfect competition"; that is, sufficient for market exchanges to achieve Pareto efficiency.

As a result, welfare economists chose perfect competition as the benchmark against which to assess whether Pareto efficiency might be increased in specific contexts by intervening in the workings of the invisible hand. Departures from perfect competition thus became designated as "market failures", and identification of such failures became the criterion by which economists assessed whether interventions in markets, presumed to be by governments, could be justified on efficiency grounds.

Among other conditions, perfect competition requires that markets exist for all goods with an economic value (Cornes *et al.* 1996). Arrow (1970) demonstrated that Pareto-relevant externalities arise when this condition is not satisfied. The market-failure approach to neoclassical welfare economics pioneered by Pigou involved governments trying to 'internalise' externalities, thus aligning the private costs of individual economic agents with the collective or social costs attributable to their activities.

In his seminal article "The problem of social cost", Ronald Coase (1960) demonstrated that the Pigovian logic associating market failure with Pareto inefficiency is internally inconsistent. He began by observing that this logic assumes that all exchanges in all markets are costless. In his earlier article, "The nature of the firm", he had highlighted that exchanges in market are themselves costly (Coase 1937). He referred to these costs as *transactions costs*, although the variant *transaction costs* has since become more common[5].

One of Coase's (1960) insights was that markets do not exist to trade goods but to trade property rights in relation to those goods. A property right is an enforceable authority to undertake particular actions related to a specific domain (Commons 1968). Hence transaction costs are the resources expended in establishing and maintaining property rights (Allen 1991 p. 3) or, equivalently, the costs "of arranging a contract to exchange property rights ex ante and monitoring and enforcing the contract ex post, as opposed to production costs, which are the costs of executing a contract" (Matthews 1986 p. 906). In a further definition, "[t]ransaction costs are the costs incurred by participants in an exchange, in order to initiate and complete the transaction" (Dudek and Wienar 1996). Production costs are also known as transformation costs (Williamson 1985). In the context of projects "producing" abatement of the effects of some environment-harming emission (e.g., atmospheric carbon), transformation costs are normally referred to as abatement costs.

Coase (1960) observed that a Pigovian perfectly-competitive world precludes Pareto-relevant externalities, since the absence of transaction costs in this world means that all such externalities would be eliminated spontaneously. The economic rent that would be dissipated if they were to arise represents a potential Pareto improvement that rational self-interested parties could share costlessly by negotiating a new property rights configuration. The same Pareto-efficient assignment of property rights will result regardless of the original assignment. Given perfect competition, therefore, the market cannot fail and government intervention can never be Pareto efficient. In the actual world of positive transaction costs, furthermore, Coase (ibid.) demonstrated that negotiations over property rights still ensure that all Pareto-relevant externalities are internalised. Hence the status-quo configuration of property rights is invariably Pareto efficient, so there is no market-failure case for government intervention in this case either. When transaction costs are positive,

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[5] Although transaction costs are ultimately associated with the cost of acquiring information about exchange, they are distinct from information costs which arise irrespective of exchange, for instance in a Robinson Crusoe economy (Eggertsson 1990).

nevertheless, the resulting Pareto-efficient assignment of property rights does depend on the initial assignment.

As Coase (1992) later observed, his intention was only to highlight the internal inconsistency of the market-failure approach. He recognised that by no means is Pareto-efficiency the only legitimate yardstick of collective welfare. In any case, it follows from the first fundamental theorem of neoclassical welfare economics that there is a distinct Pareto-efficient solution corresponding with each initial distribution of property rights and that these solutions are Pareto non-comparable. Consequently, Paretian logic cannot be used to compare collective welfare under the status-quo configuration of property rights with that under another configuration of property rights resulting from an intervention (Bromley 1997). Indeed, there is no way of making welfare comparisons between alternative configurations of property rights without some "set of value judgements to provide a frame of reference, why one system is better than the other" (de Alessi 1990 p. 153).

4.2. The comparative institutions approach

Coase (1960 p. 43) argued that the appropriate measure for economists to use in assessing the efficiency of intervening in the status quo is the opportunity cost of the intervention. Demsetz (1969) followed Coase's lead by proposing that interventions in markets be assessed according to a "comparative institutions approach" which would "attempt to assess which alternative real institutional arrangement seems best able to cope with the economic problem ..." (ibid. p. 1). Consistent with this approach, Williamson's (2000 p. 601, original emphases) "remediableness criterion … holds that an extant mode of organization for which no superior *feasible* alternative can be described and *implemented* with expected net gains is *presumed* to be efficient".

Transaction-cost economics, which subscribes to the idea that property-rights transactions are the basic units of economic analysis, emerged in response to the challenge of implementing the comparative institutions approach. Its objective is to identify the institutional framework, or governance structure, that minimises the transaction costs of resolving particular property-rights allocation problems (Williamson 1985). Implicit in this cost-effectiveness framework is an assumption that the distribution of the sum of these costs between transacting parties is of policy consequence only to the extent that it influences the sum itself (Challen 2000).

This approach to economics recognises that property rights are products of institutions. Institutions have been described as "sets of ordered relationships among people which define their rights, exposures to the rights of others, privileges, and responsibilities" (Schmid 1972 p. 893) which are "perfectly analogous to the rules of the game in competitive team sport" (North 1990 p. 4). They reduce uncertainty in human interaction by "parameteriz[ing] expectations of the likely behavior of others" (Runge 1981 p. 602). In addition to the transaction costs of establishing and maintaining property rights, therefore, transaction costs are also incurred at a deeper level in creating, changing and applying institutions (Furobotn *et al.* 1992).

4.3. Significance of informal institutions

Institutions can be classified as formal and informal. Informal institutions are known also as social norms. The distinction between formal and informal institutions is implied by Posner's (1997 p. 365) definition of a social norm as "a rule that is neither promulgated by an official source, such as a court or legislature, nor enforced by the threat of legal sanctions, yet is regularly complied with ...". It is a shared understanding about actions that are obligatory, permitted or forbidden (Crawford *et al.* 1995). Social norms often "result from (and crystallize) the gradual emergence of a consensus" (Posner *et al.* 1999 p. 370). They are ubiquitous and include: etiquette; customs; codes of personal conduct; rules of voluntary associations; norms against cheating, stealing, lying and overusing common-pool resources; and norms of reciprocity, promise-keeping, and standard business practice (Fehr *et al.* 1998; Posner *et al.* 1999).

Policy interventions typically involve planning, and their immediate focus therefore tends to be on formal institutions. Nevertheless, the cost-effectiveness of any intervention normally depends on how well the intervention process and its formal institutional outcomes are matched to prevailing social norms. This is because "[t]he cost of social rewards to achieve conformity to norms is low because it is produced spontaneously in the course of social interaction in networks of personal interaction" (Nee 1998 p. 87). Singleton (1998 p. 17) observed accordingly "successful [formal] institutions are those that can in effect be piggybacked onto preexisting systems of social control". Alchian (1977 pp. 129-130) remarked likewise "[t]he level of noise, the kind of clothes we wear, our intrusion on other people's privacy are restricted not only by laws backed by police force, but by social acceptance, reciprocity, and voluntary social ostracism for violators of accepted codes of conduct". In contrast, the transaction costs of enforcing formal institutions will escalate to the extent that they are antagonistic to prevailing social norms and thus become "infused with the rectitude of civil disobedience" (Singleton 1998 p. 129).

4.4. Sources of transaction costs

In the new institutional economics of which transaction-cost economics is part, "there is close to unanimity … on the idea of limited cognitive competence — often referred to as bounded rationality" (Williamson 2000 p. 600). According to this idea, calculations by individuals include only immediate and readily assimilated information, and the complexities of actual economic exchange cannot be completely accounted for in the specification of contracts. The resulting contractual incompleteness "poses added problems when paired with the condition of opportunism[6] …. Because human actors will not reliably disclose true conditions upon request or self-fulfil all promises, contract as mere promise, unsupported by credible commitments, will not be self-enforcing" (ibid. p. 601). It follows that economic activities are subject to asymmetric information and costly transactions.

The approach of transaction-cost economics to analysis of this situation drew considerable insight from the theory of agency arising from the seminal contribution of Jensen and Meckling (1976). This theory defines an agency relationship as being established when a principal delegates some rights to an agent who is bound by a contract to represent the

[6] Williamson (1985 p. 47) defined opportunism as "self interest seeking with guile".

principal's interests in return for a reward of some kind. Wallis *et al.* (1999 p. 69) characterized this relationship as follows:

> By delegating authority to an agent, the principal economises on scarce resources by adopting an informed and able agent, but simultaneously takes on the risk that, since the interests of the principal and agent will never be identical, the agent may fail to maximise the wealth of the principal … [I]n a typical agency relationship agents almost always possess more information about the task assigned and the relative efficacy of their own performance. Agents often take advantage of this asymmetry of information by engaging in shirking or opportunistic behaviour inimical to the interests of principals …

For the principal, the total cost of agency is the sum of investments made in limiting opportunistic behaviour (including shirking) by the agent plus the costs associated with the residual opportunism (Eggertsson 1990). The size of this cost depends on the quality of the principal-agent relationship. The more that the agent exploits the asymmetry of information by engaging in behaviour contrary to the interests of the principal, the greater will be total agency costs.

This framing of economic exchanges led to a focus on identifying ways of structuring contracts in order to reduce agency costs. For instance, one strategy might be to design contracts where the interests of principal and agent overlap (e.g., by sharing profits). Another is to introduce an accounting system for monitoring agent behaviour. A further option is for agents to offer the principal some collateral as security against them acting opportunistically. Contracting in ways that involve competition between agents might also, by increasing the cost of their opportunistic behaviour, lessen a principal's agency costs (ibid.).

Transaction-cost economics is concerned not only with agency costs but also with the costs for principals of organising their activities that occur even if agents are loyal and desist from acting opportunistically. Furthermore, if all complex contracts are unavoidably incomplete, and adaptation is therefore the central problem of economic organisation, the focus of agency theory on *ex ante* incentive alignment "is a truncated way to study organization" (Williamson 2000 p. 599). Hence the focus of transaction-cost economics is predominantly on the *ex post* stage of contract.

Contractual incompleteness can make transactions particularly problematical when some of the transacting parties are obliged to make investments in assets specific to that transaction (Williamson 1985). This feature of a transaction has been called *asset specificity* (ibid.). These investments are irreversible to the extent that they have a significantly higher value within the relationship than in alternative uses (i.e., they yield a quasi-rent). This puts an investing party in a weak bargaining position regarding the sharing of the *ex post* surplus, since the incompleteness of contracts precludes all possible contingencies being accounted for *ex ante*. The investor fears that the other party/s may opportunistically exploit this incompleteness, by claiming a larger portion of the *ex post* surplus than initially agreed upon (e.g., by reducing the price paid to the investor), and thus decides not to proceed with the transaction. One way of avoiding this problem, and the deadweight loss it entails, is for the other party/s to offer the investor some guarantee that the investor's quasi-rents will not be appropriated, for instance by offering a long-term contract designed to constrain future opportunities for that appropriation.

4.5. General classifications of transaction costs

Williamson (1985) distinguished the costs of contracting as *ex ante* and *ex post* transaction costs. These correspond with activities undertaken in the processes of achieving an agreement and then continuing to coordinate implementation of the agreement, respectively. Dahlman (1979) had earlier delineated the following classes of transaction costs: (i) search costs; (ii) bargaining costs; and (iii) monitoring and enforcement costs. Search costs include resources expended in defining the causes and scope of the problem and the range of possible solutions, locating potential partners or parties to a transaction, and establishing what contribution they are capable of making, as well as gathering information about their preferences and reputations for reliability. Bargaining costs entail negotiating over possible solutions, each of which is likely to differ in terms of the distribution of returns to the parties. Monitoring and enforcement tasks are ongoing for the term of the transaction. Aside from out-of-pocket expenditures, transaction costs also include the opportunity costs (e.g., time lost due to transactional delays, diversion of managerial attention from other tasks) of each participant's involvement in a transaction (Dudek and Wienar 1996).

Hanna (1995) has presented a classification of transaction costs associated with natural-resource conservation programs. She began by observing that programs of this kind involve a mix of three types of decisions: conservation, regulation, and allocation. Conservation decisions focus on increasing provision of a natural resource to some target level (e.g., by directly investing in its replenishment or limiting its extraction). Mechanisms for controlling the means and rate of conservation are determined through regulation decisions. Allocation decisions determine the division of the conservation task between various parties. She then proposed that the transaction costs associated with these three types of decisions are incurred in four management stages: description of the resource context; regulatory (or program) design; program implementation; and program enforcement. In this schema, the first two stages generate *ex ante* transaction costs, with *ex post* transaction costs incurred during the latter two stages.

Thompson (1999) observed that benefit-cost analysis as generally applied to evaluating conservation policies "fails to consider the costs of the institutions that support public policies" (ibid. p. 518). He called these costs "institutional transactional costs" and viewed them as comprising the costs of enacting a policy by a legislature[7], implementing that policy by an administrative agency[8], and enforcing that policy by the agency and the courts. Enforcement costs were further decomposed into detection costs[9] and prosecution costs[10]. Clearly, his concern was with policies developed and implemented by governments rather than by civil organisations. In applying a cost-effectiveness framework to evaluate alternative policies seeking to ameliorate point-source water pollution, he "assum[ed] that in comparing policies, variables are adjusted so that the policies achieve the same result [and therefore] the "benefits" of these policies are equivalent" (ibid. p. 520). The costs accounted

[7] The process of enactment was viewed as including two steps: the selection of a regulatory instrument, and the mechanics of drafting and voting on the legislation implementing the chosen instrument. Lobbying expenditures by interest groups (e.g., industry and environmentalist groups) during each step were regarded as part of enactment costs.

[8] These were defined as the costs "that must be undertaken before those who must comply with the policy may do so" (Thompson 1999 p. 532).

[9] These included costs of self-monitoring by regulated parties, as well as external audits.

[10] These are "the costs of dealing with facilities that might bring challenges to the execution of these systems, along with the costs of inducing violators of these policies to comply with them" (Thompson 1999 p. 534).

for in this framework included the abatement costs normally considered in benefit-cost comparisons of conservation policies (i.e., the costs for the regulated party of regulatory compliance) in addition to institutional transaction costs as he defined them.

McCann and Easter (1999) estimated and compared the transaction costs associated with alternative government policies to reduce agricultural nonpoint source pollution in the Minnesota River, USA, using a modified version of Thompson's (1999) cost-effectiveness framework. The modified framework contained the following categories of transaction costs:

- Research, information gathering, and analysis;
- Enactment of enabling legislation;
- Design and implementation of the policy;
- Support and administration of the ongoing program;
- Monitoring and detection; and
- Prosecution.

The transaction costs of a particular conservation policy were calculated as the sum of these six cost categories. Transaction costs borne by farmers (e.g., in completing paper work) as well as by government agencies in each of these categories were accounted for. Fixed and variable transaction costs were distinguished, relating to the set-up and continuing costs in each category. Decision makers were assumed to choose the policy or policy mix minimising the sum of discounted abatement and transaction costs associated with attaining an exogenous abatement target. Abatement costs were defined to include costs that were financed publicly as well those incurred by private polluters. These private costs consisted of non-cash expenses like family labour as well as out of pocket expenses.

4.6. The significance of political transaction costs

One of the categories of transaction costs delineated by Thompson (1999) and discussed in section 4 was concerned with the costs of enacting policy by a legislature. He defined this type of cost as including lobbying expenditures by interest groups. These costs of lobbying are one element of what Horn (1995 pp. 30-31) has called "political transaction costs". Challen (2000) has argued forcefully that transaction costs of this kind need to be accounted for more explicitly when comparing alternative institutional arrangements than has conventionally been the case. He regarded these costs as an important component of "transition costs, that is, the costs of decision making for institutional change and the costs of implementing institutional reforms" (ibid. p. 7).

Building on North's (1990) conclusion from the study of economic history that institutional path-dependencies occur where opportunities for institutional reform are constrained by the current institutional structure, Challen (2000 p. 7) argued as follows that:

> … the constraints arise through a current institutional structure determining the costs of transition to alternative structures. An institutional *status quo* determines the processes for institutional change and also creates vested interests for certain groups within society who resist institutional changes that threaten these interests. Where the holders of these interests have the ability to impose costs on the political decisions makers for institutional reform, they can influence the costs associated with certain options for reform and hence the relative appeal to political decision makers of the different options.
>
> The consequence of transition costs and path-dependencies for institutional analysis is that institutional history influences practical opportunities for institutional change in the present. By

extrapolation, institutional changes in the present will influence the costs of institutional change in the future and hence the opportunities and options for institutional change in the future.

Where current institutional choices increase the transition costs of possible future institutional changes, Challen (ibid. p. 8) called these cost effects "intertemporal opportunity costs" (ibid. p. 8) and argued that cost-effectiveness comparisons of options for institutional change would need to account for these costs to be reliable. The value of conserving future institutional flexibility stems from contracts being unavoidably incomplete in the face of complexity, and thus from the potential this flexibility allows, as uncertainty unfolds and new information becomes available, for adapting the terms of a contract to maximise collective welfare given the new understanding of circumstances.

This issue is relevant for assessing the transaction-cost-effectiveness of focusing GHG abatement projects on smallholders compared with larger landholders since it seems reasonable to assume that the former exert less political power than the latter. Hence the vested interests created by involving the former in projects would be expected to be stronger than if the latter were involved. It follows that transaction costs in the form of intertemporal opportunity costs would be higher if GHG abatement projects focused on larger landholders rather than smallholders.

Aside from this consequence of the political power of larger landholders for the transaction-cost-effectiveness of engaging them instead of smallholders in projects, there are further possible consequences for the cost-effectiveness of monitoring and enforcing their compliance with the contractual terms of the projects. For instance, the greater political power of larger landholders may be such that it provides them with significantly greater scope than smallholders to opportunistically avoid complying with their project commitments. For instance, their stronger connections with influential politicians may serve to encourage those responsible for monitoring or enforcement to "turn a blind eye" when dealing with them.

Armed with the information provided in this review we are in a better position to identify the transaction costs incurred in CDM projects. However, before we can proceed with this task we need to identify the features that distinguish a carbon market from a conventional market. In particular, we need to address the problem of accounting for carbon sequestered. This problem is discussed in the following section.

5. ACCOUNTING FOR CARBON SEQUESTRATION

In order to receive certification and enter the CER market, a project will have to incur various transaction costs in showing that it is reducing net emissions compared with its absence. In other words, emission reductions must be additional to a business-as-usual scenario. This means that the project proponents will have to estimate a baseline and demonstrate "additionality". Also, the project will have to account for possible "leakage" and the problem of "permanence". The impacts of projects on carbon sequestration will also have to be monitored. These various aspects of accounting for carbon sequestration are briefly explained below.

5.1. Additionality

Under the Kyoto Protocol, projects that qualify for credits have to satisfy the *additionality* requirement that "reductions in emissions must be additional to any that would occur in the absence of the project". This means that "sequestration projects, such as reforestation, qualify only if the project is not financially viable without CDM, or if CDM funding is required to overcome other barriers to implementation" (Smith *et al*., 2000).

Additionality can be established by showing that reforestation would be less profitable than the land use systems it replaces, or by showing there are barriers to tree establishment. Adoption may be limited by lack of finance for establishment costs, access to planting materials, or lack of technical assistance and marketing infrastructure (Smith and Scherr, 2002). Additionality could also be expressed in terms of higher risk than a conventional investment (Moura Costa *et al*. 2000).

In order to establish additionality, it is necessary to establish a baseline. Only those emission offsets above the baseline will be eligible in the CER market.

5.2. Baselines

The baseline over the period of a proposed project could be static, if the project replaces a stable system such as a pasture, or dynamic, when expected trends in deforestation and land-use changes must be accounted for. In general, baselines should be easier to establish for reforestation and afforestation projects on degraded land, as opposed to forest protection projects that require assumptions about future rates of deforestation in the absence of the project. The baseline is an important area of uncertainty and may need to be revised as the project progresses.

Establishing baselines will require information such as identification of pressures on the land and its resources, history of land use in the project area, soil types and topography, and socio-economic activities (Brown, 2001) and the likely evolution of these factors through time. Possible approaches to baseline estimation range from a case-by-case basis to a generic estimate based on sectoral and regional characteristics (Moura Costa *et al*. 2000).

One way of estimating a baseline was illustrated by de Jong *et al*. (2000) who used a series of land-cover maps of Mexican forests and estimated historical rates of carbon storage depletion. On the basis of these historical rates, they projected trends of carbon losses 50 years into the future. Another strategy has been followed by the FACE (Forests Absorbing Carbon Dioxide Emission) Foundation, which uses a monitoring and information system (MONIS) to estimate the amount of carbon sequestered. The system stores graphical site information as well as administrative, financial and technical information. The CO2FIX model is used for establishing baseline and project scenarios. The project partners collaborate with national and international research institutes to acquire the necessary measurements (FACE 2000). See Appendix 1 for further details.

5.3. Permanence

The problem of permanence arises because LUCF projects tend to be temporary in nature, since CO_2 captured during forest growth is released upon harvest. In contrast, projects in the energy sector that reduce emissions are permanent, in the sense that an avoided emission will never reach the atmosphere. Smith *et al.* (2000) state: "non-permanent forestry projects slow down the build up of atmospheric concentrations, unlike energy projects, which actually reduce emissions. Non-permanent forestry projects should therefore be regarded as an intermediate policy option". Grainger (1997) points out that biological mitigation can sequester large amounts of carbon over a much shorter time scale than is required for energy consumption patterns to change.

The problem of permanence must be addressed before LUCF projects are acceptable in a CER market. Proponents of LUCF projects point to several advantages of temporary sequestration, such as (i) some proportion of temporary sequestration may prove permanent, (ii) deferring climate change has benefits, (iii) temporary sequestration 'buys time' while affordable energy technologies are developed, and (iv) temporary sequestration projects have value in saving time to gain information on the process of global warming (Lecocq and Chomitz 2001). Cacho *et al*. (2002) explored the issue of permanence and incentives under different accounting methods and found that the ton-year approach (see Section 6.5) offers very little incentive to sequester carbon beyond the incentive provided by the timber market.

Many authors believe that permanence is not an unsurmountable problem (e.g., see Sedjo 2001; Sedjo and Toman 2001). Sedjo (2001, p. 17) argues "carbon sequestration should be viewed more as a temporary activity like the parking of a car than a long-term activity like the purchase of a parking space". He advocates the development of rental markets for carbon. This and similar ideas, such as the Colombian proposal for 'expiring CERs' (Blanco and Forner 2000) may provide viable alternatives, but they require further economic analysis to determine whether they will provide incentives adequate to effect desired behavioural change.

An important question concerns whether smallholders are more likely to have incentives for liquidating sequestered carbon earlier than other participants. It is reasonable to expect that smallholders are likely to default if they face population pressure and limited food supply leading to land clearing for agriculture. This is related to the issue of leakage and the need to increase agricultural-land productivity (see below). In general, we may expect that land under stable community management may be subject to longer planning horizons than private land not subject to such management, and therefore to have advantages in terms of permanence, provided a clear stream of benefits is obtained by the community. This issue is discussed in more detail later.

5.4. Leakage

Leakage "occurs when the emission reduction achieved within the project causes increased emissions outside the project boundary, or at a later period of time. Leakage could occur for example if local communities agree to preserve a forested area, with the intention of increasing deforestation in other areas, as compensation" (Smith *et al*., 2000). Leakage may work through the price system, as reduced wood supply may lead to price increases and hence provide incentives to increase forest clearing elsewhere. Leakage is not unique to LUCF projects. It can arise in the energy sector as well.

According to IPCC (2001), leakage of between 5 per cent and 20 per cent may occur through relocation of carbon-intensive industries from Annex 1 to non-Annex 1 countries. Almost all tropical forests have people living in or around them, so failure to compensate communities for forest protection projects can lead to leakage. To prevent leakage in LUCF reforestation projects, productivity of agricultural land will have to be increased (Smith and Scherr 2002) to ensure that food supply is not reduced. It may also be necessary to promote labour-using technologies (such as agroforestry) to provide employment for those displaced from forests.

Ideally, project leakage could be accounted for by country-wide baselines, but a second-best alternative may be to have 'rules of thumb' for rough corrections in the amount of CERs obtained depending on type of project and location (Sedjo and Toman 2001).

5.5. Measuring Carbon Stocks

The recommended approach to measuring carbon sequestration in LUCF projects is to use permanent sampling plots to monitor both the baseline and the project. Well established statistical techniques can be used to determine the sampling design and intensity required to achieve a given level of precision (McDicken, 1997). For large projects, random sub samples of permanent sampling plots can be monitored each year. Larger projects may also benefit from imaging techniques and remote sensing based either on satellites or low-flying aeroplanes (Brown, 2001).

Accounting for carbon in sequestration projects involves measuring four pools (Hamburg, 2000):

- aboveground living biomass
- belowground living biomass
- necromass
- soils

Not all of these are likely to be acceptable as sources of sequestration in a carbon market, and not all pools need to be measured at the same level of precision or at the same frequency during the life of the project. In the initial inventory the relevant carbon pools must be measured, to establish the baseline, but in subsequent monitoring only selected pools need to be measured, depending on the type of project (Brown, 2001). The level of precision to which each pool can be measured at reasonable cost was estimated by Hamburg (2000). Table 3 presents a summary of these estimates. The measurement of each pool is briefly explained below.

Table 3. Level of accuracy and ease of implementation from measuring different carbon pools in a forest ecosystem (based on Hamburg, p. 34)

Pool	CV	Ease of implementation
Aboveground biomass	5%-10%	simple
Belowground biomass	10%-20%	simple, but requires high initial investment.
Soil, organic layer	10%-20%	moderate
Soil, mineral layer	highly variable	difficult
Necromass	40%	difficult

Aboveground living biomass

There are standard, well accepted methods of measuring aboveground biomass carbon in forested areas. The simplest procedure consists of measuring a sample of trees and using allometric equations to estimate biomass. Allometric equations relate tree biomass (B) to quantities (V_i) that can be measured by non-destructive means. Allometric equations have the general form (Ketterings *et al*. 2001):

$$B = f(V_1, V_2, ..., V_n) \qquad (1)$$

The independent variables (V_i) may include diameter at breast height (D), height (H) and wood density (ρ). Experience with generic equations has shown that D explains more than 95 per cent of the variation in tree biomass (Brown, 2001). Brown (1997) has published allometric equations for tropical environments, and presents wood density values for a large number of species. The assumption that 50 per cent of aboveground living biomass is carbon is well accepted (Hamburg, 2000; Brown, 2001), so it is straightforward to convert measured biomass to carbon units.

Allometric methods are very robust among species and genera, and can predict biomass of closed canopy forest to within ±10 per cent uncertainty (Hamburg, 2000). In some special cases, it may be necessary to use destructive techniques to estimate allometric equations for a project (the techniques used to undertake these measurements are explained by Brown (1997)), but in general, parameter values available in the literature can provide acceptable levels of precision. Hence the main expense would be field measurement of trees.

Belowground living biomass

Belowground living biomass consists mostly of roots. This is an important pool that can represent up to 40 per cent of total biomass (Cairns et. al. 1997). It can be very expensive to sample directly and requires destructive techniques (Brown, 2001). This pool can be estimated with some accuracy, but at lower precision than aboveground biomass.

The simplest approach to estimating belowground biomass is to apply a constant root/shoot ratio (R/S ratio). Although the R/S ratio varies with site characteristics and stand age, a range of R/S ratios can be obtained from the scientific literature (Hamburg, 2000). To avoid measuring roots, a conservative approach recommended by MacDicken (1997) is to estimate root biomass at no less than 10 per cent or 15 per cent of above-ground biomass. Hamburg (2000) recommends a default R/S ratio for regrowing forests of 0.15 in temperate ecosystems and 0.1 in tropical ecosystems. Although ratios as high as 0.4 have been measured in temperate forests, the author recommends erring on the side of caution to avoid the possibility of crediting non-existent carbon.

Soil Carbon

Soil carbon can also be expensive to measure directly, particularly because of the strong influence that soil characteristics have on carbon dynamics. Hamburg argues that by using a few generalized principles it should be feasible to measure soil carbon to an acceptable level of accuracy for biological mitigation projects. Hamburg recommends that the soil carbon be measured to at least one metre of depth, and that measurements of soil carbon and bulk density[11] be taken from the same sample.

Fortunately, for projects that are known to have non-decreasing effects on soil carbon, it may not be necessary to measure soil carbon after the baseline is established. Rates of soil oxidation (a process that releases CO_2) under different land uses are available in the literature (Brown, 2001). As a general rule, reforestation projects in agricultural or degraded land would tend to increase soil carbon. If the marginal cost of measuring this carbon pool is greater than the marginal benefit of the carbon credits obtained, the project developer would be better off not measuring this pool.

The Alternatives to Slash and Burn (ASB) group have argued that most of the sequestration potential in the humid tropics is aboveground rather than in the soil. In tree-based systems planted to replace degraded pastures, they found that the time-averaged carbon stock increased by 50 t/ha in 20 years, whereas the carbon stock in soil increased by 5-15 tC/ha (Tomich *et al*. 1998, Palm *et al*. 1999).

Modelling can complement monitoring techniques (Brown, 2001). This can be particularly useful to forecast slow changes in soil carbon pools. An example of this technique is presented by Wise and Cacho (2002).

Necromass

The necromass pool includes the carbon contained in dead trees, leaves, branches and other vegetation. Annual leaf litter inputs do not need to be accounted as part of the necromass pool, since this input is balanced by decomposition losses within the soil and the net effect is included in the measurement of the soil pool (Hamburg 2000).

The amount of necromass varies considerably with forest type and disturbance history, and estimating this component accurately can be very time consuming and subject to high uncertainty. Fortunately this component can be ignored (Hamburg, 2000) if we are confident that it will not decrease as a result of the project. Brown (2001) states that dead wood, both lying and standing, is an important carbon pool in forests and should be measured. Methods

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[11] Bulk density is greatly affected by soil organic matter concentrations

for this component have been tested and require no more effort than measuring living biomass.

6. POTENTIAL COSTS OF CARBON SEQUESTRATION PROJECTS

To compete in carbon markets, the cost of sequestering carbon in LUCF projects will have to be lower than the market price of carbon. In the discussion that follows and throughout the paper currency ($) is measured in US Dollars. Pearce *et al*. (1998, cited in Smith *et al*. 2000) estimate a range of carbon prices from $5/tC to $23/tC. The lower the cost at which the carbon can be sequestered the greater the profit to the project partners (Smith and Scherr, 2002). Most studies suggest that the costs of carbon mitigation options, particularly those based on forestry, are quite modest. Estimates range from less than $5/tC to about $25/tC in several tropical countries (Table 4). However these estimates do not always include all the relevant costs (Smith *et al*. 2000, IPCC 2001).

Table 4. Cost estimates for carbon sequestration projects

Project	Cost range ($/t C)	Source
Farmers to conserve forests on their farm	7-24	a
Adopt multistrata agroforestry, Peruvian Amazon.	8-31	a
Profafor, Ecuador	16	d
Scolel Te, Mexico	10-12	c
Forestry projects in developing countries	2-25	d
Forestry projects in industrialised countries	5-82	d
Reforestation w/ short-rotation species (in land with low opportunity cost)	< 5	b
Industrial plantations in China, Thailand, India and Brazil	<5	e

a Smith and Mourato (in press); b: various sources reviewed by Smith and Scherr (2002), c: De Jong *et al* (2000); d: various sources, Smith *et al* (2000) Table 1; e: Hardner *et al* (2000) and Austin *et al* (1999), cited by Smith (2002).

It is difficult to compare estimates because they use different methods and assumptions. Sources of differences among the studies cited in Table 4 include: (i) the categories of carbon pools that are included, (ii) whether the study is based on stocks or flows, (iii) whether marginal or average costs were used, (iv) whether actual or projected costs were used, and (v) whether appropriate discounting was applied (Smith *et al*. 2000, IPCC 2001). It is noteworthy that the costs of addressing the problem of permanence have generally been ignored in these studies.

In order to estimate the likely costs of a particular project, it helps to distinguish abatement costs and transaction costs. In general, abatement costs are fairly straightforward to estimate, based on well-established discounted cash flow and modelling techniques. Transaction costs, on the other hand, are highly dependent on the particular socio-economic situation of the project participants and the institutional characteristics of the host country.

6.1. Abatement 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 rather than the most profitable alternative activity, or the cost of switching from the previous land use to the new (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.

In a study in Mexico, de Jong *et al*. (2000) assumed that farmers will shift to agroforestry if the incentives (net present value (NPV) of benefits) are higher than the NPV of the costs of implementing the new land use. They constructed income-expenditure profiles for 12 alternative interventions in forests, pastures and agricultural land. They defined the cost of carbon sequestration (C_C) over a period of 70 years as:

$$C_c = C_I + C_m + C_o - B_P \qquad (2)$$

where C_I is the implementation cost, C_m the cost of management services (including project promotion and training), C_o is the opportunity cost (land rent value) and B_P are revenues from timber sales and labour savings under the project activity. All these values are expressed in present value terms and so depend on the discount rate assumed. This definition includes unambiguous abatement costs ($C_I + C_o - B_P$), but C_m may include transaction costs, as it includes the cost of monitoring carbon stocks.

Tomich *et al*. (2002) estimated the opportunity cost of several agroforestry systems in Sumatra, Indonesia. They defined opportunity cost as the "net present value of foregone returns to the alternative land use". Based on discounted cash flow analysis, they estimated the minimum price required per ton of carbon to encourage smallholders to participate in a carbon-conservation project. They found that carbon payments necessary to shift incentives from forest conversion to conservation varies from $0.10/tC for community-based forest management, to $4/tC for large-scale oil palm plantations, to $10/tC for rubber agroforests. However, when the option for logging the forest was included as an opportunity cost, the incentive payments required increased significantly (to $8.50/tC, $10/tC and $16/tC for community forestry, oil palm and rubber agroforestry, respectively). These figures include only abatement costs, so if transaction costs are high these projects may be economically infeasible.

To the extent that economies of scale are available in undertaking carbon sequestration projects, it might be argued that this provides a case in terms of abatement-cost effectiveness for pursuing any given sequestration target with as few projects as possible. It would follow that efforts to arrange such projects should focus on plantations rather than smallholders. However, abatement-cost-effectiveness depends on more than realisation of economies of scale. It depends too on the opportunity costs of the resources utilised in the projects. For instance, the opportunity cost of labour for smallholders may be lower than for plantations. Otsuka and Place (2001a, p. 29) observed from studying natural resource management in agrarian communities in Asia and Africa that "since the principal input required for investment in land and trees is labor, poor households endowed with cheap labor may have an advantage over the rich". As discussed earlier, CDM requires that sustainable development goals be met. Consequently, large-scale plantations that use large amounts of fertiliser and chemicals may not qualify, unless the employment generated meets the sustainable development definition of the host country.

Plantations are usually located in areas better suited to agriculture and closer to markets (Otsuka and Place 2001a), suggesting that the opportunity costs of their land may exceed those of smallholders. As Suyanto, Tomich *et al.* (2001 p. 141) observed from their study of agroforestry management in Sumatra, "we have to recognize that rural people in hilly and mountainous areas, such as our study sites, are generally very poor and that in such areas agroforestry has a comparative advantage over food production". Where foregoing subsistence production leads to high opportunity costs by jeopardising food security, however, this will represent a considerable barrier to adoption.

The costs of obtaining credit are likely to be lower for plantations. To the extent that they tend to gain more secure property rights in land than poorer smallholders, furthermore, their risk of missing out on the rewards from long-term land-based investments should be lower (Otsuka and Place 2001a), and thus their risk-avoidance costs should be commensurately lower.

It is evident from the above that the abatement-cost-effectiveness of pursuing carbon sequestration goals through projects with smallholders vis-à-vis fewer projects with plantations can only be determined empirically on a case-by-case basis. Nevertheless, economies of scale may be important at the project level, particularly when fixed costs are high. Some evidence for this is presented in Appendix 1.

6.2. Estimating Abatement Costs

As mentioned above, abatement costs are relatively straightforward to estimate through discounted cash flow techniques. Carbon sequestration rates can also be estimated within an acceptable level of accuracy through modelling. In this section, a simple modelling approach is presented to illustrate how the costs of abatement by smallholder agroforestry systems can be estimated. Initially, the analysis is performed from the standpoint of the host-country planner, hence social prices are used and performance is measured in economic terms. The use of social prices assumes that price distortions (caused by government policies) are eliminated. We also present estimates of returns to family labour and assess prospects for employment creation. The analysis is then extended to the standpoint of landholders, who face actual prices as experienced in the presence of existing distortions. Hence private prices are used and performance is measured in financial terms. In this latter analysis we estimate the opportunity cost of land-use changes for landholders on degraded land.

An economic analysis of four agroforestry systems that are common on the island of Sumatra, Indonesia, is presented in Table 5. A brief description of each agroforestry system is presented below, followed by an interpretation of the results. Additional details on assumptions and methods are presented in Ginoga *et al*. (2000). Although the original analysis was performed in Indonesian rupiah (Rp), this section presents results in US dollars ($). To simplify comparison of carbon prices with other studies, an exchange rate of Rp10,000 per $ was used.

Rubber plantations in Sumatra cover about 2.6 million ha, representing roughly 70 per cent of Indonesian rubber production (Ministry of Agriculture, 1999). Rubber production has a long history in Sumatra and various production systems exist, ranging from jungle rubber in community land to large commercial plantations (Budidarsono *et al*. 2001, Tomich *et al*. 2002). Smallholder systems usually consist of one to five ha. The rubber system represented in Table 5 assumes a fast-growing clone seedling. The BEAM agroforestry model was used to simulate this system (Grist *et al*. 1998).

Table 5. Economic performance of selected agroforestry systems in Sumatra

	Agroforestry System			
	Rubber	Cinnamon	Damar	Oil Palm
Economic performance:				
NPV ($/ha)	173	180	1,064	1,621
Establishment cost ($/ha)	378	1,383	577	2,299
Return to labour ($/pd*)	0.80	0.64	1.17	1.29
Years to positive cash flow	14	12	5	15
Labour requirements:				
Establishment (pd/ha)	4,842	2,411	903	542
Operation (pd/ha/yr)	164	43	132	85
Total (pd/ha/yr)	249	189	141	56
Carbon sequestration:				
Average biomass carbon (t C/ha)	42.36	22.70	102.67	26.62
Carbon cost $/t C	8.92	60.96	5.62	8.64

* pd represents person-days

Cinnamon is another important agroforestry system in Sumatra. The area of cinnamon in Indonesia is about 119,905 ha, of which 116,761 ha (97 per cent) are located in Sumatra. In multicropping systems, cinnamon trees are usually planted in rows about four metres apart, and spaced about 1-2 metres apart along each row (Wibowo, 1999) Secondary crops such as potatoes, chilli and coffee are planted between rows. Multicropping is practised until cinnamon trees reach an age of about six years, after which the system becomes a monoculture of cinnamon, with negligible amounts of annual crops or bananas grown on the edge. Cinnamon trees are harvested in year twelve. The example in Table 5 represents a cinnamon/chilli system.

The damar system is a complex agroforest developed by the Krui people of Lampung, south Sumatra. The system consists of a sequence of crops building up to a “climax that mimics mature natural forest” (ASB 2001). The main tree species is damar (*Shorea javanica*), a source of resin that provides a flow of income. Other outputs include fruits, pepper and firewood. The data for this analysis were kindly provided by ICRAF.

Another important tree-based system is oil palm. About eight per cent, or 222,096 ha, of oil-palm plantations in Indonesia are located in the Jambi province of Sumatra (Ministry of Agriculture, 1999). Oil-palm plantations are usually operated by large-scale companies or state companies. Only about 23 per cent of oil-palm plantations are operated by smallholders. The plantation represented in Table 5 consists of a large, 10,700 ha, system established over a period of 10 years. The data for this analysis were kindly provided by ICRAF

The economic analysis of these agroforestry systems (Table 5) shows that all systems are attractive at a real discount rate of 15 per cent. The NPVs range from \$173/ha to \$1,621/ha, with oil palm providing the highest profit, followed by damar agroforestry. Following the guidelines established by the Alternatives to Slash and Burn (ASB) program, the establishment cost was calculated as the NPV of the stream of costs incurred until the cash flow becomes positive, and the return to labour was calculated as the wage rate that makes NPV=0 (Tomich *et al*. 1998). Returns to labour range from \$0.64/pd for the cinnamon system to \$1.17/pd for the damar system. Compared to an average wage rate of \$0.51/pd in the Jambi province, all four systems provide attractive returns to labour. Labour requirements are fairly high, especially for establishment. This indicates that there is scope for employment generation, especially if there is staggered establishment of these systems in order to provide a steady stream of employment in a region.

The amount of carbon sequestered by aboveground biomass for each of these systems was estimated with simple growth models based on available data and using allometric equations from Brown (1997) and Ketterings *et al*. (2001). The growth in carbon stocks of the three agroforestry systems over 70 years is presented in Figure 5. A period 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 (Figure 5) 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.

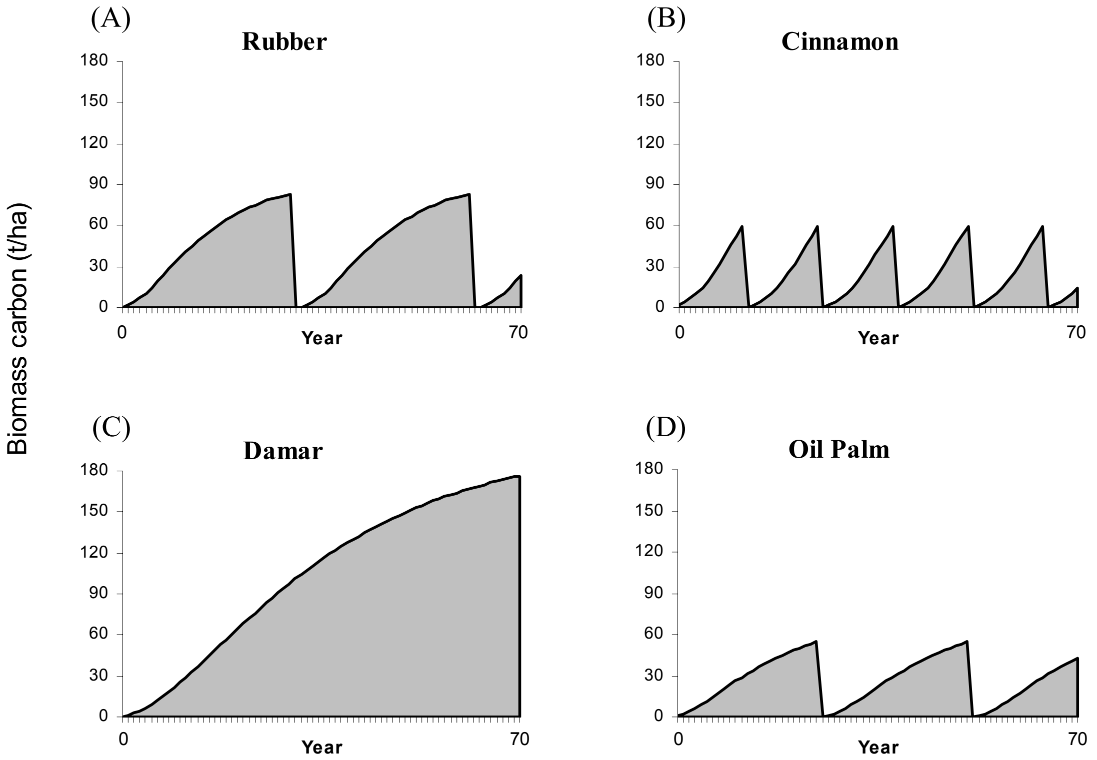

Figure 5. Carbon sequestration trajectories of selected agroforestry systems; simulated results for southern Sumatra, Indonesia

A rough measure of the cost of carbon sequestration in each system is presented in the last row of Table 5. These carbon cost values were obtained by dividing the establishment cost by the average biomass present in each system. The lowest cost per ton of carbon is provided by the damar system ($5.62/t) while the highest cost corresponds to the cinnamon system ($60.96). The 'carbon costs' in Table 5 are not the abatement costs represented in the supply curves in section 3 and also discussed above, since they are financial costs rather than the opportunity costs based on the most profitable alternative use for a particular plot of land. Finally, observe that the carbon sequestration rates in Figure 5 assume a baseline of zero. This is a good enough approximation if the agroforestry system replaces an annual crop. However, if it replaces a forest, the baseline carbon stock must be subtracted from the average biomass carbon to estimate the carbon sequestration attributable to the project, and a negative carbon balance would result.

A further limitation of the figures presented above is that the yield estimates upon which they are based assume good-quality land. However, land of this quality is likely to be recently deforested and therefore not eligible for a CDM project. Reforestation of degraded land may be an acceptable CDM activity under both sustainability and additionality criteria, although productivity of degraded land, and hence its carbon sequestration capacity, will be low. To simulate degraded land and undertake further analysis, the yields of the four agroforestry systems were arbitrarily reduced to one half of the original yields.

As explained before, to measure the opportunity cost to the landholder of changing land use we must use private prices (actual prices in the presence of existing distortions caused by government policies), as they will determine the profit the landholder actually receives. In other words, we address the question "given existing price distortions, how much do we need to pay landholders to entice them to change land-use practices?" So we turn from economic to financial analysis, and assume a higher discount rate (20 per cent instead of 15 per cent). 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 latter has NPVs ranging from –$7.1/ha to $36/ha depending on the amount of fertiliser used. The higher value ($36/ha) was taken as the basis to estimate opportunity costs of land-use changes (Table 6).

The results of the financial analysis for degraded land indicate that only cinnamon is profitable, as the other three systems have negative NPVs. The sequestration cost of the cinnamon system is negative. This means that, strictly speaking, the cinnamon system does not meet the additionality requirement unless other barriers to establishment exist (such as lack of credit). Of the other three systems damar, provides the cheapest option for sequestering carbon ($1.41/tC), with oil palm the most expensive ($9.55/tC), and rubber intermediate ($6.25/tC).

Table 6. Financial performance and costs of selected agroforestry systems on poor land; modelling results for Sumatra, Indonesia.

	Agroforestry System			
	Rubber	Cinnamon	Damar	Oil Palm
NPV ($/ha)	-96.35	114.99	-36.46	-91.10
Average C stock (t/ha)	21.18	11.35	51.34	13.31
Opportunity cost ($/ha)[1]	132.35	-78.99	72.46	127.10
Sequestration cost ($/t C)	6.25	- 6.96	1.41	9.55

[1] Cost (in terms of NPV) of switching land use from cassava to agroforestry.

Consider an investor who plans to establish a project and sell CERs. If faced with the options in Table 6, a rational investor would select cinnamon first (provided it satisfies the additionality criterion) followed by damar, rubber and oil palm. This is true in the absence of transaction costs, or if transaction costs are equal for all four systems. However, recall that the oil-palm figures are based on a large-scale project covering 10,700 hectares, whereas the other three systems are run by smallholders. So two questions arise: (i) are oil-palm systems acceptable under the CDM sustainability criterion? and (ii) are transaction costs for the oil-palm system lower than for the smallholder systems? If the answer to (i) is 'no', then question (ii) is irrelevant. However, if the host country considers that the use of degraded land to generate employment and foreign exchange meets its sustainability criterion, the answer to (i) may well be 'yes'. In which case question (ii) becomes relevant. Comparing damar with oil palm, for example, the question becomes: "Are the transaction costs of a smallholder damar system likely to be more than $8.14/tC (=9.55-1.41 from Table 6) higher than the transaction costs of a large oil-palm estate?" This question cannot be answered unless the size of the smallholder project is known, because a large proportion of transaction costs tend to be fixed, as discussed in the next section.

As shown above, it is possible to estimate abatement costs associated with particular land-use systems through modelling and fairly simple economic analysis. This can be useful as a screening device to identify potential agroforestry systems for a particular site. From the standpoint of the host country, or the global planner, the abatement cost of feasible projects can be aggregated into a supply curve of sorts. The costs estimated above are average costs rather than marginal costs. Hence, the resulting curve is not a supply curve in the strict sense, but it is still a useful tool in project selection. The actual costs of a project must be estimated based on local data, as the opportunity costs and baselines can vary considerably between sites.

6.3. Transaction Costs

Given that some of the transaction costs for GHG abatement projects are likely to be fixed (i.e., do not vary with project size), it might also be supposed that it would be more transaction-cost-effective to pursue a given carbon sequestration goal with a smaller number of projects with plantations than with a larger number of projects with smallholders. Again, however, other factors need to be considered before such a conclusion can be justified in any case.

For instance, any advantage of plantation-based projects in terms of fixed transaction costs needs to be set against any advantages projects with smallholders might have in terms of variable transaction costs. To the extent that the opportunity costs of labour are lower for smallholders than for plantations, for instance, variable transaction costs associated with self-monitoring compliance with project conditions may be lower for smallholders than for plantations. The comments in section 4 to the effect that political transaction costs of involving larger landholders in carbon sequestration projects may be higher than for smallholders also give some reason to suspect that involving smallholders may be more cost-effective for some aspects of transactions — for instance, gaining landholder cooperation with agreed monitoring and enforcement procedures — than involving plantations.

On the other hand, we might reasonably expect some fixed and variable transaction costs to be higher for projects involving smallholders. This might be the case, for instance, when smallholders tend to be located significantly further than plantations from the centres in which the personnel responsible for searching for landholder partners, negotiating contracts, monitoring and enforcing contractual compliance, and so on, are based.

As was found for abatement-cost-effectiveness, it seems that comparisons of transaction-cost-effectiveness between involving smallholders and plantations in carbon sequestration programs can only be determined empirically, case by case.

6.4. Measuring Transaction Costs of Carbon Sequestration Projects

Dudek and Wienar (1996) adapted the kinds of general classifications of transaction costs outlined in section 4 of this paper to develop a six-fold classification of climate-mitigation projects. Their categories are: search costs, negotiation costs, approval costs, monitoring costs, enforcement costs and insurance costs. We follow this classification, but included an additional category: *administration costs*. Each cost category is discussed below.

Search costs

Search costs will be incurred as investors and hosts seek partners for mutually advantageous projects. They include the costs of investors and hosts surveying a range of alternatives prior to making a decision. Examples of search costs are brokers' fees, charges for information services, costs of advertising a willingness to engage in a transaction, and delays experienced while seeking a suitable partner (Dudek and Wienar 1996). In projects involving smallholders, search costs would also include gathering agricultural, social and economic information about the region; as well as contacting and establishing relationships with individual smallholders and farm groups. Some of these costs will be related to establishing the baseline.

Negotiation costs

Negotiation costs are the costs of interested partners coming to an agreement. They include the costs of deciding the details of: project design; the responsibilities of each partner; assignment of benefits (e.g., payment in cash or technology, or in GHG abatement credits); and the schedule over which benefits will be paid. Legal costs may also be incurred in specifying the terms of the contract. Delays caused by negotiations can also be costly. Negotiation costs may be incurred internally to each interested partner (e.g., between the directors of a company considering becoming an investor), as well as between the partners (Dudek and Wienar 1996). With smallholders, the cost of negotiating with individuals, including farm visits and establishment of personal relationships can be high. Also, the cost of writing contracts when literacy is limited, and legitimisation of contracts through a village committee or headman can be important (Simmons 2003). However, negotiating with plantations may sometimes be high for other reasons, e.g., their greater use of lawyers, or their greater access to political influence.

Approval Costs

Approval costs occur when the negotiated exchange must be approved by a government agency. For instance, they will be incurred when the GHG abatement credits earned by a project are presented to an accredited agency for certification. The host government, and possibly also the investor government, may also require advance approval of the project. Approval costs are likely to be mostly experienced in terms of delay and uncertainty, although they might also arise as out-of-pocket costs involved in generating and compiling the information required in an application for approval (Dudek and Wienar 1996).

Verification costs fall within the approval costs category. Verification refers to checking the validity of the claims of a project. This includes reviewing the assumptions of the project proposal and the validity of the methods for monitoring carbon stocks. Verification is a necessary but not sufficient condition to enter the market. Certification, on the other hand, occurs *ex post*, once sequestration has occurred. Certification is explained later as part of monitoring costs.

Administration costs

Administration costs are associated with the resources expended in administering the translation of a project design, as developed in the negotiation stage of a transaction, into practice. They are defined here to include the costs of negotiating refinements to projects as new knowledge becomes available. Examples of the kinds of transaction costs likely to be incurred by carbon sequestration projects in this category are: keeping records of project participants, administration of 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

Monitoring costs are the costs of the efforts partners need to make to observe the transaction as it unfolds, and to verify compliance with the agreed terms of the transaction (Dudek and Wienar 1996). Monitoring will also be required to measure the GHG abatement actually achieved by the project in real time (as opposed to forecasts). Certification is part of monitoring costs. Certification is given only on real accomplishments, so it occurs *ex post*, once sequestration has occurred (Moura-Costa *et al*., 2000). The methods used to measure carbon accumulation in LUCF projects were discussed in section 5. MacDicken (1997) points out that projects that fix less than two or three tons of carbon per hectare per year cannot be monitored in a cost-effective way, because the cost of measuring these quantities is similar to the cost of measuring 10 to 15 tons of carbon per hectare per year.

Enforcement costs

Enforcement costs are the expenses of insisting on compliance if monitoring detects divergences from the agreed terms of the transaction. They may be incurred in the form of litigation or administrative proceedings (Dudek and Wienar 1996). Enforcement of contracts is possibly one of the most important transaction costs. When dealing with developing country 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. So the project needs to provide smallholders with credible prospects and sufficient incentives to prevent abandonment (Simmons 2003). Strategies to reduce risk of contract default include channelling loans through farm groups, monitoring within the community, and strict rules and harsh penalties for dealing with defaulters (Eaton and Shepherd 2001).

Insurance costs

Insurance costs arise from the risk of project failure. Project failure 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 Wienar (1996) suggested that the riskiness of a transaction would depend to large extent on the credibility of the proposing nation. Various insurance options may be exercised to reduce the perceived riskiness of transactions, including purchase of a financial insurance policy, development of contingency plans in case of transaction failure, deduction of a risk premium from the price paid to the host, purchases on spot markets, and diversification of the projects an investor is involved in. Some of these strategies can also be used to deal with leakage. Project design could alter who bears the risk or insurance costs among buyers, sellers and producers. At this stage, most projects do not provide insurance for the farmer (see Appendix 1). Profafor gives back the leased land to the community, if the community can prove that they were not responsible for the damage; Scolel te calculates the estimated carbon to be stored by the farmer and pays them 90 per cent of the value, keeping the other 10 per cent in a contingency fund.

Dudek and Wienar (ibid.) observed that the various categories were 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.

6.5. Accounting methods and landholder incentives

In section 6.2, we discussed abatement costs assuming a 70-year planning period to approximate a project that operates in perpetuity. Thereby we abstracted away from the problem of permanence. However, it may be difficult to insure a project of such duration, particularly when the land is handed down to the next generation. Also, a 70-year project may raise sovereignty objections by the host country, which may be hesitant to tie down the land for such a long time. In this section, therefore, we assume a more realistic 25-year project.

Ideally, carbon sequestration services provided by a project would be paid when they occur, and the costs of any releases of CO_2 from a project to the atmosphere would be recovered as they occur . Under this system, any carbon payments received during the life of the project would be paid back when the trees are harvested or when the project ends, hence releasing the project from any further obligations. In practice, it may be difficult to recover the payments from landholders. Nevertheless, it is worth exploring this system as a benchmark. The net present value of profits obtained under the ideal carbon-accounting system (NPV_I) for a 25-year project is:

$$NPV_I = \sum_{t=0}^{25} \left[v_t - c_t + p_b \cdot \Delta b_t \right] \cdot (i+r)^{-t} - p_b \cdot b_{25} \cdot (1+r)^{-25} \qquad (3)$$

where v_t (\$/ha/yr) are the revenues obtained from the sale of outputs in year t; c_t (\$/ha/yr) are the costs incurred in year t (so c_0 is the initial cost of planting the agroforestry system); p_b is the price of carbon (\$/tC); Δb_t (t/ha/yr) is the amount of carbon sequestered during year t; and r is the discount rate (0.2 in this example). Note that Δb_t can be negative in the event of fire or partial harvest. The final term in the equation above represents the redemption by the landholder of the carbon payments received during the life of the project, thus releasing the landholder from any further obligations.

Of the methods proposed to deal with non-permanence of forestry projects, the ton-year approach (Moura-Costa and Wilson 2000; Fernside at al. 2000) has perhaps received the most attention in IPCC discussions. This method has appeal because it is based on the decay path of CO_2 in the atmosphere over 100 years. Under this accounting system a LUCF project would have to keep CO_2 off the atmosphere for 46.4 years in order to receive the same credit as an energy project that decreases emissions. The *Equivalence Factor* (E_f) is the inverse of this number (Moura-Costa and Wilson 2000), and measures the effect of keeping one ton CO_2 out of the atmosphere for one year; $E_f = 1/46.4 = 0.0215$. The net present value of profits obtained under the ton-year accounting system (NPV_T) is:

$$NPV_T = \sum_{t=0}^{25} \left[v_t - c_t + p_b \cdot b_t \cdot E_f \right] \cdot (1+r)^{-t} \qquad (4)$$

where b_t is the stock of biomass carbon (tC/ha) at time *t,* and the remaining variables have been previously defined. This method is based on stocks of carbon (b_t) rather than flows (Δb_t), but it takes account of time through the equivalence factor. For more details on this and other accounting methods, see Cacho *et al*. (2002).

Table 7 shows the results of applying these two accounting methods to the four Indonesian agroforestry systems described previously. Degraded land and private prices were assumed as explained in section 6.2. The price of carbon was assumed to be \$20/tC. Each ton of biomass carbon represents 3.67 tons of CO_2 sequestered, so this carbon price is equivalent to \$5.42/t CO_2.

As before, the only system that is profitable on its own is cinnamon. The other three systems have negative NPVs. Carbon payments based on the ton-year accounting method increase the NPVs slightly, but do not make them positive, so there is no incentive for landholders to sequester carbon under this payment method. Carbon payments based on the ideal system, in contrast, result in positive NPVs for all systems (Table 7).

Table 7. Effect of carbon accounting methods on the financial performance of selected agroforestry systems on degraded land; modelling results for Sumatra, Indonesia

	Accounting method	Agroforestry System: Rubber	Cinnamon	Damar	Oil Palm
Landholder's profit (NPV)					
(\$/ha)	No credits	-94.83	114.33	-34.61	-89.79
(\$/ha)	ton-year	-78.35	130.71	-22.66	-77.41
(\$/ha)	Ideal	56.85	265.06	75.31	24.08
Investor's expense (NPV)					
(\$/ha)	Ideal	151.68	150.73	109.92	113.87
(\$/tC)	Ideal	7.60	12.63	6.49	8.02
Carbon sequestered					
(tC/ha)		19.96	11.93	16.94	14.19

Under the ideal accounting system, the investor's expense for carbon payments, in present-value terms, ranges between about \$110/ha for damar and \$152/ha for rubber; and the cost to the investor per ton of carbon ranges from \$6.49/tC for damar, to \$12.63/tC for cinnamon. The investor's expense was calculated from equation (3) as the NPV of the carbon payments made during the life of the project minus the payments redeemed at the end of the project. The underlying assumption is that landholders will adopt a particular system if the NPV of their profits > 0 (i.e., that there are no other barriers to adoption).

The ton-year approach has the important advantage that no guarantee is required to ensure that the project will continue for the agreed duration. For this reason, the transaction costs of negotiating, monitoring and enforcing contracts based on this approach would normally be considerably lower compared with contracts based on the ideal accounting system. Since the annual payments are adjusted by the equivalence factor, there is no need to recover payments if the project is abandoned and the carbon is released. However, this method does not provide enough incentives to adopt carbon-sequestration activities in degraded land in Sumatra.

Further insight can be obtained by exploring the effects of accounting methods on discounted cash flows (Figure 6). Cumulative discounted cash flows are negative for all projects during the establishment phase, but they eventually become positive under the ideal accounting system (Figure 6). Although carbon payments under the ideal system make cash-flow constraints less binding, delayed cash flows from establishing agroforestry may remain an important obstacle. This suggests that smallholders would need to reserve part of their land to produce annual crops and livestock products that maintain sufficient cash flows in the early years and provide food security. A community-managed scheme, whereby relatively large tracks of communal land are devoted to agroforestry and individual plots remain in agriculture managed by smallholders, may therefore be a practical project design.

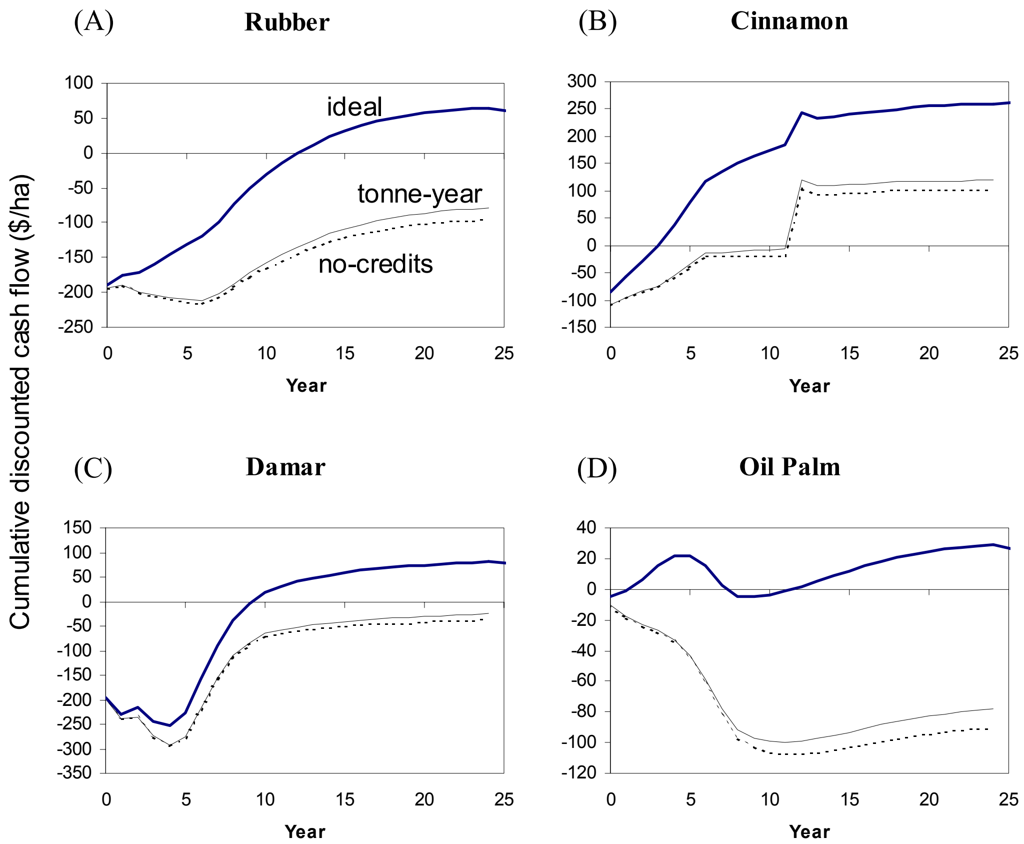

Figure 6. Discounted cash flows (cumulative) of four agroforestry systems in Sumatra under three accounting methods: no-carbon credits (dotted line), ton-year (solid thin line) and ideal (solid thick line); modelling results for degraded land in Sumatra, Indonesia.

The shortcoming of the ton-year approach as an incentive is that it is based on a purely physical measure and does not take time-preference into account. If the investor is willing to spend $7.60/tC, in present-value terms, by implementing a smallholder-rubber project (Table 7), then we can ask, how can the ton-year approach be adjusted to provide the same payment, but eliminate the need to redeem carbon credits upon project termination? In other words, the pertinent question is how the cash flow yielding a given NPV would best be scheduled. Ideally (in a zero transaction-costs world) it would track the path of carbon, but in a real, positive transaction-costs world this is likely to be too costly, so something like the ton-year approach becomes appropriate. This question can be easily answered by finding the equivalence factor (E_f) in equation (4) that makes $NPV_T = NPV_I$ in equation (3). It turns out that the value of E_f in this 'modified ton-year' approach is 0.2 for the Indonesian systems analysed. This is almost a ten-fold increase over the original E_f of 0.0217.

The cash flows for the modified ton-year (MTY) approach are compared to those of the ideal system in Figure 7. The final discounted cumulative cash flow (in year 25) gives the NPV, and the NPVs are equal for both accounting systems. However, early payments under the MTY approach are lower than under the ideal system (Figure 7), thus 'saving' money for later in the project, and avoiding the need for, and the risk associated with, carbon-credit redemption.

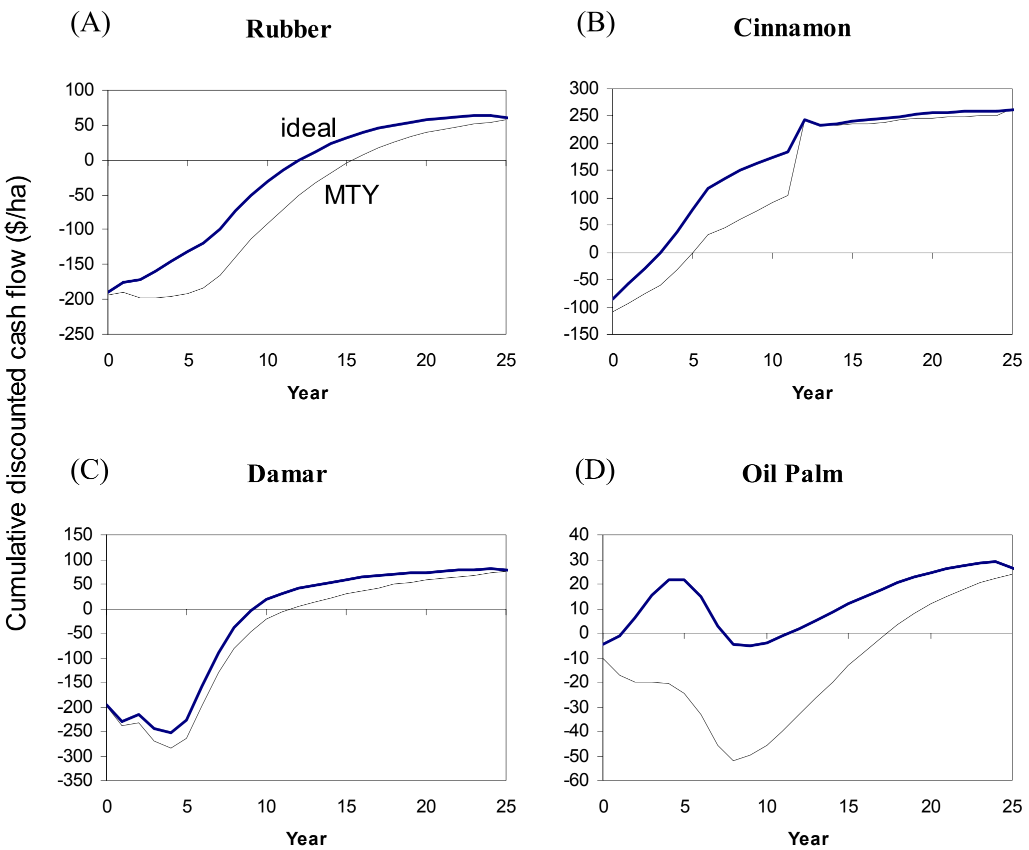

Figure 7. Discounted cash flows (cumulative) of four agroforestry systems in Sumatra under two accounting methods: modified ton-year (MTY, solid thin line) and ideal (solid thick line); modelling results for degraded land in Sumatra, Indonesia.

Although the essence of this analysis is based on actual data, some modelling based on arbitrary assumptions was required to represent degraded land. It is possible the assumptions regarding land productivity are unduly pessimistic. There may be more appropriate production systems for this type of land, or higher fertilisation rates may increase financial performance. Another option would be a phased approach, where degraded land is first planted to fast growing, nitrogen-fixing trees (such as *Gliricidia*) that yield firewood and forage. Once fertility is improved more valuable agroforestry operations may become feasible.

7. DESIGNING PROJECTS TO BENEFIT THE POOR

The poor in any country have limited opportunities to adopt technologies or change their social behaviour, particularly when they are not part of the cash economy. Also, environmentally sound technologies with relatively small project sizes and long repayment periods deter banks with their high transaction costs. IPCC (2001) reviews a number of innovative approaches to address these issues, including leasing, environmental and ethical banks, micro credits, small grants facilities targeted at low income households, environmental funds, energy service companies and green venture capital. In this section, we discuss other ideas regarding the design of projects to encourage participation by smallholders.

7.1. Good Project Design

Authors such as Smith (2002), IPCC (2001) and Baumert *et al*. (2000) have recommended strategies to reduce the transaction costs of making the CDM operational in smallholder contexts and thereby contribute to sustainable development. Here we discuss a selection of these strategies and add some ideas of our own. These strategies can be classified into nine major categories:

- Generate information (e.g., regarding production systems and baselines);
- Disseminate information;
- Teach smallholders to measure carbon;
- Select areas where community cohesion is strong and encourage community self-regulation;
- Use project bundling (involving a portfolio of mitigation projects);
- Bundle payments for other environmental services (e.g., biodiversity);
- Make good use of ‘double-dividend’ instruments (e.g., carbon taxes, auctioned permits);
- Promote secure land tenure; and
- Develop smallholder contracts.

Each of these strategies is briefly discussed below.

Generate information

This includes the sort of research that is undertaken by CGIAR centres and national research agencies. It is also illustrated by the example presented above for Sumatra. By producing information on suitable production systems and their profitability, we can decrease the search costs of starting a new project. Generating information on projects where smallholders are likely to be competitive suppliers (e.g., low opportunity costs) is also needed.

Establishment of baselines can be an expensive activity, particularly in areas subject to rapid changes in population and government policies. At COP 7 (the 7th Conference of the Parties to UNFCCC) it was agreed that small projects (less than 15,000 tC) should be allowed to use simplified methods to estimate baselines and monitor emissions. Moura-Costa at al. (2000) suggest that generic baselines, based on sector, region or country can be developed and integrated in a system of 'technology matrices' similar to those used in the energy sector. These methods need to be developed and may represent efficient use of development research assistance.

Perhaps more work is required in developing efficient ways of storing information and making it available to potential market participants. The Profafor project and the FACE Foundation (see Appendix 1) have made some progress in this front. In all FACE projects, a monitoring and information system called MONIS is used to determine the amount of carbon sequestered. The system links alphanumeric and graphic information of the forestation contract sites, and stores administrative, financial and technical information for each forestation plan. It also keeps track of production of seedlings and technical assistance (FACE 2000).

Disseminate information

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 centres. Once a few examples of successful systems are established word of mouth may work well. This has been the case in the Profafor project in Ecuador, and Scolel Te 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 about the potential of the smallholder sector to supply carbon credits to potential buyers.

Train smallholders

According to ASB (Hairia *et al*. 2001), informal discussions with farmers in Jambi, Sumatra, have shown that they are used to assessing the volume of wood in their trees[12] (at 0.25 m^3 increments, as used in the market). This suggests that, if farmers learn the value of carbon biomass, they can monitor their plots at low cost. Delaney and Roshetko (1999) state that it took two days for a crew to learn inventory methods to measure carbon in agroforestry gardens in Java. This provides further evidence that it may be possible to train smallholders to identify and measure their own trees and complete a sample sheet. The sample sheet could then 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 allometric equations.

Can smallholders be relied upon to measure trees and provide their sample sheets to project managers? There is of course an agency problem inherent in expecting smallholder to undertake these tasks, to the extent that scope exists for them to opportunistically mismeasure or misreport carbon sequestration in their projects in order to reduce their costs of project compliance. However, practical ways to limit this scope, and the transaction costs it entails,

[12] Interestingly, in the farmer's mind trees without wood value have no volume.

may exist. For instance, a system of randomly checking reports from smallholders may, if combined with substantial penalties for misreporting, make opportunism in this area too costly to countenance. Also, if the contract benefits the community as a whole, and if rewards from the whole contract depends on all smallholders doing the right thing, an incentive exists for community members to monitor and police one another.

Hence scope exists for reducing any transaction-cost disadvantages smallholder agroforestry systems may experience compared to industrial plantations in respect of monitoring and enforcing contractual compliance. This is particularly the case when it is considered that the accuracy of carbon measurements depends on the number of sampling sites. Involving smallholders can achieve high measurement accuracy by allowing sampling intensity at a fairly low cost.

Select cohesive communities and encourage community self-regulation

One way to reduce the costs of smallholder involvement in carbon sequestration projects may be to develop projects with smallholders on a community basis, namely by way of common-property regimes, rather than with them individually. This possibility is considered in some detail in section 7.2, "A role for common-property regimes?"

A possible implication of such a strategy may be that cost-effectiveness concerns will lead much of the attention on developing community-based projects with smallholders to be directed at communities already possessing much of the capacity required to manage such projects. This implication may be of concern to the extent that the CDM would tend to neglect the communities least able to organise to help themselves and that presumably are most in need of outside intervention to alleviate their problems of poverty.

One of the benefits of a community-based strategy for organising projects with smallholders is that it affords potential for allowing informal regulation within communities to substitute for formal regulation imposed from the outside (IPCC 2001). As explained in the next section, such an outcome can reduce the transaction costs of projects considerably. Nevertheless, realising the potential of a community-based strategy to promote informal regulation can be expected to depend importantly on the strategy being pursued in a way that smallholder community members perceive to be fair. As argued below in the section "Participatory approaches to project design", providing opportunities for community members to participate in a decision-making process is usually a key prerequisite for gaining such a perception. The section highlights how the benefits of participatory approaches in terms of promoting informal project compliance mechanisms (thus reducing the *ex post* transaction costs of projects) can usually be expected to come at the expense of increases in the *ex ante* transaction costs of projects brought about by initiating a more inclusive decision process.

Project bundling

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). An intermediary has several advantages over the current bilateral arrangements. Firstly, they are likely to increase the attractiveness of investing in small-scale carbon projects to a wider set of investors who are either risk averse or financially constrained by the high pre-implementation transaction costs and disproportionately large implementation costs of smaller projects (Wexler *et al.* 1994). Secondly, they are 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). A number of institutions could act as the financial intermediary, including multilateral development banks, governments, NGOs, commodity exchanges, private sector entities and local community organisations. 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).

The potential for project bundling is illustrated by the FACE Foundation (see Appendix 1). They currently have six projects in Latin America, Europe, Asia and Africa (of which Profafor is the largest). They have developed infrastructure including GIS, database and modelling tools, and protocols for monitoring and certifying carbon stocks. This means that project design and baseline estimation should be lower for new projects.

Bundle payments

There is scope for exploiting synergies between the UNFCCC and other international agreements such as the Convention on Biological Diversity (CBD). Where projects provide services relevant to both conventions it may be possible to bundle payments to smallholders and communities. This may be through financing project design and implementation, or by providing payments to bridge the gap required to effect land-use change. Non-government organisations such as Conservation International and the Nature Conservancy may also become important sources of funding and/or expertise for projects in environmentally sensitive areas. Costa Rica has been particularly innovative in its use of bundling strategies (e.g., see Appendix 1)

Double-dividend instruments

Double-dividend instruments, such as taxes and auctioned permits offer interesting possibilities. For example, revenues from carbon taxes or emission permits can be invested to fund the development of socially and environmentally friendly projects. At a more general level, national responses to climate change can be deployed as a portfolio of policy instruments in ways that reduce disincentives for agroforestry investment. The effectiveness of climate change mitigation can be enhanced when climate policies are integrated with the non-climate objectives of national and sectoral policy development (IPCC 2001).

Land tenure

In a study of agroforestry management in Sumatra, Suyanto *et a.l* (2001, p. 140) state: "The expansion of formal credit institutions into these relatively remote areas and the establishment of official land title will become increasingly important as further intensification of the land use is required".

In a large study in Uganda, Ghana and Sumatra, Otsuka and Place (2001b) found that commercial trees have been planted in communal land as much as in private land. They went on to observe: "It is widely believed ... that because of weak individual rights or tenure insecurity, trees are not planted and well managed under communal ownership … If the communal tenure institutions provide sufficient incentives to plant and manage trees,

however, the enhanced efficiency of land use can reduce the incidence of poverty in marginal areas. Furthermore, the establishment of agroforestry in sloping land will help reduce soil erosion and contribute to the partial restoration of tree biomass and biodiversity" (Otsuka and Place 2001b, p. 368).
Securing land tenure and empowering communities politically, however, are seen as necessary but not sufficient conditions for improved community management of natural resources. Economic empowerment is also required (Smith and Scherr, 2002).

Outgrower schemes

Outgrower schemes can inject capital, technical knowledge and access to inputs. Typical outgrower schemes consist of contracts between smallholders and agribusiness companies to produce high-value foods. Although these schemes are often associated with lower output prices and are viewed negatively by NGOs (Smith 2002), there are examples of successful contracts (Glover and Kusterer 1990). Smallholders may wish to participate in contracts based on revenue implications, cost implications and exposure to risk. They may receive advantages such as access to product markets, access to credit and more stable prices (Simmons 2003).

Although smallholder contracts may be subject to high *ex ante* transaction costs, these may be ameliorated by farm groups or other community organisations playing a part in negotiations. A contract is more likely to be successful if it provides benefits to the community as a whole. If it creates inequalities then it may be possible to compensate the losers in some way. There is evidence that interaction between farm groups and NGOs can increase the chances of success of a contract (Simmons 2003)

7.2. A role for common-property regimes?

As discussed above, one strategy for enhancing the cost-effectiveness of engaging smallholders in a CDM project might be to develop projects whereby smallholders participate in groups, for instance distinguished by local community boundaries, rather than individually. Such projects would thus be managed as common property rather than individual property. As defined by McKean (2000 pp. 29-30, 36, original emphasis), "a *common property regime* is a property-rights arrangement in which a group of resource users share rights and duties towards a resource. … [C]ommon property is shared private property and should be classified just as we classify business partnerships, joint-stock corporations, and cooperatives". Pursuit of this strategy would result in devolution of a significant share of the responsibility for project governance from state property regimes to common-property regimes.

There is now considerable empirical evidence that common-property arrangements can reduce the transaction costs of governance under certain conditions (Baland and Platteau 1996; Bromley 1992; Lam 1998; Meinzen-Dick, Knox *et al.* 2001; Ostrom 1990; Shivakoti and Ostrom 2002; Singleton 1998; Tang 1992). Considerable progress has been made in systematically delineating these conditions through case-study research, most notably by Ostrom (1990). This represents a significant break from the early presumption in the property-rights tradition of economics that the management costs internal to common-property regimes of preventing their members acting opportunistically, as Garrett Hardin (1968) predicted they would in his famous article "The tragedy of the commons", would be so high as to generally make such regimes less cost-effective than individual or state property regimes (e.g., Demsetz 1967). McKean's (2000 p. 36) retort to this presumption was not to deny that "sharing private property does have its weaknesses" but rather to point out that:

> … all arrangements of shared private property, from firms to resource cooperatives, contain internal collective-action problems because they are comprised of more than one individual owner. Just as there can be shirking and agency problems in a firm, there can be temptations inside a common-property regime to cheat on community rules. But there are productive efficiencies to be captured through team production that may be larger than losses due to shirking, making centralized or large-scale forms of production like the firm worthwhile anyway. Similarly, there may be gains from joint management of an intact resource that can outweigh losses due to cheating (or the cost of mechanisms to deter cheating) in a common-pool regime.

A key finding of the empirical research into common-property regimes of resource governance is that endurance of such regimes tends to depend on their members exploiting their local knowledge in order to devise institutional arrangements that are well-fitted to their biophysical circumstances, as well as their individual patterns of behaviour and other informal aspects of their culture (Ostrom 1990). To the extent that this condition is met, the shape of these institutional arrangements, including those concerned with monitoring and enforcing members' compliance with them, will be more likely to coincide with their pre-existing beliefs and behaviour, and thus result in lower transaction costs. A related finding is that procedures for making decisions in common-property regimes need also to be consonant with informal aspects of local culture (e.g., norms of fairness) if compliance with those decisions is not to be resisted as a matter of principle, thus escalating the transaction costs of monitoring and enforcing those decisions (Singleton 1998).

The transaction costs of smallholders acting as a common-property regime in undertaking GHG abatement projects will be reduced to the extent that their prior experience has developed their capacities for collective action. As Knox and Meinzen-Dick (2001 pp. 10, 29) observed, "[i]f people have experience with collective action in other spheres (e.g., advocacy and political organization, credit and savings groups), they are more likely to be successful in jointly managing natural resources. … Often, it will not be a matter of creating institutions, but rather verifying, strengthening or adapting them".

Singleton (1998) observed also that the ability of a collectivity, such as the membership of a common-property regime, to reduce its transaction costs of internal organisation depends on the extent to which it is a community. She noted that Taylor (1982) had identified the defining features of community as shared beliefs, stable and multi-faceted relations, and rough equality. Multi-faceted relations within a collectivity lower transaction costs by giving members additional assurance that they will be able to reciprocate one another's acts of cooperation or opportunism, thus reducing the costs of negotiating agreements. Furthermore, they lessen the costs of uncovering information about one another's preferences, beliefs and trustworthiness. Agrawal and Ostrom (2001 p. 88) remarked accordingly that "[b]y shifting decision-making powers … closer to those who are influenced by these decisions, it is hoped, information asymmetries can be reduced so as to produce more efficient decisions: better information will lead to better decisions".

A further key finding is that successful regimes of this kind usually are supported by sympathetic, or at least tolerant, state property regimes. For instance, state agencies can assist by acting as an external arbitrator of intractable conflicts between members of a common-property regime, by legitimising agreements they reach voluntarily, and by funding some of the research they require to understand their problems and develop solutions (Ostrom *et al.* 1999). As recognised by Baland and Platteau (1996 p. 347), this finding points to the value of a "co-management" approach to resource governance wherein policy interventions are concerned with helping state property and common-property regimes shore up one another's weaknesses.

Aside from the possible advantages of common-property regimes in terms of the transaction costs of engaging smallholders in CDM projects concerned with GHG abatement, establishment of regimes of this kind also offers prospects of reducing any advantage large landholders might bring to such projects by way of economies of scale in undertaking abatement activities. It may be possible for smallholders in such regimes to realise significant economies of scale by pooling their land, labour and other resources in order to undertake larger projects in combination and provide greater opportunities for productivity-enhancing specialisation in the use of labour and other resources.

7.3. Participatory approaches to project design

Hanna (1995 pp. 60-61) argued as follows that the transaction costs of enforcing compliance with institutional change in resource-management contexts are affected by how the change occurs:

> Compliance with regulations increases and, hence, management costs decline when regulations are acceptable and considered legitimate by those whose interests are being regulated. To be legitimate, the content of a regulation, the process by which it is made, the way it is implemented, and the effects of its distribution must be perceived as fair by resource users. To be equitable, a resource management process must represent the range of user group interests and have a clear purposes and a transparent operation. In addition, an equitable process must address explicitly the distributional changes embedded in options under consideration.

In addition, she observed that the transaction costs of monitoring and enforcing regulations tend to be lessened to the extent that the regimes for doing so are well-matched to resource dynamics and resource-user operations.

A well-established strategy for increasing the legitimacy of regulatory interventions and for improving the fit of regulations with local biophysical and cultural circumstances is to encourage participation by resource users in the process of designing and implementing those interventions. However, while this strategy, if well-executed, can be expected to reduce the transaction costs of monitoring and enforcing the regulations emerging from a process of institutional intervention, it can also be expected to increase the transaction costs of reaching agreement on the regulatory program to be implemented. In other words, participatory processes of institutional intervention can be expected to reduce the *ex post* transaction costs at the expense of increasing the *ex ante* transaction costs. Hence it is important when comparing the cost-effectiveness of centralised, or top-down processes of institutional intervention with participatory, or community-based processes to account for the implications for both *ex ante* and *ex post* transaction costs.

However, adopting a participatory, community-based process affects *ex ante* transaction costs in the first instance, of course, and premature judgements drawn from these early effects led to the emergence of "[t]wo persistent myths … about community-based programs: that they cost more and that they take longer" (World Bank 1996 p. 247). Marsden *et al.* (1994 p. 154) observed similarly that "some argue that all these 'participatory processes' lead to over-complication, to stultifyingly slow progress and to decision-making processes which are so extended and non-directional that nothing appears to happen". In contrast, Shrybman (1986) argued that participative processes tend to avoid much of the cost and delay associated with administrative or judicial resolution of disputes that frequently accompany top-down implementation and enforcement of policies. Priscoli *et al.* (1986 p. 69) remarked in a similar vein "[o]ur experience is that consultation for complex and difficult decisions does not lengthen the process. In fact, the reverse may be true; consultation may prevent lengthy litigation and other delays".

As various authors in Agrawal and Gibson (2001) illustrate, however, community-participation programs must be designed deliberately to facilitate inclusive participation if they are truly to establish widespread local legitimacy. If rights to participate in designing projects and the rules for their implementation are simply granted to entities already capable of participating in one way or another, including local elites, it should come as no surprise if these rights are used to consolidate or further strengthen the positions of those entities. Rather than leading a greater share of community members to perceive project rules as fair, Singleton (2001 p. 142) predicts that "the substantive content [of the institutions emerging from community-participation programs] is likely to favor the powerful …, while shirking, foot-dragging, and other 'weapons of the weak' will be deployed by the less powerful in an effort to shape the process by which formal rules are deployed in local practice".

8. ORGANISATIONAL INITIATIVES FOR REDUCING TRANSACTION COSTS

In this section, we discuss the potential roles of various organisations (e.g., governments, non-government organisations (NGOs), international research organisations, etc.) in minimising transaction costs in the carbon market in general, and for smallholder forest-carbon projects in particular.[13] Although the discussion focuses on the structure (and proposed structure) of CDM, it is recognized that other mechanisms could be developed to operate a project-based carbon market.

Table 8 provides a summary of the categories of transaction costs incurred in designing and implementing carbon projects, and the types of organisations and their functions that could be established to minimize these costs in the carbon market.

8.1. Pre-implementation of project

Since those interested in the carbon market are not necessarily known to each other, a mechanism to link potential investors and project hosts was suggested early during the climate treaty negotiations. For example, a 'bulletin board' could act as a point of access to information about CDM/JI projects and financing opportunities where potential stakeholders could post and/or elaborate their project interests. This would help to reduce search and information costs for individuals and thereby reduce barriers to entry. Consequently, a greater

[13] It should be kept in mind that reducing transaction costs to the investor and host organisation by establishing new organisations is likely to increase the administrative costs of the overall system. The size of this trade-off has not been estimated.

Table 8. Potential roles of organisations in reducing transaction costs

Organisation(s)	Function
Search costs	
Information brokers, Project exchange-bulletin Board	Provide information on potential investors and project developers/hosts
NGOs, multilateral and national organisations	Disseminate knowledge on carbon markets, climate change etc.
Development projects	Provide information on the needs and priorities of large numbers of smallholders
Brokerage aid organisations, NGOs	Bring investors and project proponents together
Negotiation costs	
Financial intermediaries	Negotiate compensation of smallholders for modifying land use.
NGOs, Host government	Offer projects as investment instruments or bundle projects into portfolios, set the price investors pay for participation
Approval costs	
Approval authorities (national and international)	Determine whether project meets stipulated criteria and guidelines
Auditing body	Verify and certify the reduction
Administration costs	
Development projects, Aid organisations and NGOs	Coordinate carbon projects with development projects to reduce costs that do not directly relate to carbon sales such as supporting local capacity building
International-CDM Executive Board	Standardize and simplify procedures
Public and private intermediaries, consultants, universities, NGOs, aid organisations	Provide technical, legal, financial, social, environmental, management expertise in project design and development
International research organisations	Disseminate scientific knowledge on, for example, forest dynamics and carbon storage capacity and develop low-cost monitoring methods
Monitoring costs	
Community and centralized monitors	Monitor and report ongoing project performance
Enforcement costs	
Dispute settlement authority, NGOs	Mediation, conciliation and sanctions
Insurance costs	
Insurer (3rd party)	Safeguard the reduction and assume responsibility for failed projects

number of both hosts and investors may enter the market, particularly those interested in small projects where search and information would constitute a larger percentage of their total costs (Wexler *et al.* 1994).

Organisations could also be established (or existing ones used) to seek out and facilitate matches between potential investors and project hosts. International organisations, development agencies and NGOs are potential candidates for this activity. This would reduce search costs to individuals and open the market to a wider class of entities for which participation would not have been cost-effective if these costs were borne individually (Wexler *et al.* 1994).

An example of this is an 'on-line information board' called CDM Marketplace.com.[14] It allows emitters, project sponsors and developers, host country partners, investors and the CDM services industry to work together on CDM projects and access to information on project management, financial due diligence, verification, certification, corporate finance, insurance trading, tax and legal support.

8.2. Standardisation and simplification of procedures

At the international level there are still many uncertainties regarding the design and governance of the CDM. Nevertheless, it has become clearly apparent that there is a need for a simpler design and a standardization of procedures. The project-basis transactions currently in place significantly raise the transaction cost of investment in CDM-type projects as compared to the cost of mitigation through other means.

The project-by-project approach has presented project developers with considerable transaction costs for design, preparation, and defence of baselines. This is partly due to the unpredictable and inconsistent outcomes, and investor gaming that has taken place (Lazarus *et al.* 2001). Standardization of baselines has been advocated as a means to both decrease transaction costs and increase predictability. A multi-project approach has been proposed to create consistent benchmarks or algorithms that can be applied to broad categories of projects, thereby greatly reducing the scope and need for project-specific analysis (Lazarus *et al.* 2001).

However, a major challenge with multi-project baselines is how to aggregate across geographical areas and project types and determine a corresponding baseline value or method. The grouping should be broad enough to encompass many CDM projects and reduce transaction costs, but not so broad that baseline accuracy is compromised, excessive credits are awarded, or significant investment opportunities are lost (Lazarus *et al.* 2001).

Monitoring and verification protocols also need to be standardized to reduce the variability in data collection and reporting methodologies. This would enable more reliable information to be collected for international reviews as well as enhancing the value of the information for learning purposes (Wexler *et al.* 1994).

[14] The on-line service is currently operated by Arthur Andersen, JLT Risk Solutions, DNV, Credit Lyonnais and SGS

8.3. Centralisation of technical expertise

To date, individual participants (project developers/managers) have designed carbon projects to meet the necessary requirements. Evaluations of technical, economic, legal and political aspects of the project have been carried out 'in house' or through the hiring of consultants (see Appendix 1).

Costs could be reduced by centralizing technical, legal and economic expertise in one or more organisations in order to assist potential project developers in formulating JI/CDM projects. Several existing organisations could execute some or all of the project development functions. Examples include private companies, national research and development laboratories, universities and private brokerage houses (Wexler *et al.* 1994).

Project bundling, as discussed in section 7, also offers efficiencies in terms of technical expertise. Intermediaries are already in the international market. In the case of the Scolel Te Carbon sequestration project, a local trust manages the carbon produced on individual farms and sells it to international investors. Trexler and Associates are developing standardized portfolios of both energy and forestry carbon projects. They offer companies pre-screened and high-quality mitigation activities, while minimizing the transaction costs common in such projects.

The World Bank's prototype carbon fund (PCF) is acting as a financial intermediary as well as performing a number of other project functions. They fund projects that meet the requirements of the UNFCCC for the purposes of the Kyoto Protocol. Independent experts are hired to provide baseline validation and verification/certification procedures for emissions reductions in accordance with the developing UNFCCC rules. PCF resources are provided by both the public and private sectors. The portfolio includes about 11 JI and CDM-type projects from both economies in transition and developing countries. To date, most of the projects are concerned with renewable energy and energy efficiency.

The PCF has tended to purchase emission reductions directly from the projects. However, it works also through some established intermediaries, such as local or regional energy investment funds, energy service companies, commercial banks, and others to aggregate smaller projects and build capacity for smaller economies to supply competitively priced emission reductions.

The pre-implementation phase of the PCF consists of 20 steps and require about 70 weeks to implement. The PCF reduces the transaction costs for the investor and host organisations by carrying out most of the required assessments 'in house'. However, it is unclear whether the PCF procedures would actually reduce the overall transaction costs, especially based on World Bank rates estimated at $10,000 per week. Pre-implementation costs for each project are estimated at between $100,000-$200,000 (PCF 2000). The PCF pre-implementation phase provides a standard set of procedures. The detailed process is meant to ensure that the project has a high probability of success and will meet CDM requirements (see Appendix 2).

The World Bank has also created the PCF*plus* program to supplement the PCF. The objectives of the program are to build capacity of host countries and the PCF participants through outreach, research, and training activities as well as enhance the operations and activities of the PCF and its partners, and reduce risks and transaction costs. Further details of

the program can be found at
http://www.prototypecarbonfund.org/router.cfm?show=/html/pcfplus.htm&Item=15

Transaction costs can also be reduced through the establishment of national organisations to identify, review, register and administer CDM and JI projects. These organisations can provide information on project requirements, methods and the like. A number of national organisations already exist, one of the more successful being the Costa Rica AIJ office, which has been able to attract and support a large number of project-development activities as well as been an effective point of contact for potential investors.

8.4. Implementation of projects

Working with existing development projects and or development workers is likely to lower abatement and transaction costs, as well as the risk of leakage. The Scolel Te project, for example, was implemented by researchers and farmers who had a long history of partnership in jointly implementing and developing projects (Smith and Scherr 2002).

8.5. Periodic Monitoring

Uncertainty over monitoring procedures at the international level has added to the level of transaction costs incurred in monitoring. Community monitoring systems together with organisations to centralize monitoring information have been proposed as options to provide timely information on project developments, retain credibility of the system, and develop community and institutional expertise.

The Plan Vivo system is considered a cost-effective system for managing the supply of carbon services from small-scale farmers and rural communities and promoting sustainable rural livelihoods. The technical and administrative framework for monitoring and registering carbon offsets is built around the principles of flexibility, simplicity, verifiability and transparency. To reduce the risk of carbon offsets losses, processes have been incorporated to ensure accurate recordings of carbon offsets and increase the likelihood of activities being maintained in the long term. According to an SGS report (2001)[15], "the Plan Vivo System has great potential for use in developing CDM compliant projects". The system has been implemented by the Fondo BioClimatico in the Scolel Te project in Mexico and the Women for Sustainable Development in India.

The internal verifier (or host) in this system performs functions in addition to monitoring carbon offsets. The host also acts as an intermediary between the producer and the investor/purchaser of carbon. Their responsibilities include registering the carbon offset activities, providing technical support to producers and administering the sale of the carbon offsets.

To prepare for independent verification of projects, host organisations are required to provide evidence to support their carbon offset calculations of registered producers. Technical specifications of carbon offset activities should describe management requirements necessary to achieve a stated carbon offset. The activities must also be shown to be socially and

[15] The report is available at (http://www.eccm.uk.com/climafor/verification.html).

economically viable in the long term to ensure a flow of carbon and livelihood benefits. In addition, documentation is required for monitoring and evaluation of carbon offset activities.

The Fondo BioClimatico systems and procedures cover most of the requirements of the Plan Vivo System, but they are not yet cost-effectively implemented. Lack of written documentation, clear decision making and mutual agreement on details for baseline setting have increased transaction costs at the local level

8.6. Enforcement

Ensuring trees remain on the land for the duration of the projects is one of the greatest difficulties facing forestry-based projects. Scolel Te has attempted to instill a forestry culture into stable rural communities, whilst Profafor has enforced legally-binding contracts with heavy fines for land conversion, early and clear cutting. From these case studies it is evident that project enforcement costs may be high in the future unless communities and smallholders understand the long-term benefits in remaining in the project and are provided with adequate incentives. Project developers could reduce these enforcements costs in a number of ways, including:

- invest in community participation and capacity building at the beginning of the project;
- involve community groups in decisions on project design;
- share the payments for carbon services;and
- use funds derived from the project to finance activities that enable local people to increase their well being as well as support the sequestration of carbon;

Effective involvement of local communities in the project cycle reduces risks not only for local communities but also for investors. Local benefits are likely to reduce the risk of forfeiting carbon payments because of project failure.

8.7. Verification and Certification

To ensure credibility and confidence in the system, it has become widely accepted that verifiers and certifiers of projects should be third parties. These could be national governments, universities, nongovernmental organisations, consultants, or multilateral organisations familiar with conditions in the host countries (Wexler *et al.* 1994). To develop such a system there are three requirements: (i) a published standard; (ii) an accreditation body (one that "certifies the certifiers"); and (iii) certification agencies accredited to use the standard (Moura-Costa *et al*. 2000).

8.8. Insurance

Project participants need to be insured in case of failure of the projects to meet the emission reduction targets. All partners in forest carbon projects face the risk of re-emissions during the lifetime of the project due to natural hazards. Investors face the additional threat of producers converting their land to other uses.

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. For the producers, however, no compensation or insurance is provided. In the event of fire, producers must submit a report to the project manager, to demonstrate that the fire was not their fault. The transaction costs for producers are therefore potentially high.

Although operating a centralized insurance institution would entail administrative costs, costs to individual projects might be lower. If all projects participate with the same insurer, costs could be reduced because risk would be shared, and because individual projects would not need to set aside funds to cover their full risk. Using a third-party insurer is not, however, without risk. The agent ultimately could prove unreliable, for instance by failing to keep adequate reserves or properly evaluate risks (Wexler *et al.* 1994).

9. SUMMARY AND CONCLUSIONS

This paper was motivated by opportunities in some developing countries for emerging markets for carbon sequestration services to help solve their problems with poverty, as well as the deforestation that often arises from these problems. However, capitalising on these opportunities requires that participation in these markets extends to the smallholders among which poverty is most likely to be found.

Concerns have been raised that smallholders will tend to be uncompetitive sellers in carbon markets. These concerns have focussed largely on the supposed disadvantages smallholders face vis-à-vis plantations in respect of the transaction costs of engaging them successfully in these markets. Accordingly, the primary emphasis in this paper was on exploring the validity of these concerns. Nevertheless, some of the reasons for suspecting smallholders might be uncompetitive in terms of transaction costs suggest that they may be uncompetitive too in terms of the costs of producing carbon sequestration services *per se* (i.e., abatement costs). Hence, the likelihood of smallholders being generally less competitive than plantations in terms of abatement costs was also considered in the paper.

If smallholders under current circumstances are indeed likely to be uncompetitive suppliers to carbon markets, due to disadvantages in terms of transaction costs, abatement costs or both, then obviously it is important to discover this before seeking to promote their participation in these markets as a way of reducing their exposure to poverty. The more that is known about such disadvantages, if they exist, the better will policy makers in host nations and international agencies be equipped to modify smallholders' circumstances so as to neutralise the disadvantages, including through institutional innovation. Even if it is not possible for carbon markets to provide poverty-alleviation benefits as a free by-product, piggy-backing on carbon markets to provide such benefits may in some settings be more cost-effective than pursuing other strategies.

Some features of carbon markets indeed seem conducive to smallholder participation. Firstly, market exchanges of carbon sequestration services do not entail transport of those services. Given that smallholders typically reside in areas remote from commercial centres, transaction costs associated with transport often reduce significantly their ability to compete in national or international markets. Secondly, carbon sequestration is a service without scope for quality differences, so the relatively high production costs (abatement costs in this case) often faced by smallholders in meeting national or international quality standards do not arise in this arena.

In this paper the focus is on agroforestry and tree plantations in developing countries. A simple economic model is developed and the process of estimating abatement costs is illustrated. A case study with four Indonesian agroforestry systems is used to show that some smallholder systems have an advantage, in terms of lower abatement costs, over a large-scale (oil palm) plantation.

Nevertheless, other potential obstacles to smallholder competitiveness in carbon markets have been identified. Perhaps the most significant of these relates to the fixed transaction costs of designing and implementing contracts for individual carbon sequestration projects. As highlighted in the paper, participation in the market for carbon sequestration services entails a unique set of types of transaction costs, including those relating to establishing additionality and permanence, preventing leakage, and measuring carbon stocks within project sites. The larger are the fixed costs associated with these and other aspects of contracting, the less competitive will it be to contract with a larger number of smallholders compared with a lesser number of plantations.

The problem of permanence is addressed in the paper in two ways. Initially, a long-term project (70 years) is assumed, and economic and financial analyses are undertaken from the standpoint of both the host country and the landholder. This analysis yields estimates of the cost of sequestering carbon in any given agroforestry system and allows ranking of projects on profit, or cost-effectiveness, grounds. Recognising the difficulty of implementing such a long project in the real world, where policies and governments change often, the analysis then turns to carbon accounting methods. In this second analysis, the price of carbon is exogenously determined and landholders receive annual payments based on the amount of carbon they sequester on their land. Payments are given by the investor based on either an ‘ideal’ or a ton-year accounting system.

In the ideal accounting system, flows of carbon between trees and the atmosphere result in either a debit or a credit to the smallholder, depending on whether CO_2 is released or sequestered by trees. This means that any carbon-sequestration credits received during the project must be redeemed upon harvest, or when the project ends, whatever occurs first.

The ton-year accounting system is based on the decay rate of CO_2 in the atmosphere and requires that each unit of carbon sequestered be kept a minimum of 46 years to receive a credit that is equivalent to a permanent emission reduction. The appeal of this method is that no liability results if the forest is destroyed (i.e. by fire or early harvest), so insurance and contracting costs will be lower than under the ideal system. The problem with the ton-year method, however, is that the payments are not sufficient to provide incentives to landholders to plant trees. This is shown in the paper for the four Indonesian systems.

A modified version of the ton-year approach is proposed, one that results in the same cost to the investor as the ideal system, but that eliminates the need to redeem credits at the end of the project, and does provide an incentive to plant trees. Comparison of the discounted cash flows of the ideal and modified ton-year systems provides valuable insights, but there is still much room for further economic analysis of carbon accounting methods.

Regarding transaction costs, it was not possible to obtain quantitative estimates for the Indonesian case studies. However, a survey of five existing projects in Latin America provided valuable insights into the nature of transaction costs in carbon-sequestration projects, as well as good ideas to reduce these costs.

In particular, it was observed in the paper that disadvantages of contracting with smallholders in exploiting economies of scale might be reduced by contracting with smallholders in groups, namely as common-property regimes, rather than as individuals. While such a strategy seems to offer considerable potential for increasing participation by smallholders in carbon markets, and thus helping to address their problems with poverty, it is important to recognise that it will work only in so far as the savings in the transaction costs of contracting with smallholders exceed any increase in transaction costs this strategy entails for smallholders themselves. Transaction costs incurred by smallholders would be greater under this strategy than under a strategy of contracting with them individually, because now they need to expend additional time and resources ensuring that they cooperate successfully with one another in negotiating and complying with the terms of their group contract. These additional costs will be less to the extent that the smallholders have already developed capacities for collective action of this kind, and thus the strategy will work more successfully with some groups of smallholders than others.

Nevertheless, it is possible to develop these capacities where they are lacking. Doing so represents an investment activity with its own transaction costs that need to be considered in assessing whether to proceed with the attempt. Facilitating inclusive participation by smallholders in the process of designing and implementing the group contracts is now a widely-recognised way of strengthening their capacities (i.e., 'empowering' them) to act collectively. Whilst such efforts can be expected to increase the *ex ante* transaction costs of putting group contracts in place, they can also be expected to reduce the *ex post* transaction costs of gaining group members' compliance with these contracts. Where the latter effect is likely to outweigh the former, then these efforts can be economically justified. The challenge of actually achieving inclusive participation by, and empowerment of, smallholders should not be under-estimated, however. Many efforts of this kind fail to recognise and address existing power differences within a group that exclude some members from effective participation, and thus tend only to further consolidate their disempowerment and lack of commitment to group decisions.

Aside from the disadvantages of contracting with smallholders vis-à-vis plantations in terms of fixed costs and economies of scale, there are other factors to consider in assessing whether smallholders, as individuals or in groups, will be able to supply competitively to markets for carbon sequestration services. A further disadvantage for smallholders may lie in their typically greater distance from the towns or cities where those acting on behalf of purchasers of these services are likely to be based — and thus the increased transaction costs of communication and transport that will be required. Other disadvantages faced by smallholders may derive from their typically wide geographical dispersion. This dispersion can also increase the transaction costs of communicating with and travelling to smallholders in the process of designing and ensuring implementation of contracts. Moreover, it can increase the transaction costs of smallholders acting cohesively in negotiating and implementing group contracts, as well as reduce the scope under such contracts for smallholders to share agroforestry inputs in order to exploit economies of scale in sequestering carbon.

In addition to these disadvantages faced by smallholders, there are reasons to suspect they might have some cost advantages over plantations in sequestering carbon through agroforestry projects. To the extent that plantations are normally located on more productive lands that are closer to markets, the opportunity costs of the land they would devote to agroforestry will tend to exceed those of the land smallholders would use. The opportunity costs of the labour that plantations would utilise in agroforestry projects can also be expected to exceed the opportunity costs of labour for smallholders, since the closer proximity of plantation labour to towns makes it more likely to be in demand for other profitable uses and also more likely to have benefited from schooling and other education opportunities. The subsistence pressures on poor smallholders to devote their land and labour to food production might nevertheless lessen their willingness to reallocate some of these resources to agroforestry. This constraint to smallholders participating in carbon markets might be weakened if they were able to undertake agroforestry projects cooperatively on communal lands, thereby allowing their subsistence activities to proceed fairly normally.

It might also be suspected that in many situations the political transaction costs of contracting with smallholders will be less than for contracting with plantations. This will be true to the extent that the history and greater wealth of plantations bestows upon them greater political power that can be exploited to fashion opportunistically the design and actual execution of contracts as far as possible in line with their private interests.

When all the above factors affecting the competitiveness of smallholders vis-à-vis plantations in supplying carbon sequestration services to international markets are considered together, it becomes evident that it is not possible to conclude that smallholders will always be less competitive, as has tended to be the case in previous literature, nor that they invariably will be more competitive. Rather, the competitiveness of smallholders in particular contexts needs to be determined case by case. Where they are found to be uncompetitive given existing circumstances, innovative institutional arrangements including participatory community-based management of carbon sequestration projects might be explored as a means of enhancing competitiveness and improving the prospects of international carbon markets contributing towards poverty alleviation.

The paper concludes with a discussion of organisational initiatives that may reduce transaction costs at the project level, at the expense of increasing the administrative costs of the overall (international) system, particularly in terms of *ex-ante* transaction costs. There is still much room for debate regarding which of these organisations are desirable and likely to be efficient as compared to a system of bilateral project agreements.

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11. APPENDIX 1: SELECTED AIJ PROJECTS

AIJ (Activities Implemented Jointly) projects were designed as pilot projects to provide lessons for future carbon projects. As a result they have incurred high learning costs, particularly as the CDM rules are still uncertain. As the carbon market develops, more operational entities are likely to enter, resulting in reduced transaction costs for individual projects.

Table A.1 presents a summary of selected AIJ projects relevant to our analysis. These projects were selected because they include reforestation and afforestation activities, deal (or plan to deal) with large numbers of landholders and have made enough information available to allow us to form at least a partial picture. There is a great deal of variation in the way costs are reported and in the types of costs reported (although they include some transaction costs, e.g. of external monitoring, as well as abatement costs). So it is not possible to provide a detailed breakdown of costs for the general case; however, these case studies provide valuable information and ideas for project design. Continuing analysis as these projects evolve will provide further insights. More details on these and other projects are reported in Milne (2002).

Table A.1. A selection of AIJ reforestation projects

	Profafor	Scolel Té	Klinki	SIF	Virilla
Country	Ecuador[a]	Mexico	Costa Rica	Chile	Costa Rica
Land Type	Andean highlands (>2800m)	Highland and lowland tropical communities	Pastures and marginal farmland	Pastures and marginal farmland	Pastures
Duration (yr)	25	30	25	51	25
Target area (ha)	75,000	2,000	6,000	7,000	1,000
Area planted	22,500	500	48	na	131
CO_2 sequestered (kt)	35,000	1,210	7,216	1,414	847
Carbon, total (kt)	9,537	330	1,966	385	231
Carbon per year (t/ha/yr)	5.09	5.50	7.12	1.08	9.23
Project cost ($1,000)	8,810	3,681	10,703	20,600	3,395
Annual cost ($/ha/yr)	4.70	61.35	38.78	57.70	135.81
Carbon cost ($/t C)	0.92	11.16	5.44	53.47	14.71
Sources	a, b, c	d, e	f, g	h	i

Sources: (a) Verweij & Emmer (1998); (b) Milne *et al* (2001); (c) FACE (2001); (d) UNFCCC (1997); (e) Hellier pers. com. (2002); (f) UNFCCC (1998); (g) Barres pers. com. (2002); (h) UNFCCC (2001); (i) UNFCCC (2000).

It should be stressed that these were estimates, based on expected funding and are largely based on reports submitted by the projects to the UNFCCC. In the case of Klinki, the project did not receive the USIJI approved $10.7 million. Instead, it received only about $100,000 in donations. Profafor began by setting annual planting targets but, under new management in 2000, they focused on sustainable forest management to increase the likelihood of trees remaining in the ground for the duration of the project. To date, they have planted 22,500 ha which is less than half of the initial target of 5,000 ha/yr (the project is now ten years old). Scolel Te and Profafor now make contracts with farmers for 100 years, and their carbon sequestration estimates may need to be re-assessed.

The bilateral arrangements, under the current AIJ structure, significantly raise the pre-implementation transaction costs of forest carbon projects. In particular, the project-by-project approach has presented project developers with considerable transaction costs for the design of the project, feasibility studies, establishment of monitoring systems, and defence of baselines.

In the implementation phase, a number of the AIJ projects have suffered from lack of funding. Since the CDM is not yet operational and there is still great uncertainty over issues such as permanence, leakage and baselines regarding LULUCF projects, few investors have been willing to make long-term investments in forest carbon projects. Due to lack of donations, the Klinki project has significantly reduced its size of plantings and has instead had to increase its search costs for US funding.

On the other hand, the costs incurred by projects in searching for landholders to participate in the project have reduced over time. In the case of Profafor and Scolel Te, word of mouth and the successful establishment of project plantations on nearby lands, has led to interested farmers approaching the project managers.

In terms of negotiation and enforcement costs, most project managers have made legally binding contracts with the farmers, stipulating the amount of project payments and conditions of payments. Most of the projects are still in a plantation-establishment phase where farmers continue to receive project payments and technical assistance, so enforcement of contract conditions has not been necessary.

Monitoring costs are expected to be high in the initial establishment of measurement plots and then fall overtime. In the case of Profafor, they have made an initially high investment in a remote sensing monitoring system that is expected to reduce future monitoring costs, especially in terms of the number of site visits to isolated communities. Scolel Te has also invested heavily in setting up its monitoring systems, but in terms of local capacity building rather than technology. Its emphasis on building the project from the 'bottom-up' is hoped to reduce the risk of project failure and enforcement costs later on. The Klinki forestry program is also working closely with farmers and hopes that this high initial investment of their time in establishing the plantations will maximise the carbon sequestered.

Although the CDM market is still not operational, both Scolel Te and Profafor are selling carbon offsets. Scolel Te is buying and selling Verifiable Emission Reductions (VERs) and Profafor has had their carbon offsets certified by a third party for sale to the FACE Foundation. The project implementation costs of the Scolel Te project are now funded by the sale of the VERs ($4/tC).

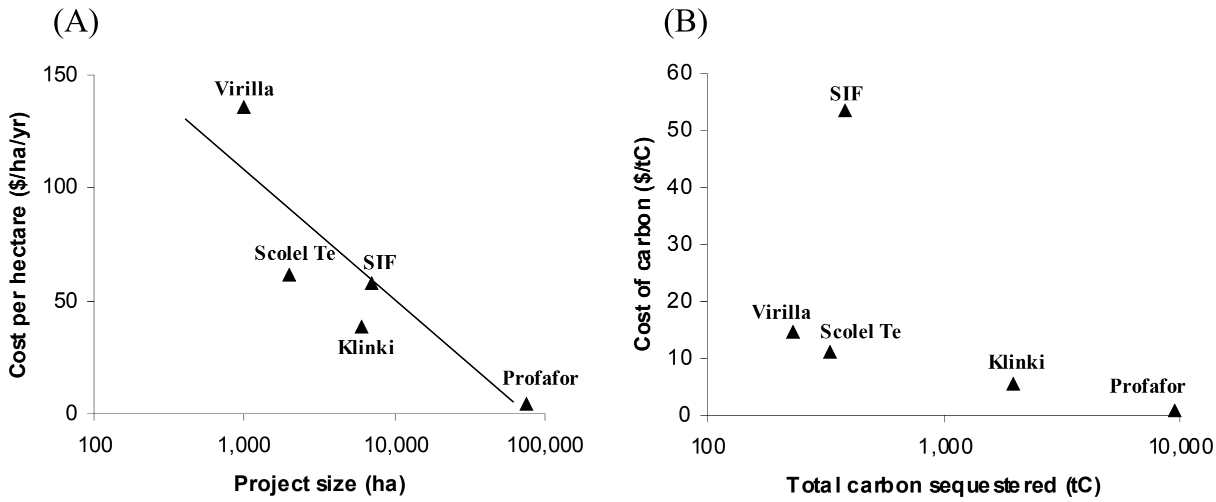

Figure A1. Annual costs per hectare (A) and costs of carbon sequestration (B) for a selection of five AIJ projects. Note the logarithmic scale in the horizontal axis

Since most of the AIJ projects are financed, designed and developed by Annex 1 country partners, the pre-implementation costs are borne predominantly by the Annex 1 country. As the projects develop and the capacity of host country partners increases, such as in Costa Rica, the share of transaction costs incurred by the host country is also likely to increase. In addition, as national climate-change offices develop in host countries and the CDM market and rules become more certain, we may see more carbon projects developed by host countries. In the future, pre-implementation and implementation transaction costs may be significant for host countries, as in the case of the Virilla Basin project, which falls under the Costa Rican Forest Environmental Services Program.

Projects in this sample (Table A1) cover areas ranging from 1,000 ha to 75,000 ha, with annual costs ranging between \$4.70/ha to \$135.81/ha. Costs of carbon sequestration range between \$0.92/tC and \$53.47/tC. Carbon sequestration costs were estimated by dividing total project costs by total carbon sequestered, so they assume that carbon will be stored in perpetuity and do not account for the timing of sequestration.

If there are economies of scale, we would expect cost per hectare to decrease as project size increases. This trend can be observed with the five projects presented in Figure A.1 (A). Also, if carbon monitoring costs are an important component of total cost, and if they have a high fixed-cost component, then we would expect a negative correlation between the amount of carbon sequestered and the costs per ton of carbon. This trend is observed for four of the five projects (Figure A1(B)). The SIF project has much higher costs per ton of carbon and it would not be competitive in a carbon-credit market. These data are from reports submitted voluntarily to UNFCCC and the numbers are not independently verified. Also, the sample is too small to draw any definite conclusions. Although the trends are interesting, as indicated by the slope of the line in Figure A1(A), we cannot tell whether the economies of scale are in monitoring or other activities.More details on each project are presented in the following sections.

11.1. Profafor

Background

Profafor began in Ecuador in June 1993, supported and funded by the FACE Foundation and the Ecuadorian Ministry of Environment[16]. FACE, through the resident engineer at Profafor, directly acquires the exclusive right to sequester and offset CO_2 by means of afforestation and/or reforestation carried out by the local landholders. The project supports the Ministry of Environment's Forest Plan in the Andean region.

At the start of the project, Profafor aimed to reforest 75 000 ha in the Andean region (*páramo*)[17] with exotics and native species, at a rate of 5000 ha per year. The project drew up 15- to 20-year contracts with rural indigenous and *mestizo* (mixed Indian and Spanish) communities as well as private landowners to lease at least 50 ha of their land for plantations. Profafor's new management has become more focused on growing indigenous species and promoting the environmental and intergenerational benefits of plantations. As a result, an increasing number of participants are growing a combination of exotic and native species. In 2000, the project decided to make new contracts for 99 years, in an attempt to increase the duration of the carbon sequestered. To date, Profafor has implemented around 162 contracts (Milne *et al* 2001).

In the case of community contracts, the project negotiates directly with Community Boards to lease communal land for establishing plantations. No contracts have been established with individuals within a community. Many communities have selected areas with low opportunity cost, these being steep slopes and degraded sites. Others have planted on former grazing land (Milne *et al* 2001).

Project Activities

Potential producers (beneficiaries) are expected to submit the following documentation to Profafor:

- Profafor application form signed by the necessary authorities;
- the deed accrediting ownership of land;
- a current certificate from the property registry showing ownership of 15 years; and
- a map or drawing of the area to be reforested.

[16] Formerly the Ecuadorian Institute for Forestry and Natural Areas (INEFAN).
[17] The high altitude lands of the páramo are found at elevations of 2,800 to 4,800 metres, composed principally of native grasses and a few low shrubs and trees.

Beneficiaries are expected to register their plantations with the Land Registrar and prepare progress reports, aided by the project forest engineers, in order to receive establishment payments from the project.

The project provides establishment and maintenance subsidies and technical assistance for the first three years of the project. In return, the beneficiaries are obligated to maintain the plantations under a selective cutting regime. However, some community groups have requested more meetings with the Project and information on forest management, production of mushrooms and marketing of timber. The project beneficiaries are entitled to all the revenues from firewood, pulpwood and timber and non-timber products from the plantation but they will not earn revenues from the trading of carbon offsets. FACE will receive 100 per cent of the certified emission reductions (CERs).

Profafor has hired and trained forest engineers to manage the project monitoring, nurseries, and plantation contracts in the Sierra and coastal regions. Their primary responsibilities are to:

- prepare visits and evaluate potential beneficiary sites for Profafor forestation contracts;
- qualify and measure the designated forestation area by Global Position System (GPS);
- identify suitable species depending on site conditions;
- assess and develop Forestation and Management Plans for beneficiaries supported by Profafor;
- distribute funds to beneficiaries;
- provide technical assistance for each contract regarding plantation establishment and maintenance;
- supervise activities carried out by beneficiaries; and
- train tree nursery workers and monitor plant production in temporary and permanent nurseries that provide material for Profafor contracts.

Nurseries have been established and /or contracted to transport seedlings and other inputs to each beneficiary's site. So far, 24 private nurseries have been contracted.

Profafor has promotional staff who are in charge of contacting community organisations and potential beneficiaries. Information campaigns are organised to:

- explain what Profafor is, its goals, objectives and scope;
- outline economic, social and environmental benefits of joining Profafor;
- explain contract conditions, duties, timeframes; and
- provide assessment regarding the documents to be presented in order to be considered as beneficiaries.

Profafor has also hired local consultants to help implement social and environmental impact assessments to ensure the project will have positive or neutral social and environmental outcomes. The project has funded research on the possibilities for usage and methods of cultivation of native species and the best options for increasing the number of native species planted under the project.[18]

Contracts

Profafor has hired a team of legal advisors to help design the terms of the plantation and mortgage contracts. Some of these contract regulations are:

- Under 15- to 20-year contracts, the beneficiary is obligated to meet the cost of replanting if trees are felled before the end of the contracts.
- If beneficiaries decide to convert the plantation back to cattle farming or any other land use during the contract period, the project retains 30 per cent of the timber revenues.
- Beneficiaries may clear-cut after 20 years, but Profafor retains 30 per cent of the timber revenues. If the beneficiary decides to renew the contract, the 30 per cent is reinvested into replanting.

Under a 99-year contract, it is assumed that after 20 years some trees will be cut and replanting will occur. Beneficiaries are obliged to invest part of the income from timber in new plantings and in this way retain the capacity to absorb CO_2 for 99 years.

According to the contract agreement, in the event of fire in the plantation or other *force majeure* (hurricanes, frost, drought, volcanic eruptions, etc.) the beneficiary must submit a written report to the project to demonstrate

[18] *Proyecto de Investigaciones sobre la Ecologia de Páramos y Bosques Andinos,* (Ecopar), a project based in Quito, was contracted by Profafor to undertake the ecological studies.

that the fire was not their fault. The report should also be accompanied by reports from the Ministry of Environment and the Municipality, a Civil Defence report and if applicable, a legal document that provides evidence that a process of prosecution has started against known offenders. If the beneficiary can demonstrate that they were not guilty, an addendum is made to the contract, reducing the contact area to the plantation area remaining. Otherwise, the beneficiary must meet the costs. If the fire burns down the whole plantation, the contract is terminated and the lease removed. There is no compensation or insurance provided to the beneficiaries (Jara, personal communication).

Table A.2 Profafor project stakeholders and their roles

Stakeholders	Country	Function
FACE Foundation	Netherlands	Project investing entity, program coordinator
BV NEA[19]	Netherlands	Project financial backer/client until at least the end of December 2003.
Consultants	Netherlands	Site inspections with FACE of FACE projects
NEO	Netherlands	Working on improving remote sensing techniques with FACE
Forestry and Nature Research (IBN-DLO)	Netherlands	Establishing baseline and project scenarios (using CO2FIX model)
IFER	Czech Republic	Modification of the monitoring system MONIS and FieldMap, a ground-based system for plantation monitoring
SGS International	Netherlands	Verification and certification of CO_2 credits for all of FACE's projects
Business for Climate[20]	Netherlands	Buying and selling CO_2 credits from FACE's sustainable forestry projects.
Triodos Climate Clearing House	Netherlands	Trading certified CO_2 credits from FACE.
Utrecht Provincial Government and Private companies	Netherlands	Investors in carbon credits from FACE projects
UNFCCC	Multilateral	Registration of FACE projects for AIJ status
Ministry of Environment	Ecuador	Signing of Profafor Project MOU and registration of Project plantations
Profafor	Ecuador	Project implementation and management
Consultants-Economists and geographers	Ecuador	Working in Profafor's interdisciplinary team to carry out EIAs and and SIAs
Ecopar	Ecuador	Ecological studies
Community and private tree nurseries	Ecuador	Production and distribution of seedlings
Perez, Bustamante & Ponce (PBP)	Ecuador	Legal representation and advice
Price Waterhouse Co. (PWC)	Ecuador	Financial advice (budgetary administrative and accounting management)
Communities and individual landholders	Ecuador	Producers/beneficiaries (plantations over 25- 99 years)

The documents submitted to Profafor by potential beneficiaries are sent to the legal advisers who are responsible for negotiating financial arrangements and preparing the respective memo on the terms agreed to with the

[19] BV NEA is FACE's biggest client and legal successor to the Dutch Electricity Generation Board (Sep), the Foundation's instigator.
[20] The company was set up by FACE, Triodos Bank and Kegado.

beneficiary. The memo is sent to the Municipality Property Registrar to formalize the contract in the presence of Profafor and the beneficiary (Profafor 2002).

Project Stakeholders

Stakeholders in the Profafor project and their roles are listed in Table 11.2. Further information on the FACE Foundation and other organisations is presented below

FACE Foundation. The Dutch non-profit organisation, Forests Absorbing Carbon Dioxide Emission (FACE) Foundation, was established in 1990 to promote the sequestration of atmospheric carbon dioxide (CO_2) through afforestation and reforestation activities. The "climate-neutral" Foundation works independently and through third parties including timber companies, small farmers, and national parks (Arquiza 2000). FACE receives 100 per cent of the credits from their projects, of which Profafor, in Ecuador is currently the largest.

In all FACE projects, a monitoring and information system called MONIS has been set up to ultimately determine the amount of carbon sequestered. The system links alphanumeric and graphic information of the forestation contract sites, and allows for the entering of administrative, financial and technical information for each forestation plans, production of seedlings and technical assistance. The CO2FIX calculation model is used for establishing baseline and project scenarios. The project partners collaborate with national and international research institutes to acquire the necessary measurements (FACE 2001).

FACE requires its project partners to report on the planting and maintenance of the forests, as evidence to financial backers that the intended amount of CO_2 has been sequestered. The contract stipulates that the project partner is obliged to provide regular and accurate reports of planned and executed activities. During the planting phase, the party implementing the project must provide half-yearly reports on activities carried out, in terms of quantity, quality and financial aspects. FACE officials, external forestry consultants and financial experts, visit each project at least twice a year, to inspect and discuss its progress. Further inspections take place upon the conclusion of each three-year planting phase.

Société Générale de Surveillance (SGS) International. In 1999, FACE commissioned SGS International to verify and certify the CERs and sustainable forest management of all its projects. To reduce costs, FACE applied to the Forest Steward Council (FSC) for a group certificate. Under the scheme, the certifying authority assesses the circumstances, background and criteria of the plantations, testing them in a number of the contracted sites. The subsequent checks and assessments can then be conducted on a random basis.

Tridos Climate Clearing House. Tridos Bank is the founder of the Tridos Climate Clearing House, a climate fund which purchases certified stored CO_2 from FACE and sells a percentage to interested companies. Tridos Bank has offices in the Netherlands, Belgium and the UK and finances projects demonstrating a green or social nature, describing itself as one of Europe's 'leading ethical banks'. It claims to have a proactive policy with regard to development, not only of sources of sustainable energy, but also of organic farming, culture, wildlife and nature conservation (IEA 2001).

11.2. Scolel Te Carbon sequestration project

The Scolel Te forestry and land-use pilot project is situated in Chiapas, southern Mexico, covering two distinct bio-climatic and cultural regions: highland Mayan Tojolobal communities and lowland Mayan Tzeltal communities (http://www.eccm.uk.com/scolelte). The major farming systems include coffee maize and cattle. In 2000, the project was working with 370 farmers in 15 villages, over an area of about 352 hectares. The project aims to forest 2000 hectares over 27 years with *Pinus oocarpa*, *Pinus michoacan, Cupressus sp*., *Cedrela ororat, Caloophylum brasiliense,* and *Cordio alliodora*.

The project steakeholders are detailed in Table A.3. The project was set up by the University of Edinburgh's Institute of Ecology and Resource Management and the Edinburgh Centre for Carbon Management (ECCM) in the United Kingdom, *El Colegio de la Frontera Sur* and Ambio in Mexico. It began as a DFID Forest Research program funded research project to assess whether carbon trading could work at the farmer/community level. The main objective was to develop a prototype scheme for managing the supply of carbon services from sustainable forest and agricultural systems. In its second phase, the model has been scaled up to a regional level. EECM has actively marketed the project to leverage funds from public and private sources within the UK and from multinationals. The Fondo BioClimatico has also begun marketing the emission reductions (Hellier, pers. com.)

Table A.3 Scolel Te project stakeholders and their roles

Stakeholders	Country	Function
UK DFID Forestry Research Program	UK	Major funding institution for project methods development
International Energy Agency	England	Research funding for large scale sequestration potential
UK Darwin Initiative	UK	Funding for research into biodiversity benefits of project
Commission for Environmental Cooperation	Multilateral	Funding to assist with USIJI application
FIA and FIPIC	Belgium/France	Purchaser of CO_2 credits
Future Forests	UK	Reseller of Voluntary Emission Reductions
Unit for International Cooperation and Agreement, National Institute of Ecology (INE)	Mexico	Signing of Project MOU Research funding
UNFCCC	Multilateral	Registration of project for AIJ status
El Colegio de la Frontera Sur (ECOSUR)	Mexico	Research on CO_2 sequestration potential and baseline calculations, technical support
The Edinburgh Centre for Carbon Management (ECCM)	Scotland	Project design and development. Seeking investment funds
Ambio	Mexico	Project implementation and administration. Advice and technical support to farmers and communities
Fondo BioClimatico (registered trust fund)	Mexico	Registering viable management plans. Financial and technical assistance to farmers. Marketing of Voluntary Emission Reductions.
Farmer representatives		Intermediaries between the *Fondo BioClimatico* and farmers' groups.
Farmers' Associations and Organisations	Mexico	Network contact points with farmers and communities. (Includes *Union de Credito Pajal*, CODESMAC and UREAFA)
Community technicians	Mexico	Trained by FBC staff to extend technical support and assist with monitoring activities.
Local farmers/communities	Mexico	Providers of the environmental service, monitoring and reporting
SGS		Independent review of project management systems

ECOSUR, ECCM and Ambio have been the principal researchers for the project, directly involved in monitoring the carbon sequestration and socio-economic impacts of the project. Complementary research activities have been carried out alongside the Pilot project, related to the feasibility of large-scale carbon sequestration programs. These include studies on:

- carbon fluxes associated with land use change, involving direct measurement of biomass in different types of vegetation (funded by the US EPA and the Mexican Government);
- research and development of appropriate protocols for community forestry planning and administration of carbon sequestration schemes (funded by DFID's Forestry Research Programme);
- the cost and potential for large-scale carbon sequestration in southern Mexico, using economic models and geographic information such as satellite images (funded by the International Energy Agency - Greenhouse Gas R&D Programme) (http://www.eccm.uk.com/scolelte/).
- Regional carbon baselines for land use change through an GIS based analysis of predisposing and driving factors affecting deforestation (funded by DFID's Forestry Research Programme);

- Development of transparent carbon accounting protocols for use in projects involving many small-scale participants (Hellier, pers. com.)

In implementing the project ECCM has been responsible for providing technical support to Ambio, a Mexican environmental consultancy company responsible for day-to-day management of the project. Ambio works with various farmers' organisations including the *Union de Credito Pajal*, CODESMAC and UREAFA. Capacity building of local counterparts — Ambio staff, social advisors, farmer representatives/lead farmers and individual farmers — has taken place through workshops.

The project forestry activities are planned and undertaken by groups and communities of small farmers affiliated to local organisations such as the *Unión de Crédito Pajal*. They identify reforestation, agroforestry and forest restoration activities that are both financially beneficial and intended to sequester or conserve carbon. Ambio helps farmers to draw up work plans, called *Planes Vivos,* to reflect the farmers' needs, priorities and capabilities. These are assessed for technical feasibility, social and environmental impact and carbon sequestration potential. Viable plans are registered with *Fondo BioClimatico* and are eligible for financial and technical assistance (http://www.eccm.uk.com/scolelte/).

A farmer's holding averages about five hectares but only one to two hectares is put under the project. Payments are made to the farmers on the basis of carbon sales through the Fondo BioClimatico. In the normal course of events, payments are made to farmers in the first three years and in years five and 10 (Hellier, pers. com.). Most of the plans are established with individual farmers but the *Fondo BioClimatico* is now working with three communities on afforestation and forest management activities on communal lands (Hellier, pers. com.)

The *Plan Vivo* System is implemented at the local level whereby local organisations and farmers plan, manage and monitor the carbon sequestration activities. The system, developed and tested through the Project, was subjected to a trial verification by SGS in December 2001 (http://www.eccm.uk.com/climafor/verification.html). According to the SGS report the *Fondo BioClimatico* has successfully established a number of forestry and agroforestry systems with farmers and rural communities. The *Fondo BioClimatico* systems and procedures were found to meet most of the requirements of the *Plan Vivo* System, but further work is required to make them cost-effective for independent verification.

The Project is selling Voluntary Emission Reductions (VERs) through the *Fondo BioClimatico*, managed by the local NGO, Ambio (http://www.fao.org/docrep/003/y0900e/y0900e06.htm). The average cost of carbon sequestration within the project is currently estimated at around $13/tC, and the credits are currently available at this price (Hellier, pers. com.).

11.3. Klinki Forest Project

The Klinki project in Costa Rica was developed by Reforest The Tropics, Inc. (RTT), to offset carbon emissions through tropical farm forestry and provide a model for future forest expansion. It aimed to convert 6,000 ha of pastures and marginal farmland to commercial plantations with fast-growing Klinki pine trees (*Araucaria hunsteinii*) and other tree species such as *E. deglupta* hybrid, Gallinazo (*Jacaranda* sp.) Chancho (*Vochysia guatemalensis*), Almendro (*Dipteryx panamensis*) and Pilon (*Hyeronima* sp.) (Barres, pers. Com.; UNFCCC 1998; Dutschke and Michaelowa 2000).

The Program is made up of a number of projects, designed to be financially profitable long-term investments for the farmer while sequestering and storing carbon for at least the duration of the project. In the project development phase, a survey was carried out with farmers to gauge their interest in the project. A reported 40 farmers indicated their willingness to establish trees on their land (ELI 1997).

Under an approved budget $10 million, a planned trust fund was to cover the project costs over the 25 years. However, given the lack of funding flows after the Program's approval, the Program design had to be scaled down. Another year and a half was then required to establish RTT, through which funds could be raised from other sources.

The project is jointly managed and monitored by RTT and CACTU and is based on legally contractual agreements (or conservation easements[21]). The contractual agreement covers the responsibilities of RTT (payments to farmers over a five year period, provision of seedlings and technical assistance) and of the farmer (providing their land for 25 years for carbon sequestration, cede to RTT in the name of the donors the rights to register the carbon sequestered, to establish and manage the forest free of cattle and weeds which compete with the seedlings and maintain a fully and completely stocked plantation).

Table A.4 Klinki project stakeholders and their roles

Stakeholder	Country	Function
CACTU/ ASOFORES Cantonal Agricultural Center of Turrialba	Costa Rica	Project development, administration, technical assistance, monitoring and verification
CATIE Tropical Agriculture Research and Higher Education Centre	Costa Rica	Technical assistance
Ministry of Natural Resources, Energy and Mines	Costa Rica	Host country acceptance of the AIJ project
RTT Reforest the Tropics, Inc	USA	Program finance and marketing. Project implementation (contracting farmers, administration)
Lawyer	Costa Rica	Legalised project contracts
Emitters (incl. businesses, schools and churches)	USA	Project finance
Yale School of Forestry and Environmental Studies	USA	Project finance and research on soil carbon
USDA	USA	Initial review of Program (no longer actively involved)

The conservation easements allow the beneficiary 'to secure an immediate injunction in case of a violation of the easement terms' (Chomitz *et al.* 1999, p. 9). As payment for the sequestration services and as a contribution to the investments in the establishment and maintenance of the plantation, RTT gives the farmer cash grants for a total of $1,000 per hectare planted over the first five years of the contract (see Table A5). The payments are likely to rise by 25 per cent due to the doubling of the recent cost of nursery stock (Barres, pers. com.). The beneficiary in return guarantees for 30 years an equivalent of the amount received from the Project. Where the land is sold before the end of the contract, the landholder is legally contracted to return the project funds, unless the new landowner wishes to continue with the contract (Chacon *et al*. 1998).

Table A.5 Payments to farmers in the Klinki project

Year	Item	$/ha
1	Seedlings	250
1	Payment at signing of contract	75
1	Planting	150
2	Payment to farmer	150
3	Payment to farmer	150
4	Payment to farmer	150
5	Payment to farmer	75
Total		**1,000**

The farmers receive regular technical assistance from CACTU. The Program works closely with each landholder and makes frequent visits to all project farmers to increase the likelihood of the project's success. The technical assistance provided by the Program emphasizes the importance and requirements for careful planting, intensive cleaning, insect control and replanting during the 3 - 4 year establishment phase.

[21] Conservation easements are inscribed in the public land registry, restricting land use of one property to the benefit of another (Chacon *et al* 1998).

The Program is currently working with six larger landowners and plans to work with no more than ten in the research and development phase. By foresting 500 to 2,000 ha per farm, the projects are expected to generate a continual stream of income for the farmer from the sale of regular thinnings and eventually the harvested wood.

With increased funding, RTT plans to expand the Program to 30 farmers, whereby all potential project farmers will be subjected to a FIT (See-If-The- Farmer-Fits the program) trial, using the 2.5 ha trial areas. Successful farmers would then be allowed to participate in the program and incorporate the trial area in the project.

The 4-year establishment stage will be followed by a 21-year measurement period. Every 5 years, CACTU plans to carry out carbon monitoring together with thinning activities. The methods for monitoring and measurement are not yet finalised but are due for completion in 2000.

To date, 45 ha of mixed species forests have been planted on six farms in Costa Rica to offset the CO2 emissions of 37 US emitters from churches businesses and schools. An additional planting of 45 hectares has been funded for establishment in May 2002.

Funding arrangements are based on two different plans. Individual emitters are charged $2,053/ha to offset their per capita emissions and larger projects are paying $3,000/ha to cover the increased reporting costs (Barres, pers. com.). Donators receive regular report son the status of their projects.

Klinkifix was an early AIJ project and classified as a carbon offset, rather than a carbon credit project, accepting donations rather than investment. As a result, it has no formal insurance policy for donators or external verification and certification provisions.

11.4. SIF Carbon Sequestration Project

Sociedad Inversora Forestal S.A. (SIF) was created to promote the planting of forests on marginal agricultural land, utilized primarily as pastureland for sheep and goats. The project aims to plant up to 7,000 ha of *Pinus radiata* and limited amounts of *Eucalyptus globulus* on an average plot size of 60 to 100 hectares (UNFCCC 2001). Approximately 385,280 tons of additional carbon will be stored during the life of the Project. The estimate is based on an average of approximately 55 tons of average net carbon storage per hectare for the 7,000 ha targeted for this Project. The land conversion is also hoped to reduce the rate of soil erosion.

Table A.6. SIF project stakeholders and their roles.

Stakeholders	Country	Function
Ministry of Agriculture	Chile	Financers of project development and implementation
CORFO	Chile	Financers of project implementation
Ministerio de Relaciones Exteriores	Chile	Designated National Authority to approve AIJ projects
Sociedad Inversora Foresta lS.A	Chile	Project development, administration, government oversight, financing, monitoring and verification
Forestal Mininco S.A	Chile	Technical assistance
Forestal Millalemu	Chile	Technical assistance
CFix LLC	USA	Project development
SGS International	The Netherlands	Verification and certification

The project enters into land use contracts with small and medium farmers, giving SIF the use rights of the land for a defined period of time and allowing farmers to retain land ownership. Generally, the landowners do not have forestry experience, so SIF reforests the properties and provides technical assistance and technical manuals on silviculture procedures. The Project also covers the costs and risks associated with forest management. Farmers receive an annual payment for the lease of their land during the initial growing cycle and a percentage of each harvest. SIF is contractually obliged to return the property to the owner at the end of the contract in a reforested or regenerated state. The farmer retains 100 per cent of the revenues from future harvests. It is hoped that profits will be a sufficient incentive to farmers to continue reforestation or regeneration activities. There is also the threat of fines for not reforesting (UNFCCC 2001).

Once the Project has completed the contracting process, it will seek to raise funding for its planting activities from a long-term bond issue in the local capital markets, backed by the acquisition of forest assets. The bond is also expected to finance the necessary expenses throughout the 24-year growing cycle, and cover the reforestation activities prior to returning the land use rights to the original owners (UNFCCC 2001).

The Project proposal report was submitted to the UNFCCC in 2001. Crent developments in this project are not known.

11.5. Virilla Reforestation and Forest Conservation AIJ Pilot Project

The Costa Rican and Norwegian partners signed an MOU in 1996 to implement an AIJ reforestation and forest conservation pilot project in the upper Virilla River Basin of Costa Rica. The partners and their respective nationalities and rioles are detailed in Table A7. Of the targeted 4,000 ha, 1,000 ha of pastures are to be reforested with native species, and 3,000 ha of primary and secondary forest areas are to be conserved. Over 25 years, the project is estimated to sequester 249,242 tons of carbon (913,877 tons CO_2). Local benefits include the protection of aquifers, reduction in the rate of soil erosion, improvement in water quality and the stabilisation of the hydrological regime in the watershed. This is also expected to enhance the efficiency of four CNFL hydroelectric plants that are now seriously affected by erosion and sedimentation (DEFRA 2001).

Table A.7 Virilla project stakeholders and their roles.

Stakeholders	Country	Function
Norwegian Ministry of Foreign Affairs and the *Consorcio Noruego*	Norway	Project funding. Project review missions every 2 years
CNFL Compaňia Nacional de Fuerza y Luz	Costa Rica	Project funding. Development of monitoring protocol Project administration. Recruitment of participant farmers. Development of management plans. Supervision of planting activities
OCIC Costa Rican Office on Joint Implementation	Costa Rica	Executor of the National AIJ Program Administration of the Greenhouse Gas Fund Issues, certifies and guarantees carbon offsets (CTOs)
FONAFIFO National Fund for Forestry Finance	Costa Rica	Receives AIJ project funds from OCIC. Financial administration. Develops reforestation and conservation contracts with farmers. Monitors forestry activities
FUNDECOR[22] Foundation for the Development of the Central Volcanic Range	Costa Rica	Development of monitoring model. Recruitment of participant farmers. Development of management plans. Supervision of planting activities
CATIE, ITCR and UNA	Costa Rica	Development of model to estimate project CO_2 benefits from reforestation
Small and medium sized landowners	Costa Rica	Producers of environmental services

[22] **FUNDECOR** negotiates with the Ministry of the Environment and Energy (*Ministerio de Ambiente y Energía*, MINAE) and with the National Forest Fund (*Fondo Nacional de Financiamiento Forestal*, FONAFIFO) so that they can be included in the system of Payment for Environmental Services (Pago de Servicios Ambientales, PSO), and grants the green seal of the Forest Stewardship Council which certifies that the forests in question have been managed according to the very highest world standards of sustainability. (FUNDECOR 2001).

The AIJ project is part of a $53.7 million integrated project that also includes an energy conservation project and the reconstruction and expansion of the Brasil Hydroelectric Plant (JIQ 1996). The $3.4 million AIJ project is initially funded by the Norwegian Ministry of Foreign Affairs and the Norwegian private sector consortium, *Consorcio Noruego*.

The AIJ project has been incorporated into the legal and institutional framework of Costa Rica's Forestry Environmental Services Payment (FESP) program. It is classified as a 'Private Forestry Project' (PFP), which compensates farmers for their conservation and reforestation efforts on private lands. Under the FESP program, FONAFIFO, Costa Rica's National Forestry Financing Fund, enters into the legally binding contracts with landowners for 20 years. Although the contracts are stipulated for 20 years, the AIJ Project has been set up for 25 years for purposes of quantification of benefits, costs and monitoring (UNFCCC, 2000). Subak (2000) observed that in the Virilla Basin, the plantation contracts have only been made for five years and 10 years in the case of forest management contracts. If landowners breach their contracts, the funds must be repaid to the State.

Landholders receive annual payments over five years, with rates differing between forest activities as shown in Table A8. The plantation rates are higher as landowners are expected to provide some of their own labour. In addition, the opportunity cost of the land converted to plantation is expected to be higher than the land under forest protection and forest management.

Table A8: PFP's Environmental services payment schedule

Year	Plantation Establishment (US$)	Forest Protection (US$)	Forest Management (US$)
1	300	60	45
2	120	60	45
3	90	60	45
4	60	60	45
5	30	60	45
6-20	*	*	*

Source: Subak (2000); *not determined

Initially, it was estimated that 900 landholders in the Virilla Basin area would participate in the Project. However, by 1998 less than 30 landowners had signed agreements with FONAFIFO. The high opportunity cost of predominantly dairy farming land, together with the drought conditions caused by El Nino, deterred many landowners (Subak 2000).

In the upper Virilla Basin, CNFL and FUNDECOR, not the landowners, are responsible for carrying out technical studies on the landowner's property, choosing the tree species, location, organising the planting schedule and carrying out the planting activities.

However, the forestry component includes education and outreach activities to individual farmers and community organisations, and information on silviculture techniques (UNFCCC 2000).

FUNDECOR is responsible for initially developing a model, using satellite images to establish baselines and project scenarios. FONAFIFO uses the imagery to implement monitoring every three years, along with ground verification. The monitoring protocol for the entire project is developed by CNFL (http://www.northsea.nl/jiq/). An external verifier will be contracted by CNFL as well as involving local NGOs in the verification of the execution status and GHG emissions mitigation levels of the AIJ Project (JIQ 1996)

The Costa Rican Greenhouse Gas Fund, administered by the Costa Rican Office for JI (OCIC), receives the funds for AIJ investments from foreign investors and transfers them to FONAFIFO, the financial administrator of the projects. The government of Costa Rica can legally issue Certifiable Tradable Offsets (CTOs) to the project's foreign investors. Each CTO is guaranteed by the Costa Rican Government for a period of 20 years at a rate of $10/ton carbon $2.72/ton CO_2.

The Costa Rica/Norway reforestation and forest conservation AIJ pilot project provided the first international financial contribution to the FESP program (UNFCCC 2000). According to the 1996 MOU agreement for the AIJ project, Norway's offsets were to fund carbon fixation activities in a 4,000 ha area over the 20-year life of the project. However, when the PFP took effect in 1997, the Government of Costa Rica, through OCIC, issued $2 million worth of CTOs to Norwegian AIJ investors (equivalent to 231,000 CTOs) from PFP forest sequestration activities estimated to have already occurred during 1996 and 1997 (Subak 2000; UNFCCC 2000).[23]

[23] This level of sequestration is based on 382 separate legally binding contracts, applying to 72,000 ha of land throughout the country.

12. APPENDIX 2: THE PROTOTYPE CARBON FUND

The following are the steps for pre-implementation suggested by the Prototype Carbon Fund of the World Bank.

1. Receipt of Project Idea Note (PIN)
The PIN Template available on the PCF website, is completed by the project proponent and submitted to the PCF Fund Management Unit (FMU) via the website.

2. Pre-Screening of PIN
(a) Project idea is screened for basic eligibility criteria by the PCF Knowledge Manager, categorized and logged into the electronic project proposal database with an initial response to proponent.
(b) Project idea is either dropped or if it meets the basic eligibility criteria, assigned to a PCF technical specialist for follow-up. The PCF technical specialists ask the project proponent for further information, if necessary.

3. Review of PIN by FMU
FMU reviews and clears the PIN for further development and finalization.

4. Early Notification of project proposal to Host Country Government
To gain assurance from the host country government of its intention to eventually sign the "Letter of Endorsement," the Fund Manager or the responsible IFC staff asks project sponsor to inform the host country's focal point for UNFCCC, and other IFC/WB counterparts of the host country government. The relevant IFC Regional Dept is notified to gain comment on project's consistency with the CAS for that country.

At the discretion of the Fund Manager, a "Letter of No-Objection" may be requested prior to further development of the project under CDM. A sample Letter of Endorsement is provided as part of the communication.

5. Review of PIN by GEF Secretariat
(a) FMU requests GEF Coordination Unit at the World Bank to submit the *PIN* to the GEF Secretariat for clearance.
(b) The GEF Secretariat has 10 days to issue its "no objection", or to indicate GEF interest in the project proposal.
(c) If "no objection", the FMU asks the project proponent to prepare
a Project Concept Note (PCN).
(d) If GEF expresses interest, project is dropped from the PCF pipeline.

6. Host Country Endorsement
FMU asks Country Management Unit (CMU) to secure Letter of Endorsement (LOE) of the project from the host country. The received LOE is forwarded to the Legal Department. Host country endorsement of the project is sought in parallel with the preparation of the PCN. The endorsement could also come after the "no objection" by the GEF Secretariat.

7. PCF Project Organisational Workshop
FMU meets with the relevant IFC regional operations staff to confirm the project task team, including the Task Manager and the FMU staff member on the task team. The FMU also briefs the project team on the specific requirements of the PCF, including safeguard policies.
.Work program for defining the baseline concept is also discussed.

8. Preparation of Project Concept Note (PCN)
(a) FMU authorizes funds for the preparation of the PCN, which would include preparation of the formal baseline study, expected emission reductions, application of safeguard policies, and an initial review of project risks. PCN is a PCF document that evolves into the PCF Project Document (PD) as project preparations advance. **(b)** Process of environmental and social assessment and review begins.

9. Independent Risk Assessment
A risk assessment of the project is commissioned by the FMU and carried out by an independent entity, based on the PCN. At this time, special risks to PCF if any, may be addressed in this supplementary risk assessment.

10. Review of PCN by Fund Management Committee
Two weeks before FMC Meeting, FMU submits PCN to the Fund Management Committee (FMC) for review to determine if project meets selection and portfolio criteria. FMC reviews on a "no objection" basis. Upon FMC clearance, the PCN is submitted to the Participants Committee (PC) for review, along with the LOE. The PCN is also posted on the Participants Discussion Area of the website.

11. Review of PCN by Participants Committee
Participants Committee (PC) reviews PCN and approves project unless objections in writing by at least two members of the PC are conveyed to the PC Chairman within 30 calendar days of distribution of PCN. PC Chairman sends written notice to Fund Manager on the outcome of the PC review.

12. Preparation of PCF Project Document (PD): Baseline Determination & MVP
If necessary, additional project preparation funds are made available for the preparation of the PCF PD, which is annexed to the IFC Investment Document.

Preparation of the PCF PD involves the following:
(a) Feasibility study is carried out for the PCF component;
(b) the Monitoring and Verification Protocol (MVP) is developed.
Process of environmental and social assessment and review continues.
The Baseline Study and the MVP are submitted as attachments to the PCF PD.

13. Validation Process
Once the draft PCF PD (Annex to the IFC Investment Document) is cleared, the FMU:
(a) carries out re-assessment of the project risk (which may be necessary for further work);
(b) coordinates procurement of independent validator; and
(c) makes a formal decision to submit the project documents (including baseline study and MVP) for independent validation.

14. Drafting of Informal Term Sheet for Purchase Agreement
The FMU prepares an term sheet for informal review. This step represents the latest time to initiate the term sheet. Specific project circumstances may require this step to be initiated earlier. After the term sheet is drafted, LEGEN PCF initiates workplan for drafting legal documents.

15. Pre-Negotiations Workshop/Consultation
A consultation (which normally takes the form of a workshop) is held before to prepare for negotiation of the Emissions Reduction Purchase Agreement, and to informally review specific terms for Agreement.

16. Post-Validation Review of PCF PD by FMU
The FMU reviews the PCF PD, in light of the Validation Report. At this stage, the draft legal documents are also in place, if possible.

17. Appraisal Mission
During the appraisal mission, all PCF project documents, including the baseline study, MVP, Emissions Reduction Purchase Agreement, and the financing agreement are discussed with the host country.

18. FMC Review of Term Sheet and completion of Due Diligence on PD
Fund Management Committee reviews draft Term Sheet before project/ERPA negotiation.

19. Negotiation of Final PCF Contract
The PCF Financial Specialist conducts negotiations with the project sponsor on the PCF ERPA and HCA.
All legal documents are finalized at this stage.
.
20. Post-Negotiation Workshop (Optional)
Subject to the agreement by the project sponsor, a post-negotiations workshop is held to share the experience and lessons learned in the PCF component.

13. APPENDIX 3: ACRONYMS AND ABBREVIATIONS

AIJ: Activities Implemented Jointly

ASB: Alternatives to Slash and Burn

CDM: Clean Development Mechanism, one of the flexibility mechanisms of the Kyoto Protocol

CER: Certified Emission Reductions, the proposed medium of exchange under the CDM

COP: Conference of the Parties to UNFCCC

ICRAF: International Center for Agroforestry Research

IPCC: Intergovernmental Panel on Climate Change

JI: Joint Implementation

LUCF: Land-use change and forestry

UNFCCC: United Nations Framework Convention on Climate Change

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